Bulletin of

Duke University

The Graduate School

2020-2021

Duke University Registrar

Frank Blalark, *Associate Vice Provost and University Registrar*

Academic Liaison

John Klingensmith, *Senior Associate Dean*

Bulletin Coordinator

Denise Leathers

Coordinating Editor

Bahar Rostami

Publications Coordinator

Keely Fagan

Alaina Kaupa

Photographs

Cover photo: Jonathan Lee

Interior photos: Courtesy of Duke University
(Bill Snead, Megan Mendenhall, Les Todd, Jonathan Lee, Megan Morr, Julie Schoonmaker, and Jared Lazarus)

The information in this bulletin applies to the academic year 2020-2021 and is accurate and current, to the greatest extent possible, as of November 2020. The university reserves the right to change programs of study, academic requirements, teaching staff, the calendar, and other matters described herein without prior notice, in accordance with established procedures.

Duke University does not tolerate discrimination or harassment of any kind. Duke University has designated the Vice President for Institutional Equity as the individual responsible for the coordination and administration of its nondiscrimination and harassment policies generally. The Office for Institutional Equity is located in Smith Warehouse, 114 S. Buchanan Blvd., Bay 8, Durham, NC 27708, (919) 684-8222, oie-help@duke.edu. Sexual harassment and sexual misconduct are forms of sex discrimination and prohibited by the university. Duke University has designated Jayne Grandes as its director of Title IX compliance and Age Discrimination Act coordinator. She is also with the Office for Institutional Equity and can be contacted at (919) 660-5766 or jayne.grandes@duke.edu.

Questions or comments about discrimination, harassment, domestic violence, dating violence, and stalking can be directed to the Office for Institutional Equity, (919) 684-8222. Additional information, including the complete text of the discrimination grievance procedure and the harassment policy and appropriate complaint procedures, may be found by contacting the Office for Institutional Equity or visiting its website at https://oie.duke.edu/. Questions or comments about sex-based and sexual harassment and misconduct, domestic violence, dating violence, and stalking committed by a student may also be directed to Victoria Krebs, Associate Dean of Students in the Office of Student Conduct, at (919) 684-7336 or victoria.krebs@duke.edu. Additional information, including the complete text of the policy and complaint procedure for such misconduct, may be found at https://studentaffairs.duke.edu/conduct/z-policies/student-sexual-misconduct-policy-dukes-commitment-title-ix.

Duke University recognizes and utilizes electronic mail as a medium for official communications. The university provides all students with email accounts as well as access to email services from public clusters if students do not have personal computers of their own. All students are expected to access their email accounts on a regular basis to check for and respond as necessary to such communications.

Information that the university is required to make available under the federal Clery Act is available by visiting the Records Division, Duke University Police Department, 502 Oregon Street, Durham, NC 27708, or by calling (919) 684-4602. See https://police.duke.edu/news-stats/clery for more details.

The Family Educational Rights & Privacy Act (FERPA), 20 USC § 1232g; 34 CFR Part 99, is a federal law that guides the release of students' education records, of which disciplinary records are a part. For additional information about FERPA, see https://www.ed.gov/policy/gen/guid/fpco/ferpa/index.html.

Duke University is accredited by the Commission on Colleges of the Southern Association of Colleges and Schools to award baccalaureate, master's, doctorate, and professional degrees. Contact the Commission on Colleges at 1866 Southern Lane, Decatur, GA 30033-4097 or call (404) 679-4500 for questions about the accreditation of Duke University.

This publication is available in alternative format on request. Please call (919) 684-2813.

November 2020

The Mission of Duke University

James B. Duke's founding indenture of Duke University directed the members of the university to "provide real leadership in the educational world" by choosing individuals of "outstanding character, ability and vision" to serve as its officers, trustees and faculty; by carefully selecting students of "character, determination and application;" and by pursuing those areas of teaching and scholarship that would "most help to develop our resources, increase our wisdom, and promote human happiness."

To these ends, the mission of Duke University is to provide a superior liberal education to undergraduate students, attending not only to their intellectual growth but also to their development as adults committed to high ethical standards and full participation as leaders in their communities; to prepare future members of the learned professions for lives of skilled and ethical service by providing excellent graduate and professional education; to advance the frontiers of knowledge and contribute boldly to the international community of scholarship; to promote an intellectual environment built on a commitment to free and open inquiry; to help those who suffer, cure disease and promote health, through sophisticated medical research and thoughtful patient care; to provide wide-ranging educational opportunities, on and beyond our campuses, for traditional students, active professionals and life-long learners using the power of information technologies; and to promote a deep appreciation for the range of human difference and potential, a sense of the obligations and rewards of citizenship, and a commitment to learning, freedom and truth.

By pursuing these objectives with vision and integrity, Duke University seeks to engage the mind, elevate the spirit, and stimulate the best effort of all who are associated with the university; to contribute in diverse ways to the local community, the state, the nation and the world; and to attain and maintain a place of real leadership in all that we do.

— Adopted by the Board of Trustees on February 23, 2001

Duke University is committed to encouraging and sustaining a learning and work community that is free from prohibited discrimination and harassment. The institution prohibits discrimination on the basis of age, color, disability, gender, gender identity, gender expression, genetic information, national origin, race, religion, sex, sexual orientation, or veteran status, in the administration of its educational policies, admission policies, financial aid, employment, or any other institution program or activity. It admits qualified students to all the rights, privileges, programs, and activities generally accorded or made available to students.

Sexual harassment and sexual misconduct are forms of sex discrimination and prohibited by the institution. Duke has designated the Vice President for Institutional Equity and Chief Diversity Officer as the individual responsible for the coordination and administration of its nondiscrimination and harassment policies. The Office for Institutional Equity is located in Smith Warehouse, 114 S. Buchanan Blvd., Bay 8, Durham, NC 27708, and can be contacted at (919) 684-8222.

Questions or comments about harassment or discrimination can be directed to one of the following administrators in the Office for Institutional Equity:

Discrimination in employment or educational programs and activities	Cynthia Clinton, AVP Harassment and Discrimination Prevention and Compliance Office for Institutional Equity 114 S. Buchanan Blvd., Bay 8 Durham, NC 27708 (919) 668-6214
Sex discrimination in educational programs and activities	Jayne Grandes, AVP for Title IX Compliance Office for Institutional Equity 114 S. Buchanan Blvd., Bay 8 Durham, NC 27708 (919) 660-5766

Additional information, including the complete text of Duke's Policy on Prohibited Discrimination, Harassment, and Related Misconduct and appropriate complaint procedures, may be found by visiting the Office for Institutional Equity's website at https://oie.duke.edu/. For further information, visit https://www2.ed.gov/about/offices/list/ocr/index.html, or call (800) 421-3481.

Contents

Contents

Bill Snead

2020-2021 Academic Calendar

Summer 2020

February

17	M	Registration begins for all summer sessions

May

13	W	Term 1 classes begin. The Monday class meeting schedule is in effect on this day. (Therefore, all summer classes meet this day.) Regular class meeting schedule begins on Thursday, May 14. Drop/Add continues
14	Th	Regular class meeting schedule begins
15	F	Drop/Add for Term 1 ends
25	M	Memorial Day holiday. No classes are held

June

10	W	Last day to withdraw with W from Term 1 classes (undergraduates only)
22	M	Term 1 classes end
23	T	Reading period
24	W	Term 1 final examinations begin
25	Th	Term 1 final examinations end
29	M	Term 2 classes begin

July

1	W	Drop/Add for Term 2 ends
4	Sa	Independence Day holiday
27	M	Last day to withdraw with W from Term 2 classes (undergraduates only)

August

6	Th	Term 2 classes end
7	F	Reading period (until 7:00 PM). 7:00 PM. Term 2 final examinations begin
9	Su	10:00 PM. Term 2 final examinations end

Fall 2020

July

27	M	Bookbagging begins for Fall 2020

August

3	M	Registration begins for Fall 2020
10	M	New Graduate Student orientation begins
12	M	Registration ends for Fall 2020
13	Th	New undergraduate student orientation begins; Drop/add begins for Fall 2020
17	M	8:30 AM. Fall semester classes begin. Drop/Add continues
28	F	Drop/Add ends

September

7	M	Labor Day. Classes in session
26/27	Sa/Su	Founders' Weekend

October

2	F	Last day for reporting midsemester grades
19	M	Bookbagging begins for Spring 2021
28	W	Registration begins for Spring 2021
30	F	Last day to withdraw with W from Fall 2020 classes (undergraduates only)

November

9	M	Registration ends for Spring 2021
10	T	Drop/Add begins for Spring 2021
16	M	Graduate and undergraduate classes end
17-19	T-Th	Graduate and undergraduate reading period
20	F	Final examinations begin (9:00 AM)
24	T	10:00 PM. Final examinations end (10:00 PM) Thanksgiving Break; End of Fall 2020 term

2020-2021 Academic Calendar

Spring 2021

January

18	M	Martin Luther King, Jr. Day holiday. No classes are held.
20	W	8:30 AM. Spring semester begins. The Monday class meeting schedule is in effect on this day; regular class meeting schedule begins on Thursday, January 9; classes meeting in a W/F meeting pattern begin January 10. Drop/Add continues

February

2	T	Drop/Add ends
15	M	Registration begins for Summer 2021

March

5	F	Last day for reporting midsemester grades
22	M	Bookbagging begins for Fall 2021
24	W	Last day to withdraw with W from Spring 2021 classes (undergraduates only)
31	W	Registration begins for Fall 2021; Summer 2021 registration continues

April

8	Th	Registration ends for Fall 2021; Summer 2021 registration continues
9	F	Drop/Add begins for Fall 2021
23	F	Graduate and undergraduate classes end
24-26	Sa-M	Graduate and Undergraduate reading period
27	T	Final examinations begin (9:00 AM)

May

1	Sa	10:00 PM. Final examinations end
7	F	Commencement begins
9	Su	Graduation exercises; conferring of degrees

Summer 2021

February

15	M	Registration begins for all summer sessions

May

12	W	Term I classes begin. The Monday class meeting schedule is in effect on this day. (Therefore, all summer classes meet this day.) Regular class meeting schedule begins on Thursday, May 13; Drop/Add continues
13	Th	Regular class meeting schedule begins
14	F	Drop/Add for Term 1 ends
31	M	Memorial Day holiday. No classes are held

June

9	W	Last day to withdraw with W from Term 1 classes (undergraduates only)
21	M	Term 1 classes end
22	T	Reading period
23	W	Term 1 final examinations begin
24	Th	Term 1 final examinations end
28	M	Term 2 classes begin
30	W	Drop/Add for Term 2 ends

July

4	Su	Independence Day holiday
26	M	Last day to withdraw with W from Term 2 classes (undergraduates only)

August

5	Th	Term 2 classes end
6	F	Reading period (until 7:00 PM). 7:00 PM. Term 2 final examinations begin
8	Su	10:00 PM. Term 2 final examinations end

Administration

Bill Snead

University Administration

General University Administration

Vincent Price, PhD, President
Sally Kornbluth, PhD, Provost
Tallman Trask III, MBA, PhD, Executive Vice President
A. Eugene Washington, MD, Chancellor for Health Affairs and the President and Chief Executive Officer of the Duke University Health System
Pamela J. Bernard, JD, Vice President and General Counsel
Kyle Cavanaugh, MBA, Vice President for Administration
Tracy Futhey, MS, Vice President, Information Technology and Chief Information Officer
Kimberly Hewitt, JD, Vice President, Office for Institutional Equity
David L. Kennedy, Vice President, Alumni Affairs and Development
Mary Pat McMahon, MS, Vice Provost/Vice President for Student Affairs
John J. Noonan, MBA, Vice President, Facilities
Christopher Plowe, MD, Director of Duke Global Health Institute
Richard Riddell, PhD, Senior Vice President, Secretary to the Board of Trustees
Michael J. Schoenfeld, MS, Vice President, Public Affairs and Government Relations
Timothy Walsh, MBA, Vice President for Finance
Kevin M. White, PhD, Vice President and Director of Athletics
Stelfanie Williams, PhD, Vice President, Durham and Regional Affairs
Karen L. Abrams, JD, Dean, School of Law
Valerie S. Ashby, PhD, Dean of Trinity College of Arts & Sciences
Ravi V. Bellamkonda, PhD, Dean, Pratt School of Engineering
William Boulding, PhD, Dean, Fuqua School of Business
Marion E. Broome, PhD, RN, FAAN, Dean, School of Nursing
L. Gregory Jones, PhD, Dean, Divinity School
Judith Kelley, MPP, PhD, Dean, Sanford School of Public Policy
Mary E. Klotman, MD, Dean, School of Medicine
Paula D. McClain, PhD, Dean, Graduate School
Toddi Steelman, PhD, Dean, Nicholas School of the Environment
Edward J. Balleisen, PhD, Vice Provost for Interdisciplinary Studies
Abbas Benmamoun, PhD, Vice Provost for Faculty Advancement
Gary G. Bennett, PhD, Vice Provost for Undergraduate Education
Lawrence Carin, PhD, Vice Provost for Research
Jennifer Francis, PhD, Executive Vice Provost
Deborah Jakubs, PhD, Vice Provost for Library Affairs
Scott Lindroth, PhD, Vice Provost for the Arts
Luke A. Powery, ThD, Dean of Duke Chapel
Neal F. Triplett, MBA, President and CEO, Duke University Management Corporation

General Academic Administration

Sally Kornbluth, PhD, Provost
Edward J. Balleisen, PhD, Vice Provost for Interdisciplinary Studies
Abbas Benmamoun, PhD, Vice Provost for Faculty Advancement
Gary G. Bennett, PhD, Vice Provost for Undergraduate Education
Lawrence Carin, PhD, Vice Provost for Research
Jennifer Francis, PhD, Executive Vice Provost
Deborah Jakubs, PhD, University Librarian and Vice Provost
Scott Lindroth, PhD, Vice Provost for the Arts

Graduate School Administration

Paula D. McClain, PhD, Dean
Shanna Fitzpatrick, MHA, MBA, Associate Dean
John A. Klingensmith, PhD, Senior Associate Dean
Jacqueline Looney, EdD, Senior Associate Dean
Anneli Richter, MBA, Associate Dean

Message from the Dean

Welcome to The Graduate School. Duke is an energetic and vibrant university at the forefront of graduate education. The Graduate School is central to the academic mission of the university, and graduate faculty research is on the cutting edge of knowledge in the various disciplines and programs represented in the school. The hallmark of graduate education at Duke is a rich blend of deep, specialized knowledge in a field of study, intersecting with the boundaries and frontiers of other fields. Multidisciplinary approaches are seen as key to discovery and the production of knowledge. Collaborative faculty and graduate student research and study groups coalesce around problems and themes in many different university settings for work beyond departmental and individual program contexts.

The Graduate School is committed to the success of our students and serves as an advocate for their intellectual development. We believe that the analytic and research skills formed and honed during graduate study are critical for success in a variety of professional contexts. We are committed to helping students think about and begin to shape their professional career trajectories from the moment they begin their graduate student careers at Duke. We know, however, that student success encompasses aspects of their lives beyond their academic work, and we believe that graduate study should be viewed as part of a well-rounded life experience. The school offers many programs to help support and enrich the lives of graduate students during their years at Duke.

Duke's location in the Research Triangle (Raleigh-Durham-Chapel Hill) facilitates contact with other major universities and with public and private institutes and firms. Outreach to these communities is an integral part of the Duke graduate experience, both academically and culturally. To come to Duke University for graduate study is to encounter the welcoming environment of an educational community dedicated to the pursuit of excellence and to the production of knowledge that will serve the broader society.

Paula D. McClain, PhD
Dean of The Graduate School
Vice Provost for Graduate Education
Duke University

General Information

Les Todd

History of Duke University

Duke University traces its roots to 1838 in nearby Randolph County, where local Methodist and Quaker communities joined forces to support a permanent school that they named Union Institute. After a brief period as Normal College (1851-59), the school changed its name to Trinity College in 1859 and became a liberal arts college affiliated with the Methodist Church. The college moved to the growing city of Durham in 1892 when Washington Duke provided financial assistance and another local businessman, Julian S. Carr, donated land. In December 1924, the trustees graciously accepted the provisions of James B. Duke's indenture creating the family philanthropic foundation, the Duke Endowment, which provided for the expansion of Trinity College into Duke University.

As a result of the Duke gift, Trinity underwent both academic and physical expansion. The original Durham campus became known as East Campus when it was rebuilt in stately Georgian architecture. West Campus, Gothic in style and dominated by the soaring tower of the Duke Chapel, opened in 1930.

In 1972, the men's and women's colleges merged into the Trinity College of Arts & Sciences. Academic expansion of the university throughout its history has also included the establishment of graduate and professional schools. Duke is now composed of ten schools, including The Graduate School, Duke Divinity School, the School of Medicine, the School of Nursing, the School of Law, the Pratt School of Engineering, The Fuqua School of Business, the Nicholas School of the Environment, and the Sanford School of Public Policy, along with international outposts, including one in Kunshan, China.

Today, Duke embraces a diverse community of learners, including approximately 7,000 undergraduates and 8,900 graduate and professional students from a multiplicity of backgrounds. For more historical information, visit https://library.duke.edu/rubenstein/uarchives.

History of The Graduate School

The Duke University Graduate School, established in 1926, currently enrolls approximately 3,200 graduate students in a wide range of research master's (MA/MS) and doctoral (PhD) degree programs. The Graduate School offers graduate education in more than eighty departments or programs of study where students work closely with faculty across Duke's ten other schools. By attracting the best domestic and international graduate students to work in cutting-edge fields of knowledge, The Graduate School plays a key role in supporting the Mission of Duke University by serving:

"*...to prepare future members of the learned professions for lives of skilled and ethical service by providing excellent graduate and professional education; to advance the frontiers of knowledge and contribute boldly to the international community of scholarship; to promote an intellectual environment built on a commitment to free and open inquiry...to engage the mind, elevate the spirit, and stimulate the best effort of all who are associated with the University; to contribute in diverse ways to the local community, the state, the nation and the world.*"

The Graduate School helps to strengthen the intellectual life of the university by supporting and expanding on the scholarly activities of its faculty. Moreover, Duke's graduate students have many opportunities to participate in leadership roles on campus or in surrounding communities, to serve as teachers and mentors who bridge faculty and undergraduate students, or to develop professionally through conducting and presenting their own research.

The Graduate School welcomes prospective students and guests to visit its home, located on a quiet corner of Campus Drive on Duke's West Campus. Built in 1931 for the family of Duke administrator Robert L. Flowers, the historic stone building later housed University Development offices prior to The Graduate School's move in 2009. This central location provides services for more than eighty graduate departments and programs, working in conjunction with the other nine professional schools; the building is home to Graduate Academic Affairs, Admissions, Finance and Administration, and Student Affairs.

Faculty

Jonathan Lee

Graduate School Faculty

(as of September 20, 2020)

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

A

Atila Abdulkadiroglu, Professor, Economics
Stanley Abe, Associate Professor, Art, Art History, and Visual Studies
Amy Abernethy, Associate Professor, Medicine
Mohamed Abou-Donia, Professor, Pharmacology and Cancer Biology
Soman Abraham, Professor, Pathology
Justus Adamson, Associate Professor, Radiation Oncology
R. Alison Adcock, Assistant Professor, Psychiatry and Behavioral Sciences
Manuel Adelino, Assistant Professor, Business Administration
David Aers, Professor, English
Pankaj Agarwal, Professor, Computer Science
Lamonte Aidoo, Assistant Professor, Romance Studies
S. Munir Alam, Professor, Medicine
Susan Alberts, Professor, Biology, Evolutionary Anthropology
Tara Albrecht, Assistant Professor, Nursing
Elizabeth Albright, Assistant Professor of the Practice, Environmental Science & Policy
John Aldrich, Professor, Political Science
Hashim Al-Hashimi, Professor, Biochemistry
Andrew Allen, Associate Professor, Biostatistics and Bioinformatics
Anne Allison, Professor, Cultural Anthropology
Benjamin Alman, Professor, Orthopaedic Surgery
James Alspaugh, Professor, Medicine
James Alvarez, Assistant Professor, Pharmacology and Cancer Biology
WilfredAmaldoss, Professor, Business Administration
Attila Ambrus, Professor, Economics
Elizabeth Ananat, Associate Professor, Public Policy
Edna Andrews, Professor, Slavic and Eurasian Studies
Nancy Andrews, Professor, Pediatrics
James Anton, Professor, Business Administration
Carol Apollonio, Professor of the Practice, Slavic and Eurasian Studies
Wilkins Aquino, Professor, Civil and Environmental Engineering, Mechanical Engineering and Materials Science
Ayana Arce, Associate Professor, Physics
Peter Arcidiacono, Professor, Economics
Gowthami Arepally, Professor, Medicine
Dan Ariely, Professor, Business Administration
Alessandro Arlotto, Assistant Professor, Business Administration
Andrew Armstrong, Associate Professor, Medicine
Nancy Armstrong, Professor, English
Ashish Arora, Professor, Business Administration
Vadim Arshavsky, Professor, Ophthalmology
Gaurav Arya, Associate Professor, Mechanical Engineering and Materials Science
Valerie Ashby, Professor/Dean, Chemistry
Steven Asher, Professor, Psychology and Neuroscience
David Ashley, Professor, Neurosurgery
Allison Ashley-Koch, Associate Professor, Medicine
Robert Ashton, Professor, Business Administration
Aravind Asokan, Professor, Surgery
Paul Aspinwall, Professor, Mathematics
Owen Astrachan, Professor of the Practice, Computer Science
Jed Atkins, Associate Professor, Classical Studies

B

Leslie Babinski, Associate Research Professor, Public Policy
Robin Bachelder, Assistant Professor, Pathology
Cristian Badea, Assistant Professor, Radiology
Michel Bagnat, Assistant Professor, Cell Biology
Gurpreet Baht, Assistant Professor, Orthopaedic Surgery
Christopher Bail, Associate Professor, Sociology

Donald (Chip) Bailey, Associate Professor, Nursing
Lee Baker, Professor, Cultural Anthropology
Paul Baker, Professor, Earth and Ocean Science
Steven Baldwin, Professor, Chemistry
Edward Balleisen, Professor, History
David Banks, Professor of the Practice, Statistical Science
Ravi Bansal, Professor, Business Administration
Harold Baranger, Professor, Physics
Phillip Barbeau, Assistant Professor, Physics
Arjada Bardhi, Assistant Professor, Economics
Nicole Barnes, Assistant Professor, History
Carolyn Barnes, Assistant Professor, Public Policy
Huiman Barnhart, Professor, Biostatistics and Bioinformatics
Juliana Barr, Associate Professor, History
Roger Barr, Professor, Biomedical Engineering
Ana Barros, Professor, Civil and Environmental Engineering
Alberto Bartesaghi, Associate Professor, Computer Science
Thomas Barthel, Assistant Professor, Physics
Katharine Bartlett, Professor, Law School
John Bartlett, Professor, Medicine
Cameron (Dale) Bass, Associate Research Professor, Biomedical Engineering
Steffen Bass, Professor, Physics
Nima Bassiri, Assistant Professor, Literature
Xavier Basurto, Assistant Professor, Marine Science and Conservation
Larry Baugh, Assistant Professor, Biology
Patrick Bayer, Professor, Economics
Kyle Beardsley, Associate Professor, Political Science
Jeffrey Beck, Assistant Professor, Neurobiology
Matthew Becker, Professor, Chemistry
Charles Becker, Research Professor, Economics
Sarah Beckwith, Professor, English
Christopher Beeley, Professor, Divinity School
Lorena Beese, Professor, Biochemistry
Adrian Bejan, Professor, Mechanical Engineering and Materials Science
Amy Bejsovec, Associate Professor, Biology
Sharon Belenzon, Associate Professor, Business Administration
Ravi Bellamkonda, Professor, Biomedical Engineering
Alexandre Belloni, Professor, Business Administration
Philip Benfey, Professor, Biology
Lori Bennear, Associate Professor, Environmental Science & Policy
Gary Bennett, Professor, Psychology and Neuroscience
Victor Bennett, Assistant Professor, Business Administration
G. Vann Bennett, Professor, Biochemistry
Pablo Beramendi Alvarez, Professor, Political Science
David Beratan, Professor, Chemistry
Elika Bergelson, Assistant Professor, Psychology and Neuroscience
David Berger, Associate Professor, Economics
James Berger, Professor, Statistical Science
Michael Bergin, Professor, Civil and Environmental Engineering
Sarah Bermeo, Assistant Professor, Public Policy
Emily Bernhardt, Associate Professor, Biology
Fernando Bernstein, Professor, Business Administration
James Bettman, Professor, Business Administration
Vikas Bhandawat, Assistant Professor, Biology
Francesco Bianchi, Associate Professor, Economics
Darell Bigner, Professor, Neurosurgery, Pathology
Staci Bilbo, Professor, Psychology and Neuroscience
Ines Black, Assistant Professor, Business Administration
Taylor Black, Assistant Professor, English
Donald Bliss, Associate Professor, Mechanical Engineering and Materials Science
Gerard Blobe, Associate Professor, Medicine
Volker Blum, Associate Professor, Mechanical Engineering and Materials Science
James Blumenthal, Professor, Psychiatry and Behavioral Sciences
Fred Boadu, Associate Professor, Civil and Environmental Engineering
John Board, Associate Professor, Electrical and Computer Engineering
Mary Boatwright, Professor, Classical Studies
Diego Bohórquez, Assistant Professor, Medicine

Tim Bollerslev, Professor, Economics
Eduardo Bonilla-Silva, Professor, Sociology
Dirk Bonker, Associate Professor, History
Melanie Bonner, Professor, Psychiatry and Behavioral Sciences
Mark Borsuk, Associate Professor, Civil and Environmental Engineering
Hayden Bosworth, Professor, Population Health Sciences
Alan Boudreau, Professor, Earth and Ocean Science
William Boulding, Professor, Business Administration
Catherine Bowes Rickman, Associate Professor, Ophthalmology
Catherine (Kate) Bowler, Associate Professor, Divinity School
James Bowsher, Assistant Research Professor, Radiation Oncology
Michael Boyce, Assistant Professor, Biochemistry
Douglas Boyer, Assistant Professor, Evolutionary Anthropology
Katherine Brading, Professor, Philosophy
Curtis Bradley, Professor, Law School
David Brady, Professor, Electrical and Computer Engineering
Andrew Bragg, Assistant Professor, Civil and Environmental Engineering
Debra Brandon, Associate Professor, Nursing
Robert Brandon, Professor, Philosophy
Michael Brandt, Professor, Business Administration
Alon Brav, Associate Professor, Business Administration
Hubert Bray, Professor, Mathematics
Douglas Breeden, Professor, Business Administration
Richard Brennan, Professor, Biochemistry
Luke Bretherton, Professor, Divinity School
Marc Brettler, Professor, Religious Studies
Leila Bridgeman, Assistant Professor, Mechanical Engineering and Materials Science
L. Catherine (Cate) Brinson, Professor, Mechanical Engineering and Materials Science
Martin Brooke, Associate Professor, Electrical and Computer Engineering
Marion Broome, Professor, Nursing
Thomas Brothers, Professor, Music
Haywood Brown, Professor, Obstetrics and Gynecology
Anthony Brown, Professor of the Practice, Public Policy
Kenneth Brown, Associate Professor, Electrical and Computer Engineering
David Brown, Associate Professor, Business Administration
Tyson Brown, Assistant Professor, Sociology
April Brown, Professor, Electrical and Computer Engineering
Kelly Brownell, Professor, Public Policy
Nicolas Brunel, Professor, Neurobiology, Physics
Robert Bryant, Professor, Mathematics
Dorothy Buck, Research Professor, Mathematics
Daniel Buckland, Assistant Professor, Surgery
Federico Bugni, Associate Professor, Economics
A. Craig Burnside, Professor, Economics
Nenad Bursac, Associate Professor, Biomedical Engineering
Linda Burton, Professor, Sociology

C

Roberto Cabeza, Professor, Psychology and Neuroscience
Nicole Calakos, Associate Professor, Neurobiology
Robert Calderbank, Professor, Computer Science, Mathematics, and Electrical and Computer Engineering
Douglas Campbell, Professor, Divinity School
Lisa Campbell, Professor, Marine Science and Conservation
Blanche Capel, Professor, Cell Biology
Lawrence Carin, Professor, Electrical and Computer Engineering
David Carlson, Assistant Professor, Civil and Environmental Engineering, Biostatistics and Bioinformatics
Nicholas Carnes, Assistant Professor, Public Policy
Marc Caron, Professor, Cell Biology
Romain Cartoni, Assistant Professor, Pharmacology and Cancer Biology
Michael Cary, Assistant Professor, Nursing
Patrick Casey, Professor, Pharmacology and Cancer Biology
Avshalom Caspi, Professor, Psychology and Neuroscience
Nicolas Cassar, Associate Professor, Earth and Ocean Science
Krishnendu Chakrabarty, Professor, Electrical and Computer Engineering
Francis Chan, Professor, Immunology
Chi Wei (Cliburn) Chan, Assistant Professor, Biostatistics and Bioinformatics

Shailesh Chandrasekharan, Professor, Physics
Allison Chaney, Assistant Professor, Business
Nathaniel Chaney, Assistant Professor, Civil and Environmental Engineering
Albert Chang, Professor, Physics
Nelson Chao, Professor, Medicine
Stephen Chapman, Associate Professor, Divinity School
James Chappel, Assistant Professor, History
Patrick Charbonneau, Associate Professor, Chemistry
H. Cecil Charles, Associate Professor, Radiology
Evan Charney, Associate Professor of the Practice, Public Policy
Tanya Chartrand, Associate Professor, Business Administration
Jeffrey Chase, Professor, Computer Science
Aaron Chatterji, Associate Professor, Business Administration
Mark Chaves, Professor, Sociology
Yiran Chen, Associate Professor, Electrical and Computer Engineering
Ming Chen, Assistant Professor, Pathology
Qi Chen, Professor, Business Administration
Chuan-Hau Chen, Associate Professor, Mechanical Engineering and Materials Science
Xiuyuan Cheng, Assistant Professor, Mathematics
Jen-Tsan Chi, Associate Professor, Molecular Genetics and Microbiology
Ashutosh Chilkoti, Professor, Biomedical Engineering
Leo Ching, Associate Professor, Asian and Middle Eastern Studies
Rey Chow, Professor, Literature
Steven Churchill, Professor, Evolutionary Anthropology
Anna Cieslak, Assistant Professor, Business Administration
Maria Ciofani, Assistant Professor, Immunology
James Clark, Professor, Environmental Science & Policy
Charles Clotfelter, Professor, Public Policy
Merlise Clyde, Professor, Statistical Science
Jasmine Cobb, Associate Professor, African and African American Studies, Art, Art History, and Visual Studies
F. (Hadley) Cocks, Professor, Mechanical Engineering and Materials Science
Patrick Codd, Assistant Professor, Neurosurgery
Jorn Coers, Assistant Professor, Molecular Genetics and Microbiology
Wesley Cohen, Professor, Business Administration
Harvey Cohen, Professor, Medicine
Wilbur Coleman, Professor, Business Administration
Allan Collard-Wexler, Professor, Economics
Joel Collier, Associate Professor, Biomedical Engineering
Leslie Collins, Professor, Electrical and Computer Engineering
Edgardo Colon-Emeric, Associate Professor, Divinity School
Vincent Conitzer, Professor, Computer Science
Michelle Connolly, Professor of the Practice, Economics
Robert Conrad, Associate Professor, Public Policy
Harris Cooper, Associate Professor, Psychology and Neuroscience
Valerie Cooper, Associate Professor, Divinity School
G. Ralph Corey, Professor, Medicine
Christopher Counter, Professor, Pharmacology and Cancer Biology
Gary Cox, Professor, Medicine
Oana Craciunescu, Associate Professor, Radiation Oncology
Stephen Craig, Professor, Chemistry
Gregory Crawford, Associate Professor, Pediatrics
Nancy Crego, Assistant Professor, Nursing
Michaeline Crichlow, Professor, African and African-American Studies
Bryan Cullen, Professor, Molecular Genetics and Microbiology
Steven Cummer, Professor, Electrical and Computer Engineering
Mary (Missy) Cummings, Professor, Electrical and Computer Engineering
Jonathon Cummings, Professor, Business Administration
Coleen Cunningham, Associate Professor, Pediatrics
Clifford Cunningham, Associate Professor, Biology
John Curry, Professor, Psychiatry and Behavioral Sciences
Stefano Curtarolo, Associate Professor, Mechanical Engineering and Materials Science
Lesley Curtis, Professor, Population Health Sciences
Keisha Cutright, Associate Professor, Business Administration

D

Roberto Dainotto, Professor, Romance Studies

Michael D'Alessandro, Assistant Professor, English
William Darity, Professor, Public Policy
Samit Dasgupta, Professor, Mathematics
Michael Datto, Associate Professor, Pathology
Ingrid Daubechies, Professor, Mathematics
Sandeep Dave, Associate Professor, Medicine
Lawrence David, Assistant Professor, Molecular Genetics and Microbiology
Ellen Davis, Professor, Divinity School
Felipe De Brigard, Assistant Professor, Philosophy
Jennie De Gagne, Clinical Professor, Nursing
Scott de Marchi, Professor, Political Science
Louis DeFrate, Associate Professor, Orthopaedic Surgery
Olivier Delaire, Associate Professor, Mechanical Engineering and Materials Science, Physics
Emily Derbyshire, Assistant Professor, Chemistry, Molecular Genetics and Microbiology
Preyas Desai, Professor, Business Administration
Marc Deshusses, Professor, Civil and Environmental Engineering
Sarah Deutsch, Professor, History
Gayathri Devi, Associate Professor, Surgery
Mark Dewhirst, Professor, Radiation Oncology
Richard Di Giulio, Professor, Environmental Science & Policy
Stefano Di Talia, Assistant Professor, Cell Biology
Yarui Diao, Assistant Professor, Cell Biology
Fred Dietrich, Associate Professor, Molecular Genetics and Microbiology
Leslie Digby, Associate Professor of the Practice, Evolutionary Anthropology
Sheila Dillon, Professor, Art, Art History, and Visual Studies
Anita Disney, Assistant Professor, Neurobiology
Rafael Dix Carneiro, Assistant Professor, Economics
James Dobbins, Professor, Radiology
Sharron Docherty, Associate Professor, Nursing
Kenneth Dodge, Professor, Public Policy
John Dolbow, Professor, Civil and Environmental Engineering, Mechanical Engineering and Materials Science
Bruce Donald, Professor, Computer Science
Xinnian Dong, Professor, Biology
Kathleen Donohue, Associate Professor, Biology
Earl Dowell, Professor, Mechanical Engineering and Materials Science
Martin Doyle, Professor, Environmental Science & Policy
Christine Drea, Professor, Evolutionary Anthropology
Bastiaan Driehuys, Professor, Radiology
Prasenjit Duara, Professor, History
Laurent Dubois, Professor, Romance Studies, History
Jessilyn Dunn, Assistant Professor, Biomedical Engineering, Biostatistics and Bioinformatics
David Dunson, Professor, Statistical Science
Richard Durrett, Professor, Mathematics
Scott Dyreng, Associate Professor, Business Administration
Kafui Dzirasa, Associate Professor, Psychiatry and Behavioral Sciences

E

Julie Edell, Associate Professor, Business Administration
Glenn Edwards, Professor, Physics
Laura Edwards, Professor, History
Tobias Egner, Associate Professor, Psychology and Neuroscience
Martin Eisner, Associate Professor, Romance Studies
Sharyn Endow, Professor, Cell Biology
Stefani Engelstein, Professor, Germanic Languages and Literature
Harold Erickson, Professor, Cell Biology
Cagla Eroglu, Assistant Professor, Cell Biology
Jordan Etkin, Assistant Professor, Business Administration
Janet Ewald, Associate Professor, History

F

Richard Fair, Professor, Electrical and Computer Engineering
Nita Farahany, Professor, Law School
Sina Farsiu, Assistant Professor, Biomedical Engineering, Ophthalmology
Peter Feaver, Professor, Political Science
Peter Fecci, Assistant Professor, Neurosurgery

Luciana Fellin, Associate Professor of the Practice, Romance Studies
Michael Ferejohn, Professor, Philosophy
P. Lee Ferguson, Associate Professor, Civil and Environmental Engineering
Fernando Fernholz, Associate Professor of the Practice, Public Policy
Elia Ferracuti, Assistant Professor, Business
Thomas Ferraro, Professor, English
Paulo Ferreira, Associate Professor, Ophthalmology
Gregory Field, Assistant Professor, Neurobiology
Erica Field, Professor, Economics
Anthony Filiano, Assistant Professor, Neurosurgery
Gleb Finkelstein, Professor, Physics
Gregory Fischer, Professor, Business Administration
Michael Fitzgerald, Professor, Chemistry
Gavan Fitzsimons, Associate Professor, Business Administration
Grainne Fitzsimons, Associate Professor, Business Administration
Owen Flanagan, Professor, Philosophy
Joel Fleishman, Professor, Law School
Scott Floyd, Associate Professor, Radiation Oncology
Christine Folch, Assistant Professor, Cultural Anthropology
Maurizio Forte, Professor, Classical Studies, and Art, Art History, and Visual Studies
Genevieve (Giny) Fouda, Assistant Professor, Pediatrics
Donald Fox, Assistant Professor, Pharmacology and Cancer Biology
Jennifer Francis, Professor, Business Administration
Aaron Franklin, Associate Professor, Electrical and Computer Engineering
Kevin Franks, Assistant Professor, Neurobiology
Katherine Franz, Professor, Chemistry
Linda Franzoni, Professor of the Practice, Mechanical Engineering and Materials Science
Neil Freedman, Associate Professor, Medicine
John French, Professor, History
Adriane Fresh, Assistant Professor, Political Science
Henry Friedman, Professor, Neurosurgery
Richard Frothingham, Associate Professor, Medicine
Mary Fulkerson, Professor, Divinity School
Gustavo Furtado, Assistant Professor, Romance Studies

G

Esther Gabara, Associate Professor, Romance Studies, and Art, Art History and Visual Studies
Michael Gaffrey, Assistant Professor, Psychology & Neuroscience
Sarah Gaither, Assistant Professor, Psychology and Neuroscience
Kenneth Gall, Professor, Mechanical Engineering and Materials Science
Deborah Gallagher, Assistant Professor of the Practice, Environmental Science & Policy
Sara Galletti, Associate Professor, Art, Art History, and Visual Studies
Bai Gao, Professor, Sociology
Haiyan Gao, Professor, Physics
Robert Garlick, Assistant Professor, Economics
Anne Garreta, Research Professor, Literature
David Gaspar, Professor, History
Anna Gassman-Pines, Assistant Professor, Public Policy
Henri Gavin, Associate Professor, Civil and Environmental Engineering
Rong Ge, Assistant Professor, Computer Science
Michael Gehm, Associate Professor, Electrical and Computer Engineering
Kata Gellen, Assistant Professor, Germanic Languages and Literature
Charles Gersbach, Associate Professor, Biomedical Engineering
Simon Gervais, Professor, Business Administration
Jayce Getz, Assistant Professor, Mathematics
Jehanne Gheith, Associate Professor, Slavic and Eurasian Studies
Jean Gibert, Assistant Professor, Biology
Christina Gibson-Davis, Associate Professor, Public Policy
Elizabeth Gifford, Assistant Research Professor, Public Policy
Roseen Giles, Assistant Professor, Music
David Gill, Assistant Professor, Marine Science and Conservation
Michael Gillespie, Professor, Political Science
Bryan Gilliam, Professor, Music
Jeffrey Glass, Professor, Electrical and Computer Engineering
Graham Glenday, Professor of the Practice, Public Policy
Lindsey Glickfeld, Assistant Professor, Neurobiology

Thavolia Glymph, Associate Professor, History, and African and African American Studies
Sarah Goetz, Assistant Professor, Pharmacology and Cancer Biology
Deborah Gold, Associate Professor, Psychiatry and Behavioral Sciences
Benjamin Goldstein, Associate Professor, Biostatistics and Bioinformatics
Zhenqiang (Neil) Gong, Assistant Professor, Electrical and Computer Engineering
Yiyang Gong, Assistant Professor, Biomedical Engineering
Jose Gonzalez, Associate Professor, Classical Studies
Rosa Gonzalez-Guarda, Associate Professor, Nursing
Mark Goodacre, Professor, Religious Studies
Raluca Gordan, Assistant Professor, Biostatistics and Bioinformatics, Computer Science
Maria Gorlatova, Assistant Professor, Electrical and Computer Engineering
Alfred Goshaw, Professor, Physics
Kristin Goss, Associate Professor, Public Policy
John Graham, Professor, Business Administration
Jorg Grandl, Assistant Professor, Neurobiology
Bradi Granger, Research Professor, Nursing
Ruth Grant, Professor, Political Science
Arno Greenleaf, Professor, Biochemistry
Henry Greenside, Professor, Physics
Simon Gregory, Associate Professor, Medicine
Joseph Grieco, Professor, Political Science
Paul Griffiths, Professor, Divinity School
Warren Grill, Professor, Biomedical Engineering
Jennifer Groh, Professor, Psychology and Neuroscience, Neurobiology
Matthias Gromeier, Professor, Surgery
Yongtao (Grant) Guan, Assistant Professor, Biostatistics and Bioinformatics
Johann Guilleminot, Assistant Professor, Civil and Environmental Engineering
Rathnayaka Gunasingha, Assistant Professor, Radiology
Michael Gunn, Professor, Medicine
Claudia Gunsch, Associate Professor, Civil and Environmental Engineering
Tong Guo, Assistant Professor, Business Administration
Michael Gustafson, Associate Professor of the Practice, Electrical and Computer Engineering

H

Steven Haase, Associate Professor, Biology
Malachi Hacohen, Professor, History
Markos Hadjioannou, Associate Professor, Literature
Michael Haglund, Professor, Neurosurgery
Heekyoung Hahn, Assistant Research Professor, Mathematics
Richard Hain, Professor, Mathematics
Susan Halabi, Professor, Biostatistics and Bioinformatics
Laura Hale, Professor, Pathology
Amy Hall, Associate Professor, Divinity School
Kenneth Hall, Professor, Mechanical Engineering and Materials Science
Patrick Halpin, Associate Professor, Marine Science and Conservation
Gianna Hammer, Assistant Professor, Immunology
William Hammond, Professor, Community and Family Medicine
Brent Hanks, Assistant Professor, Medicine
Mark Hansen, Professor, Literature
Sara Haravifard, Assistant Professor, Physics
Michael Hardt, Professor, Literature
Brian Hare, Professor, Evolutionary Anthropology
John Harer, Professor, Mathematics
Amanda Hargrove, Assistant Professor, Chemistry
Ahmad Hariri, Professor, Psychology and Neuroscience
Ashley Harrell King, Assistant Professor, Sociology
Alex Harris, Professor of the Practice, Public Policy
Angel Harris, Professor, Sociology, and African and African American Studies
Alexander Hartemink, Professor, Computer Science
Zachary Hartman, Assistant Professor, Surgery
Campbell Harvey, Professor, Business Administration
Sharique Hasan, Associate Professor, Business Administration
Mark Haskins, Professor, Mathematics
Mona Hassan, Associate Professor, Religious Studies
Frances Hasso, Associate Professor, Gender, Sexuality & Feminist Studies
Michael Hauser, Professor, Medicine

Elizabeth Hauser, Professor, Medicine
Jennifer Hawkins, Associate Research Professor, Philosophy, Medicine
Barton Haynes, Professor, Medicine
Kerry Haynie, Associate Professor, Political Science
Richard Hays, Professor, Divinity School
Timothy Haystead, Associate Professor, Pharmacology and Cancer Biology
You-Wen He, Assistant Professor, Immunology
Yiping He, Assistant Professor, Pathology
Kieran Healy, Associate Professor, Sociology
John Heater, Assistant Professor, Business Administration
Nicholas Heaton, Assistant Professor, Molecular Genetics and Microbiology
James Heffernan, Assistant Professor, Environmental Science & Policy
Joseph Heitman, Professor, Molecular Genetics and Microbiology
Katherine Heller, Assistant Professor, Statistical Science
Homme Hellinga, Professor, Biochemistry
Ricardo Henao, Assistant Professor, Biostatistics and Bioinformatics
James Hench, Assistant Professor, Marine Science and Conservation
Cristina Hendrix, Associate Professor, Nursing
Craig Henriquez, Professor, Biomedical Engineering
Evan Hepler-Smith, Assistant Professor, History
Mark Herman, Assistant Professor, Medicine
Amy Herring, Professor, Statistical Science
Michael Hershfield, Professor, Medicine
D. Sunshine Hillygus, Professor, Political Science
Matthew Hilton, Associate Professor, Orthopaedic Surgery
Andrew Hilton, Assistant Professor of the Practice, Electrical and Computer Engineering
David Hinton, Professor, Environmental Science & Policy
Matthew Hirschey, Assistant Professor, Medicine
Engseng Ho, Professor, Cultural Anthropology, History
Helen Hoenig, Associate Professor, Medicine
Peter Hoff, Professor, Statistical Science
Maureane Hoffman, Professor, Pathology
Brenton Hoffman, Assistant Professor, Biomedical Engineering
Brigid Hogan, Professor, Cell Biology
Jiyong Hong, Associate Professor, Chemistry
Guo-Juin Hong, Associate Professor, Asian and Middle Eastern Studies
Kevin Hoover, Professor, Economics Philosophy
Stacy Horner, Assistant Professor, Molecular Genetics and Microbiology
Roarke Horstmeyer, Assistant Professor, Biomedical Engineering
Nico Hotz, Assistant Professor, Mechanical Engineering and Materials Science
V. Joseph Hotz, Professor, Economics
Jerry Hough, Professor, Political Science
Calvin Howell, Professor, Physics
Laurens Howle, Associate Professor, Mechanical Engineering and Materials Science
Rick Hoyle, Professor, Psychology and Neuroscience
David Hsieh, Professor, Business Administration
Po-Chun Hsu, Assistant Professor, Mechanical Engineering and Materials Science
Heileen Hsu-Kim, Associate Professor, Civil and Environmental Engineering
Tony Huang, Professor, Mechanical Engineering and Materials Science
Erich Huang, Assistant Professor, Biostatistics and Bioinformatics
Jiaoti Huang, Professor and Chairman, Pathology
Joel Huber, Professor, Business Administration
Tomasz Hueckel, Professor, Civil and Environmental Engineering
Lisa Huettel, Professor of the Practice, Electrical and Computer Engineering
Scott Huettel, Professor, Psychology and Neuroscience
Court Hull, Assistant Professor, Neurobiology
Margaret Humphreys, Professor, History
Janice Humphreys, Professor, Nursing
Dana Hunt, Assistant Professor, Marine Science and Conservation
Reeve Huston, Associate Professor, History
Terry Hyslop, Professor, Biostatistics and Bioinformatics

I

Salim Idriss, Associate Professor, Pediatrics
Cosmin Ilut, Associate Professor, Economics
Eun-Ok Im, Professor, Nursing
Joseph Izatt, Professor, Biomedical Engineering

J

Stephen Jaffe, Professor, Music
Richard Jaffe, Jr., Associate Professor, Religious Studies
Tsitsi Jaji, Associate Research Professor, English
Fredric Jameson, Professor, Literature
Micaela Janan, Professor, Classical Studies
Andrew Janiak, Professor, Philosophy
Ashley Jardina, Assistant Professor, Political Science
Paul Jaskot, Professor, Art, Art History & Visual Studies
Deborah Jenson, Professor, Romance Studies
Bruce Jentleson, Professor, Public Policy
Marc Jeuland, Associate Professor, Public Policy
Ru-Rong Ji, Professor, Anesthesiology
Xu Jiang, Assistant Professor, Business Administration
Yong-hui Jiang, Assistant Professor, Pediatrics
Alicia Jimenez, Assistant Professor, Classical Studies
Sue Jinks Robertson, Professor, Molecular Genetics and Microbiology
Sonke Johnsen, Professor, Biology
Zachary Johnson, Assistant Professor, Marine Science and Conservation
Tana Johnson, Assistant Professor, Public Policy
William Johnson, Professor, Classical Studies
G. Allan Johnson, Professor, Radiology
Matthew Johnson, Assistant Professor, Public Policy
Christopher Johnston, Associate Professor, Political Science
David Johnston, Assistant Professor of the Practice, Marine Science and Conservation
William Joines, Professor, Electrical and Computer Engineering
Nancy Jokerst, Professor, Electrical and Computer Engineering
L. Gregory Jones, Professor, Divinity School
Sin-Ho Jung, Professor, Biostatistics and Bioinformatics
Kyle Jurado, Assistant Professor, Economics

K

Zbigniew Kabala, Associate Professor, Civil and Environmental Engineering
Hemant Kakkar, Assistant Professor, Business
Anuj Kapadia, Assistant Professor, Radiology
Courtney Karner, Assistant Professor, Orthopaedic Surgery
Prasad Kasibhatla, Associate Professor, Environmental Science & Policy
Michael Kastan, Professor, Pharmacology and Cancer Biology
Nicholas Katsanis, Professor, Cell Biology
Gabriel Katul, Professor, Environmental Science & Policy
David Katz, Professor, Biomedical Engineering
Jeremy Kay, Assistant Professor, Neurobiology, Ophthalmology
Richard Kay, Professor, Evolutionary Anthropology
Aaron Kay, Associate Professor, Business Administration
Jack Keene, Professor, Molecular Genetics and Microbiology
Matthias Kehrig, Assistant Professor, Economics
Lisa Keister, Professor, Sociology
Judith Kelley, Professor, Public Policy
Roy Kelly, Professor of the Practice, Public Policy
Garnett Kelsoe, Professor, Immunology
Nuri Keskin, Assistant Professor, Business Administration
Ranjana Khanna, Professor, English
Daniel Kiehart, Professor, Biology
Robert Kielb, Professor, Mechanical Engineering and Materials Science
Hyeoneui Kim, Associate Professor, Nursing
Jungsang Kim, Professor, Electrical and Computer Engineering
Kent Kimbrough, Professor, Economics
Allan Kirk, Professor, Surgery

John Kirkpatrick, Associate Professor, Radiation Oncology
David Kirsch, Associate Professor, Radiation Oncology
Alexander Kirshner, Assistant Professor, Political Science
Alexander Kiselev, Professor, Mathematics
Priya Kishnani, Professor, Pediatrics
Herbert Kitschelt, Professor, Political Science
Emily Klein, Professor, Earth and Ocean Science
John Klingensmith, Associate Professor, Cell Biology
Bruce Klitzman, Associate Professor, Surgery
Mary Klotman, Professor, Medicine
Jack Knight, Professor, Political Science, Law
Josiah Knight, Associate Professor, Mechanical Engineering and Materials Science
Mitchell (Mitch) Knisely, Assistant Professor, Nursing
Jennifer Knust, Professor, Religious Studies
Dennis Ko, Assistant Professor, Molecular Genetics and Microbiology
Dwight Koeberl, Associate Professor, Pediatrics
Sarah Komisarow, Assistant Professor, Public Policy
Christopher Kontos, Associate Professor, Medicine
Regis Kopper, Assistant Research Professor, Mechanical Engineering and Materials Science
Sally Kornbluth, Professor, Pharmacology and Cancer Biology
Robert Korstad, Professor, Public Policy
Andrzej Kosinski, Associate Professor, Biostatistics and Bioinformatics
Ashutosh Kotwal, Professor, Physics
Randall Kramer, Professor, Environmental Science & Policy
Michael Krangel, Professor, Immunology
Rachel Kranton, Professor, Economics
William Kraus, Professor, Medicine
Virginia Kraus, Associate Professor, Medicine
Anirudh Krishna, Professor, Public Policy
Jeffrey Krolik, Professor, Electrical and Computer Engineering
Corinne Krupp, Associate Professor of the Practice, Public Policy
Mark Kruse, Professor, Physics
Anna Krylova, Associate Professor, History
Margarethe Kuehn, Associate Professor, Biochemistry
Cynthia Kuhn, Professor, Pharmacology and Cancer Biology
Elena Kulchina, Assistant Professor, Business Administration
Mukesh Kumar, Assistant Professor, Environmental Science & Policy
Timur Kuran, Professor, Economics, Political Science
Madan Kwatra, Associate Professor, Anesthesiology, Medicine
Nayoung Kwon, Associate Professor, Asian and Middle Eastern Studies

L

Kevin LaBar, Professor, Psychology and Neuroscience
Kimberly Lamm, Associate Professor, Gender, Sexuality & Feminist Studies
Andrew Landstrom, Assistant Professor, Pediatrics
Andrea Lanteri, Assistant Professor, Economics
Richard Larrick, Professor, Business Administration
Christopher Lascola, Assistant Professor, Radiology
Daniel Laskowitz, Professor, Neurology
Albert LaSpada, Professor, Neurology
Jeffrey Lawson, Professor, Surgery
Harold Layton, Professor, Mathematics
Alvin Lebeck, Professor, Computer Science
Terry Lechler, Associate Professor, Dermatology
Jose Lecuona Torras, Assistant Professor, Business Administration
Chang-Lung Lee, Assistant Professor, Radiation Oncology
Benjamin Lee, Associate Professor, Electrical and Computer Engineering
Seok-Yong Lee, Assistant Professor, Biochemistry
Robert Lefkowitz, Professor, Medicine
E. Ann LeFurgey, Associate Research Professor, Cell Biology
Adriane Lentz-Smith, Associate Professor, History
Behar Leventoglu, Associate Professor, Political Science
Edward Levin, Associate Professor, Psychiatry and Behavioral Sciences
Adam Levine, Assistant Professor, Mathematics
Daniel Lew, Professor, Pharmacology and Cancer Biology
Tracy Lewis, Professor, Business Administration

Darrell Lewis, Professor, Pediatrics
Chuan-Yuan Li, Professor, Dermatology
Jia Li, Assistant Professor, Economics
Xin Li, Professor, Electrical and Computer Engineering
Hai (Helen) Li, Associate Professor, Electrical and Computer Engineering
Fan Li, Associate Professor, Statistical Science
Wenhong Li, Assistant Professor, Earth and Ocean Science
Qi-Jing Li, Assistant Professor, Immunology
Xi Lian, Professor, Divinity School
Laura Lieber, Professor, Religious Studies
Wolfgang Liedtke, Associate Professor, Neurology
Shu Lin, Associate Professor, Surgery
Corinne Linardic, Associate Professor, Pediatrics
E. Allan Lind, Professor, Business Administration
Scott Lindroth, Professor, Music
Patricia Linville, Associate Professor, Business Administration
Isaac Lipkus, Professor, Nursing
Stephen Lisberger, Professor, Neurobiology
Natalia Litchinitser, Professor, Electrical and Computer Engineering
Paloma Liton, Assistant Professor, Ophthalmology
Ralph Litzinger, Associate Professor, Cultural Anthropology
Jian-Guo Liu, Professor, Physics, Mathematics
Jie Liu, Professor, Chemistry
Qing Liu, Professor, Electrical and Computer Engineering
Joseph Lo, Associate Professor, Radiology
Donald Lo, Associate Professor, Neurobiology
Jason Locasale, Assistant Professor, Pharmacology and Cancer Biology
Michele Longino, Professor, Romance Studies
Guiseppe Lopomo, Professor, Business Administration
Craig Lowe, Assistant Professor, Molecular Genetics and Microbiology
Jianfeng Lu, Associate Professor, Mathematics
Wahneema Lubiano, Associate Professor, African and African-American Studies
Mary Luce, Professor, Business Administration
Richard Lucic, Associate Professor of the Practice, Computer Science
Micah Luftig, Associate Professor, Molecular Genetics and Microbiology
Sheng Luo, Associate Professor, Biostatistics and Bioinformatics
Xunrong Luo, Professor, Medicine
Francois Lutzoni, Professor, Biology
Michael Lynch, Assistant Professor, Biomedical Engineering
Scott Lynch, Professor, Sociology

M

Li Ma, Associate Professor, Statistical Science
David MacAlpine, Associate Professor, Pharmacology and Cancer Biology
William (Hugh) Macartney, Assistant Professor, Economics
Ashwinkumar Machanavajjhala, Associate Professor, Computer Science
Everardo Macias, Assistant Professor, Pathology
Nancie MacIver, Assistant Professor, Pediatrics
Nathaniel Mackey, Professor, English
Nancy MacLean, Professor, History
Amanda MacLeod, Assistant Professor, Dermatology
Richard MacPhail, Associate Professor, Chemistry
David Madden, Associate Research Professor, Psychiatry and Behavioral Sciences
Randy Maddox, Professor, Divinity School
Bruce Maggs, Professor, Computer Science
Abdeslam Maghraoui, Associate Professor of the Practice, Political Science
Paul Magwene, Assistant Professor, Biology
William Majoros, Assistant Professor, Biostatistics and Bioinformatics
Simon Tsz Fung Mak, Assistant Professor, Statistical Science
Ali Makhdoumi, Assistant Professor, Business Administration
Anne-Maria Makhulu, Associate Professor, Cultural Anthropology, African and African American Studies
Steven Malcolmson, Assistant Professor, Chemistry
Jehangir Malegam, Associate Professor, History
Goldis Malek, Assistant Professor, Ophthalmology
Edmund Malesky, Professor, Political Science
Melanie Manion, Professor, Political Science

Brian Mann, Associate Professor, Mechanical Engineering and Materials Science
Paul Manos, Professor, Biology
Marco Marani, Professor, Earth and Ocean Science, and Civil and Environmental Engineering
Douglas Marchuk, Professor, Molecular Genetics and Microbiology
Joel Marcus, Professor, Divinity School
Jeffrey Marks, Associate Professor, Surgery
Cecilia Marquez, Assistant Professor, History
Elizabeth Marsh, Professor, Psychology and Neuroscience
Piotr Marszalek, Professor, Mechanical Engineering and Materials Science
John Martin, Professor, History
Iman Marvian, Assistant Professor, Electrical and Computer Engineering, Physics
Leslie Marx, Professor, Business Administration
Hisham Massoud, Professor, Electrical and Computer Engineering
Matthew Masten, Assistant Professor, Economics
David Matchar, Professor, Medicine
Catherine Mathers, Associate Professor of the Practice, International Comparative Studies
J. Lorand Matory, Professor, Cultural Anthropology, African and African American Studies
Hiroaki Matsunami, Associate Professor, Molecular Genetics and Microbiology
Jonathan Mattingly, Professor, Mathematics
Arnaud Maurel, Assistant Professor, Economics
William Mayew, Assistant Professor, Business Administration
Sucheta Mazumdar, Associate Professor, History
David McAdams, Professor, Business Administration, Economics
Dewey McCafferty, Professor, Chemistry
Paula McClain, Professor, Political Science
David McClay, Professor, Biology
Eleanor McConnell, Associate Professor, Nursing
Mathew McCubbins, Professor, Political Science, Law
John McCusker, Associate Professor, Molecular Genetics and Microbiology
Ryan McDevitt, Assistant Professor, Business Administration
Donald McDonnell, Professor, Pharmacology and Cancer Biology
Marjorie McElroy, Professor, Economics
Brian McGlynn, Professor, Earth and Ocean Science
Jenna McHenry, Assistant Professor, Psychology & Neuroscience
Jarvis McInnis, Assistant Professor, English
Laurie McIntosh, Assistant Professor, Cultural Anthropology
Thomas McIntosh, Professor, Cell Biology
Stuart McKinnon, Associate Professor, Ophthalmology
James McNamara, Professor, Neurobiology
Amy McNulty, Assistant Professor, Orthopaedics
Daniel McShea, Professor, Biology
Neil McWilliam, Professor, Art, Art History, and Visual Studies
Robyn Meeks, Assistant Professor, Public Policy
Thomas Mehen, Professor, Physics
Louise Meintjes, Associate Professor, Music, Cultural Anthropology
Carl Mela, Professor, Business Administration
Gilbert Merkx, Professor of the Practice, Sociology
M. Giovanna Merli, Professor, Public Policy
Michael Merson, Professor, Medicine
Adam Mestyan, Assistant Professor, History
Joel Meyer, Associate Professor, Environmental Science & Policy
Kathryn (Kate) Meyer, Assistant Professor, Biochemistry
Walter Mignolo, Professor, Literature
Mohamad Mikati, Professor, Pediatrics
Maiken Mikkelsen, Assistant Professor, Electrical and Computer Engineering, Physics
Simon Miles, Assistant Professor, Public Policy
Claudia Milian, Associate Professor, Romance Studies
Martin Miller, Professor, History
Francis Miller, Professor, Medicine
Ezra Miller, Professor, Mathematics
Robert Mitchell, Professor, English
Thomas Mitchell-Olds, Professor, Biology
David Mitzi, Professor, Mechanical Engineering and Materials Science
Paul Modrich, Professor, Biochemistry
Terrie Moffitt, Professor, Psychology and Neuroscience
Manoj Mohanan, Assistant Professor, Public Policy
Toril Moi, Professor, Literature, English

Gustavo Monteiro Silva, Assistant Professor, Biology
James Moody, Professor, Sociology
Richard Mooney, Professor, Neurobiology
Christine Moorman, Professor, Business Administration
David Morgan, Professor, Religious Studies
William Morris, Professor, Biology
Ashley Moseman, Assistant Professor, Immunology
Michael Moses, Associate Professor, English
Negar Mottahedeh, Associate Professor, Literature
Berndt Mueller, Professor, Physics
Sayan Mukherjee, Professor, Statistical Science, Biostatistics and Bioinformatics
Marta Mulawa, Assistant Professor, Nursing
Megan Mullin, Associate Professor, Environmental Science & Policy
Kamesh Munagala, Professor, Computer Science
Michael Munger, Professor, Political Science
Deborah Muoio, Associate Professor, Medicine
Susan Murphy, Associate Professor, Obstetrics and Gynecology
Allen Murray, Professor, Earth and Ocean Science
Grant Murray, Associate Professor, Marine Science and Conservation
Samira Musah, Assistant Professor, Biomedical Engineering, Medicine
Clara Muschkin, Associate Research Professor, Public Policy
Barry Myers, Professor, Biomedical Engineering

N

Andrea Nackley, Associate Professor, Anesthesiology
Joseph Nadeau, Associate Professor of the Practice, Civil and Environmental Engineering
Suresh Nallareddy, Assistant Professor, Business Administration
Philip Napoli, Professor, Public Policy
Eva Naumann, Assistant Professor, Neurobiology
Kartik Nayak, Assistant Professor, Computer Science
Mark Neal, Associate Professor, African and African-American Studies
Karen Neander, Professor, Philosophy
Thomas Nechyba, Professor, Economics
David Needham, Professor, Mechanical Engineering and Materials Science
Megan Neely, Assistant Professor, Biostatistics and Bioinformatics
Diane Nelson, Professor, Cultural Anthropology
Wanda Neu, Professor, Biomedical Engineering
Kristen Neuschel, Associate Professor, History
Christopher Newgard, Professor, Pharmacology and Cancer Biology
Lenhard Ng, Professor, Mathematics
Christopher Nicchitta, Associate Professor, Cell Biology
Miguel Nicolelis, Professor, Neurobiology
Kathryn Nightingale, Assistant Professor, Biomedical Engineering
H. Frederik Nijhout, Professor, Biology
Emerson Niou, Professor, Political Science
James Nolen, Associate Professor, Mathematics
Loren Nolte, Professor, Electrical and Computer Engineering
Devon Noonan, Associate Professor, Nursing
Mohamed Noor, Professor, Biology
Jakob Norberg, Assistant Professor, Germanic Languages and Literature
Wayne Norman, Professor, Philosophy
Douglas Nowacek, Associate Professor, Marine Science and Conservation, Electrical and Computer Engineering
Stephen Nowicki, Professor, Biology
Sally Nuamah, Assistant Professor, Public Policy
Charles Nunn, Professor, Evolutionary Anthropology, Global Health
Myaing Nyunt, Associate Professor, Medicine

O

Terrence Oas, Professor, Biochemistry
William O'Barr, Professor, Cultural Anthropology
Sean O'Brien, Associate Professor, Biostatistics and Bioinformatics
Alejandro (Alex) Ochoa, Assistant Professor, Biostatistics and Bioinformatics
Marilyn Oermann, Professor, Nursing
Seog Oh, Professor, Physics
Jocelyn Olcott, Professor, History

Mark Oldham, Associate Professor, Radiation Oncology
Mark Olson, Assistant Professor, Art, Art History, and Visual Studies
Masayuki (Masa) Onishi, Assistant Professor, Biology
Ram Oren, Professor, Ecology
Thomas Ortel, Assistant Professor, Medicine
Truls Ostbye, Professor, Community and Family Medicine
Kouros Owzar, Professor, Biostatistics and Bioinformatics
Tolu Oyesanya, Assistant Professor, Nursing

P

Willie Padilla, Professor, Electrical and Computer Engineering
Miroslav Pajic, Assistant Professor, Electrical and Computer Engineering
G. Sujin Pak, Associate Professor, Divinity School
Mark Palmeri, Associate Professor of the Practice, Biomedical Engineering
Wei Pan, Associate Professor, Nursing
William Pan, Assistant Professor, Environmental Science & Policy, Global Health
Debmalya Panigrahi, Assistant Professor, Computer Science
William Pardon, Professor, Mathematics
Robert Parkins, Professor of the Practice, Music
Ronald Parr, Professor, Computer Science
Simon Partner, Professor, History
Wulf Paschen, Professor, Anesthesiology
Sheila Patek, Associate Professor, Biology
Steven Patierno, Professor, Medicine
Dalia Patino Echeverri, Assistant Professor, Environmental Science & Policy
Subhrendu Pattanayak, Professor, Public Policy, Environmental Science & Policy
Andrew Patton, Professor, Economics
Edward Patz, Professor, Radiology
Christine Payne, Associate Professor, Mechanical Engineering and Materials Science
John Payne, Professor, Business Administration
Jay Pearson, Assistant Professor, Public Policy
Gunther Peck, Associate Professor, History, Public Policy
Zhen-Ming Pei, Associate Professor, Biology
J. Jeffrey Peirce, Associate Professor, Civil and Environmental Engineering
Aleksandar Pekec, Associate Professor, Business Administration
Ann Pendergast, Professor, Pharmacology and Cancer Biology
Pietro Peretto, Professor, Economics
John Perfect, Professor, Medicine
Sallie Permar, Associate Professor, Pediatrics
Angel Peterchev, Assistant Professor, Psychiatry and Behavioral Sciences
Melvin Peters, Professor, Religious Studies
Thomas Petes, Professor, Molecular Genetics and Microbiology
Henry Petroski, Professor, Civil and Environmental Engineering
Arlie Petters, Professor, Mathematics
Alexander Pfaff, Professor, Public Policy
Thomas Pfau, Professor, English
Henry Pfister, Associate Professor, Electrical and Computer Engineering
Dirk Philipsen, Associate Research Professor, Public Policy
Claude Piantadosi, Professor, Medicine
Henry Pickford, Associate Professor, Germanic Languages and Literature
Lillian Pierce, Associate Professor, Mathematics
Stuart Pimm, Professor, Environmental Science & Policy
Charles Piot, Professor, Cultural Anthropology, African and African American Studies
David Pisetsky, Professor, Medicine
William Pizer, Professor, Public Policy
Salvatore Pizzo, Professor, Pathology
M. Ronan Plesser, Professor, Physics
Aaron Pollack, Assistant Professor, Mathematics
Kathryn Pollak, Professor, Population Health Sciences
Herman Pontzer, Associate Professor, Evolutionary Anthropology
Jillian Popadak Grennan, Assistant Professor, Business Administration
Joseph Porter, Professor, English
Anathea Portier-Young, Associate Professor, Divinity School
Kenneth Poss, Professor, Cell Biology
John Poulsen, Assistant Professor, Environmental Science & Policy
Richard Powell, Professor, Art, Art History, and Visual Studies

Leela Prasad, Associate Professor, Religious Studies
Lincoln Pratson, Professor, Earth and Ocean Science
Glenn Preminger, Professor, Surgery
Alan Proia, Professor, Pathology
Janet Prvu Bettger, Associate Professor, Nursing
Kathleen Pryer, Professor, Biology
Kathy Psomiades, Associate Professor, English
Eve Puffer, Assistant Professor, Psychology and Neuroscience, Global Health
Manju Puri, Professor, Business Administration
Devavrat Purohit, Professor, Business Administration
Martha Putallaz Sheppard, Professor, Psychology and Neuroscience

R

David Rabiner, Associate Research Professor, Psychology and Neuroscience
Joseph Rabinoff, Associate Professor, Mathematics
Sudarshan Rajagopal, Assistant Professor, Medicine
Nirmala Ramanujam, Professor, Biomedical Engineering
Sumathi Ramaswamy, Professor, History
Adriano Rampini, Associate Professor, Business Administration
Amanda Randles, Assistant Professor, Biomedical Engineering
Schenita Randolph, Assistant Professor, Nursing
Marcos Rangel, Assistant Professor, Public Policy
Thomas Rankin, Professor of the Practice, Art, Art History, and Visual Studies
Ponugoti Rao, Associate Professor, Ophthalmology
Emma Rasiel, Professor of the Practice, Economics
Mark Rausher, Professor, Biology
Craig Rawlings, Assistant Professor, Sociology
John Rawls, Associate Professor, Molecular Genetics and Microbiology
Andrew Read, Professor, Marine Science and Conservation
Jen'nan Read, Professor, Sociology
Timothy Reddy, Assistant Professor, Biostatistics and Bioinformatics, Molecular Genetics and Microbiology
Michael Reed, Professor, Mathematics
Bryce Reeve, Professor, Population Health Sciences
Galen Reeves, Assistant Professor, Electrical and Computer Engineering, Statistical Science
William Reichert, Professor, Biomedical Engineering
John Reif, Professor, Computer Science
Catherine (Cate) Reilly, Assistant Professor, Literature
Jerome Reiter, Professor, Statistical Science
Michael Relf, Associate Professor, Nursing
Karen Remmer, Professor, Political Science
Lei Ren, Associate Professor, Radiation Oncology
Karin Reuter-Rice, Associate Professor, Nursing
Curtis Richardson, Professor, Environmental Science & Policy
David Richardson, Professor, Biochemistry
Jane Richardson, Professor, Biochemistry
Rachel Richesson, Associate Professor, Nursing
Laura Richman, Associate Professor, Population Health Sciences
Daniel Richter, Professor, Environmental Science & Policy
Daniel Rittschof, Professor, Marine Science and Conservation
James Roberts, Professor, Economics
David Robinson, Associate Professor, Business Administration
Thomas Robisheaux, Professor, History
Colleen Robles, Associate Professor, Mathematics
Howard Rockman, Associate Professor, Medicine
Susan Rodger, Associate Professor of the Practice, Computer Science
Jose Rodriguez Garcia, Associate Professor, Romance Studies
Kenneth Rogerson, Associate Professor of the Practice, Public Policy
David Rohde, Professor, Political Science
Jennifer Roizen, Assistant Professor, Chemistry
Carlos Rojas, Professor, Asian and Middle Eastern Studies
Richard Rosa, Associate Professor, Romance Studies
Deondra Rose, Assistant Professor, Public Policy
Adam Rosen, Associate Professor, Economics
Alexander Rosenberg, Professor, Philosophy
M. Zachary Rosenthal, Associate Professor, Psychiatry and Behavioral Sciences
Ashleigh Rosette, Associate Professor, Business Administration

Benjamin Rossman, Associate Professor, Computer Science, Mathematics
V. Louise Roth, Professor, Biology
Genevieve Rousseliere, Assistant Professor, Political Science
C. Kavin Rowe, Professor, Divinity School
Sudeepa Roy, Assistant Professor, Computer Science
Charmaine Royal, Associate Professor, African and African-American Studies
David Rubin, Professor, Psychology and Neuroscience
Michael Rubinstein, Professor, Mechanical Engineering and Materials Science, Biomedical Engineering, Physics, Chemistry
Cynthia Rudin, Associate Professor, Computer Science
M. Kathy Rudy, Professor, Gender, Sexuality & Feminist Studies
Martin Ruef, Professor, Sociology
Philip Rupprecht, Professor, Music
Marc Ryser, Assistant Professor, Population Health Science, Mathematics

S

Daniel Saban, Assistant Professor, Ophthalmology
Philipp Sadowski, Assistant Professor, Economics
Anne-Gaelle Saliot, Associate Professor, Romance Studies
Gregory Samanez-Larkin, Assistant Professor, Psychology & Neuroscience
Ehsan Samei, Professor, Radiology
John Sampson, Professor, Surgery
Gregory Samsa, Associate Professor, Biostatistics and Bioinformatics, Community and Family Medicine
Leslie Saper, Professor, Mathematics
Guillermo Sapiro, Professor, Electrical and Computer Engineering
Stefanie Sarantopoulos, Associate Professor, Medicine
Todd Sarver, Associate Professor, Economics
Marcella Sarzotti-Kelsoe, Research Professor, Immunology
Kevin Saunders, Assistant Professor, Surgery
Kenneth (Matt) Scaglione, Assistant Professor, Molecular Genetics and Microbiology
Katherine Schipper, Professor, Business Administration
Amy Schmid, Associate Professor, Biology
Scott Schmidler, Associate Professor, Statistical Science
Daniel Schmitt, Professor, Evolutionary Anthropology
Susan Schneider, Associate Professor, Nursing
Chadmark Schoen, Professor, Mathematics
Kate Scholberg, Professor, Physics
Christopher Schroeder, Professor, Law School
Livia Schubiger, Assistant Professor, Political Science
Thomas Schultz, Lecturer, Marine Science and Conservation
Maria Schumacher, Associate Professor, Biochemistry
Rochelle Schwartz-Bloom, Professor, Pharmacology and Cancer Biology
Daniel Scolnic, Assistant Professor, Physics
Guglielmo Scovazzi, Associate Professor, Civil and Environmental Engineering
William Seaman, Professor, Art, Art History, and Visual Studies
W. Paul Segars, Associate Professor, Radiology
Tatiana Segura, Professor, Biomedical Engineering
Paul Seli, Assistant Professor, Psychology & Neuroscience
Gregory Sempowski, Assistant Research Professor, Medicine
Steven Sexton, Assistant Professor, Public Policy
James Shah, Associate Professor, Psychology and Neuroscience
Suzanne Shanahan, Associate Research Professor, Sociology
Kevin Shang, Associate Professor, Business Administration
Elizabeth Shapiro-Garza, Assistant Professor of the Practice, Environmental Science & Policy
Merrill Shatzman, Professor of the Practice, Art, Art History, and Visual Studies
Edward Shaughnessy, Professor, Mechanical Engineering and Materials Science
Ryan Shaw, Associate Professor, Nursing
A. Jonathan Shaw, Professor, Biology
Xiling Shen, Associate Professor, Biomedical Engineering
Sudha Shenoy, Associate Professor, Medicine
David Sherwood, Associate Professor, Biology
Nina Sherwood, Assistant Research Professor, Biology
Andrew Sherwood, Professor, Psychiatry and Behavioral Sciences
Drew Shindell, Professor, Earth and Ocean Science
Mari Shinohara, Assistant Professor, Immunology
Gangadhar Shukla, Professor of the Practice, Public Policy
Modibo Sidibe, Assistant Professor, Economics

Stephanie Sieburth, Professor, Romance Studies
Neil Siegel, Assistant Professor, Law School
David Siegel, Associate Professor, Political Science
Ilene Siegler, Professor, Psychiatry and Behavioral Sciences
Peter Sigal, Professor, History
Brian Silliman, Associate Professor, Marine Science and Conservation
Susan Silva, Associate Research Professor, Nursing
Debra Silver, Assistant Professor, Molecular Genetics and Microbiology
Irene Silverblatt, Professor, Cultural Anthropology
Walter Sinnott-Armstrong, Professor, Philosophy
Dorothy Sipkins, Associate Professor, Medicine
Sim Sitkin, Professor, Business Administration
Asheley Skinner, Associate Professor, Population Health Sciences
Theodore Slotkin, Professor, Pharmacology and Cancer Biology
Kathleen Smith, Professor, Biology
David Smith, Professor, Electrical and Computer Engineering
James Smith, Professor, Business Administration
Martin Smith, Professor, Environmental Science & Policy
Sophia Smith, Associate Professor, Nursing
Clare Smith, Assistant Professor, Molecular Genetics and Microbiology
J. Warren Smith, Associate Professor, Divinity School
Lynn Smith-Lovin, Professor, Sociology
Moria Smoski, Assistant Professor, Psychology and Neuroscience, Psychiatry and Behavioral Science
Joshua Snyder, Assistant Professor, Surgery
Joshua Socolar, Professor, Physics
Scott Soderling, Associate Professor, Cell Biology
Jack Soll, Associate Professor, Business Administration
Harris Solomon, Assistant Professor, Cultural Anthropology
Helen Solterer, Professor, Romance Studies
Marc Sommer, Associate Professor, Biomedical Engineering
Allen Song, Professor, Radiology
Haijun Song, Assistant Professor, Radiation Oncology
Jing-Sheng (Jeannette) Song, Professor, Business Administration
Daniel Sorin, Professor, Electrical and Computer Engineering
Joshua Sosin, Associate Professor, Classical Studies
Derek Southwell, Assistant Professor, Neurosurgery
Leonard Spicer, Professor, Radiology
Roxanne Springer, Professor, Physics
Gopal Sreenivasan, Professor, Philosophy
Herman Staats, Professor, Pathology
Richard Staelin, Professor, Business Administration
Corina Stan, Assistant Professor, English
Heather Stapleton, Associate Professor, Environmental Science & Policy
Orin Starn, Professor, Cultural Anthropology
Daniel Stegmueller, Assistant Professor, Political Science
Rebecca Stein, Associate Professor, Cultural Anthropology
William Steinbach, Associate Professor, Pediatrics
Dori Steinberg, Associate Professor, Nursing
Rebecca Steorts, Assistant Professor, Statistical Science
Mark Stern, Professor, Mathematics
Philip Stern, Associate Professor, History
Adrienne Stiff-Roberts, Associate Professor, Electrical and Computer Engineering
Kristine Stiles, Professor, Art, Art History, and Visual Studies
Nicholas Stoia, Assistant Professor, Music
Victor Strandberg, Professor, English
Timothy Strauman, Professor, Psychology and Neuroscience
Jessi Streib, Assistant Professor, Sociology
Juan Suarez Serrato, Assistant Professor, Economics
Bruce Sullenger, Professor, Surgery
Beth Sullivan, Associate Professor, Molecular Genetics and Microbiology
Peng Sun, Associate Professor, Business Administration
Tai-ping Sun, Professor, Biology
Xiaobai Sun, Professor, Computer Science
Mary Sunday, Professor, Pathology
John Supko, Associate Professor, Music
Neeraj (Neil) Surana, Assistant Professor, Pediatrics
Kenneth Surin, Professor, Literature

Charlotte Sussman, Associate Professor, English
Jennifer Swenson, Assistant Professor of the Practice, Environmental Science & Policy
Robert Swinney, Associate Professor, Business Administration
Victoria Szabo, Associate Research Professor, Art, Art History, and Visual Studies

T

Michael (Mike) Tadross, Assistant Professor, Biomedical Engineering
Paula Tanabe, Associate Professor, Nursing
Stacy Tantum, Associate Research Professor, Electrical and Computer Engineering
Vahid Tarokh, Professor, Electrical and Computer Engineering
Purushothama Tata, Assistant Professor, Cell Biology
George Tauchen, Professor, Economics
Curtis Taylor, Professor, Economics
Donald Taylor, Associate Professor, Public Policy
Gregory Taylor, Associate Professor, Medicine
Thomas Taylor, Professor of the Practice, Public Policy
Thomas Tedder, Professor, Immunology
Stephen Teitsworth, Associate Professor, Physics
Marilyn Telen, Professor, Medicine
Leonard Tennenhouse, Professor, English
Julie Tetel Andresen, Professor, English
Michael Therien, Professor, Chemistry
Duncan Thomas, Professor, Economics
Laine Thomas, Associate Professor, Biostatistics and Bioinformatics
Eric Thompson, Associate Professor, Neurosurgery
Charles Thompson, Professor of the Practice, Cultural Anthropology
Susan Thorne, Associate Professor, History
Deirdre Thornlow, Assistant Professor, Nursing
Christopher Timmins, Associate Professor, Economics
David Tobin, Assistant Professor, Molecular Genetics and Microbiology
Christine Tocchi, Assistant Professor, Nursing
R. Larry Todd, Professor, Music
Surya Tokdar, Associate Professor, Statistical Science
Georgia Tomaras, Professor, Surgery
Michael Tomasello, Professor, Psychology & Neuroscience
Carlo Tomasi, Professor, Computer Science
Marianna Torgovnick, Professor, English
Martin Tornai, Associate Professor, Radiology
Edward Tower, Professor, Economics
Gregg Trahey, Professor, Biomedical Engineering
Kishor Trivedi, Professor, Electrical and Computer Engineering
Michael Troxel, Assistant Professor, Physics
Trong-Kha Truong, Assistant Professor, Radiology
George Truskey, Professor, Biomedical Engineering
Ephraim Tsalik, Associate Professor, Medicine
Nikoleta Tsvetanova, Assistant Professor, Pharmacology and Cancer Biology
Mustafa Tuna, Associate Professor, Slavic and Eurasian Studies
Jenny Tung, Associate Professor, Evolutionary Anthropology
Timothy Turkington, Associate Professor, Radiology
William Turner, Professor of the Practice, Divinity School
Elizabeth Turner, Assistant Professor, Biostatistics and Bioinformatics
Barbara Turner, Professor, Nursing

U

Peter Ubel, Professor, Business Administration
Dean Urban, Professor, Environmental Sciences
Marcy Uyenoyama, Professor, Biology

V

Aarthi Vadde, Associate Professor, English
Ganesan Vaidyanathan, Research Professor, Radiology
Stephen Vaisey, Professor, Sociology
Raphael Valdivia, Associate Professor, Molecular Genetics and Microbiology
Cindy Van Dover, Professor, Marine Science and Conservation

Hans Van Miegroet, Professor, Art, Art History, and Visual Studies
Georg Vanberg, Professor, Political Science
Antonius VanDongen, Associate Professor, Pharmacology and Cancer Biology
Felipe Varas, Assistant Professor, Business Administration
Shyni Varghese, Professor, Orthopaedic Surgery, Biomedical Engineering, Mechanical Engineering and Materials Science
Rahul Vashishtha, Assistant Professor, Business Administration
Stephanos Venakides, Professor, Mathematics
Avner Vengosh, Professor, Earth and Ocean Science
Mohan Venkatachalam, Associate Professor, Business Administration
Manolis Veveakis, Assistant Professor, Civil and Environmental Engineering
Antonio Viego, Assistant Professor, Literature
Steven Vigna, Associate Professor, Cell Biology
Elvira Vilches, Associate Professor, Romance Studies
Rytas Vilgalys, Professor, Biology
Jeffrey Vincent, Professor, Environmental Science & Policy
Lawrence Virgin, Professor, Mechanical Engineering and Materials Science
S. Viswanathan, Professor, Business Administration
Jonathan Viventi, Assistant Professor, Biomedical Engineering
Tuan Vo-Dinh, Professor, Biomedical Engineering
Alexander Volfovsky, Assistant Professor, Statistical Science
Pelin Volkan, Assistant Professor, Biology
Olaf Von Ramm, Professor, Biomedical Engineering
Anselm Vossen, Assistant Professor, Physics
James Voyvodic, Associate Professor, Radiology

W

Kimberly Wade-Benzoni, Associate Professor, Business Administration
Jacqueline Waeber, Associate Professor, Music
J. Ross Wagner, Associate Professor, Divinity School
Priscilla Wald, Professor, English
Julia Walker, Professor, Nursing
Kyle Walsh, Associate Professor, Neurosurgery
Christopher Walter, Associate Professor, Physics
Ingeborg Walther, Professor of the Practice, Germanic Languages and Literature
Ann Marie Walton, Assistant Professor, Nursing
Donghai Wang, Assistant Professor, Medicine
Fan Wang, Associate Professor, Neurobiology, Cell Biology
Qianben Wang, Professor, Pathology
Qiu Wang, Associate Professor, Chemistry
Xiao-Fan Wang, Professor, Pharmacology and Cancer Biology
Xiaofei Wang, Associate Professor, Biostatistics and Bioinformatics
Xiao Yu Wang, Assistant Professor, Economics
Yun Emily Wang, Assistant Professor, Music
Zhiheng Wang, Assistant Professor, Radiation Oncology
David Warner, Professor, Anesthesiology
Warren Warren, Professor, Chemistry
Adam Wax, Professor, Biomedical Engineering
Kathi Weeks, Professor, Gender, Sexuality & Feminist Studies
Yehua Wei, Associate Professor, Business
Joe Weinberg, Professor, Medicine
Kevin Weinfurt, Professor, Psychiatry and Behavioral Sciences
Kent Weinhold, Professor, Surgery
Erika Weinthal, Professor, Environmental Science & Policy
Gennifer Weisenfeld, Professor, Art, Art History, and Visual Studies
Brian Weller, Assistant Professor, Economics
Karen Wells, Associate Professor, Psychiatry and Behavioral Sciences
Kevin Welsher, Assistant Professor, Chemistry
Augustus Wendell, Assistant Professor of the Practice, Art, Art history & Visual Studies
Julianne Werlin, Assistant Professor, English
Jennifer Wernegreen, Associate Professor, Environmental Science & Policy
Anne West, Associate Professor, Neurobiology
Jennifer West, Professor, Biomedical Engineering, Mechanical Engineering and Materials Science
Andrew (Andy) West, Professor, Pharmacology and Cancer Biology
Michael West, Professor, Statistical Science
Annabel Wharton, Professor, Art, Art History, and Visual Studies
Kathryn Whetten, Professor, Public Policy

Anne Whisnant, Director, Liberal Studies
Leonard White, Associate Professor, Orthopaedic Surgery
Ismail White, Associate Professor, Political Science
Erik Wibbels, Professor, Political Science
Kirsten Wickelgren, Professor, Mathematics
Ross Widenhoefer, Professor, Chemistry
Robyn Wiegman, Professor, Literature
Jonathan Wiener, Professor, Law School
Mark Wiesner, Professor, Civil and Environmental Engineering
Makeba Wilbourn, Associate Professor of the Practice, Psychology and Neuroscience
Christopher Wildeman, Professor, Sociology
Benjamin Wiley, Associate Professor, Chemistry
Redford Williams, Professor, Psychiatry and Behavioral Sciences
Christina Williams, Professor, Psychology and Neuroscience
John Willis, Professor, Biology
Lisa Wills, Assistant Professor, Electrical and Computer Engineering, Computer Science
William Wilson, Associate Professor, Biology
Ara Wilson, Associate Professor, Gender, Sexuality & Feminist Studies
Laura Wingler, Assistant Professor, Pharmacology and Cancer Biology
Robert Winkler, Professor, Business Administration
Joseph Winters, Associate Professor, Religious Studies
Norman Wirzba, Professor, Divinity School
Thomas Witelski, Professor, Mathematics
Marty Woldorff, Professor, Psychiatry and Behavioral Sciences
Patrick Wolf, Associate Professor, Biomedical Engineering
Robert Wolpert, Professor, Statistical Science
David Wong, Professor, Philosophy
Terence Wong, Professor, Radiology
Kris Wood, Assistant Professor, Pharmacology and Cancer Biology
Jennifer Clare Woods, Associate Professor, Classical Studies
Gregory Wray, Professor, Biology
Justin Wright, Associate Professor, Biology
Qiuwen Wu, Professor, Radiation Oncology
Ying Wu, Professor, Physics
Colleen Wu, Assistant Professor, Orthopaedic Surgery
Qingrong (Jackie) Wu, Professor, Radiation Oncology
Hau-Tieng Wu, Associate Professor, Mathematics, Statistical Science

X

Youfei Xiao, Assistant Professor, Business Administration
Jichun Xie, Assistant Professor, Biostatistics and Bioinformatics
Jiaming Xu, Assistant Professor, Business Administration
Jason Xu, Assistant Professor, Statistical Science
Yi (Daniel) Xu, Assistant Professor, Economics
Hao Xue, Assistant Professor, Business Administration

Y

Hai Yan, Professor, Pathology
Dong Yan, Assistant Professor, Molecular Genetics and Microbiology
Tiantian Yang, Assistant Professor, Sociology
Xiaowei Yang, Associate Professor, Computer Science
Chung-Hui (Rebecca) Yang, Assistant Professor, Neurobiology
Jun Yang, Professor, Computer Science
Ming Yang, Assistant Professor, Business Administration
Huanghe Yang, Assistant Professor, Biochemistry
Weitao Yang, Professor, Chemistry
Tso-Pang Yao, Professor, Pharmacology and Cancer Biology
Junjie Yao, Assistant Professor, Biomedical Engineering
Tracy Yap, Associate Professor, Nursing
Benjamin Yellen, Associate Professor, Mechanical Engineering and Materials Science
Huseyin Yildirim, Professor, Economics
Eda Yildirim, Assistant Professor, Cell Biology
Fang-Fang Yin, Professor, Radiation Oncology
Henry Yin, Associate Professor, Psychology and Neuroscience
Anne Yoder, Professor, Biology

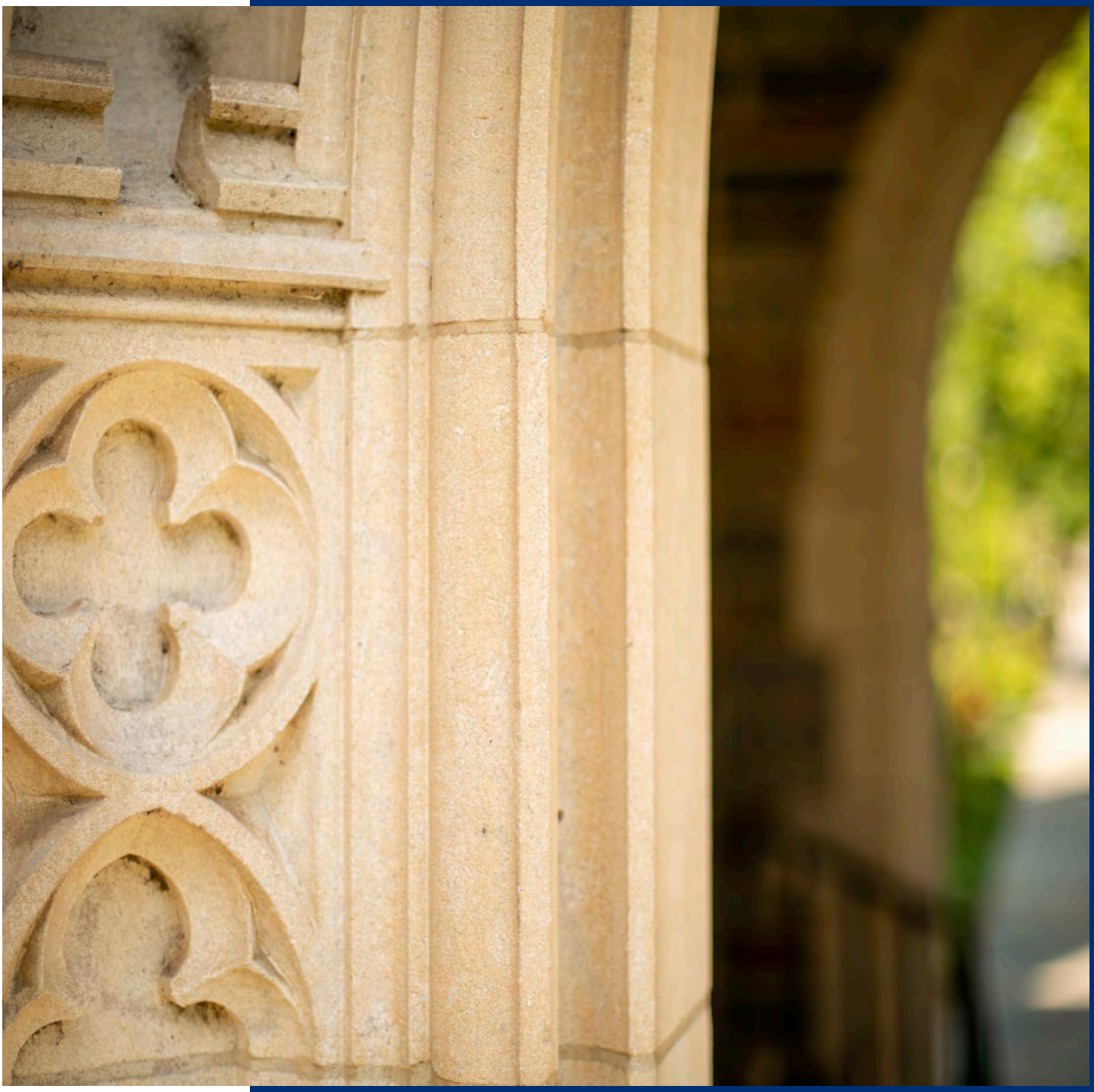
Kenichi Yokoyama, Assistant Professor, Biochemistry
Terry Yoshizumi, Professor, Radiology
Lingchong You, Associate Professor, Biomedical Engineering
Fan Yuan, Associate Professor, Biomedical Engineering

Z

Aimee Zaas, Associate Professor, Medicine
Michael Zalutsky, Professor, Radiology
Stefan Zauscher, Professor, Mechanical Engineering and Materials Science
Michael Zavlanos, Assistant Professor, Mechanical Engineering and Materials Science
Junfeng (Jim) Zhang, Professor, Environmental Science & Policy
Jennifer (Yunyan) Zhang, Associate Professor, Dermatology
Zhao Zhang, Assistant Professor, Pharmacology and Cancer Biology
Weiguo Zhang, Associate Professor, Immunology
Can Zhang, Assistant Professor, Business Administration
Xiaoping Zhong, Associate Professor, Pediatrics
Pei Zhong, Professor, Mechanical Engineering and Materials Science
Pei Zhou, Associate Professor, Biochemistry
Yuan Zhuang, Professor, Immunology
Danyang Zhuo, Assistant Professor, Computer Science
Nancy Zucker, Associate Professor, Psychiatry and Behavioral Sciences

Jared Lazarus

Admission



Jonathan Lee

Degree and Nondegree Admission

Any person who wishes to undertake graduate work at Duke University, whether for degree or nondegree purposes, must be formally admitted to The Graduate School by the dean. Prerequisites for admission include a US bachelor's degree (or its equivalent) from a regionally accredited institution. If the degree was granted by an institution outside of the United States, the institution must be accredited by the governing educational body of the country (such as the ministry of education). For almost all degree programs, satisfactory scores on the Graduate Record Examination (GRE) are also required. International applicants (both degree and nondegree) whose first language is not English are required to also submit official scores for either the Test of English as a Foreign Language (TOEFL) or the International English Language Testing System (IELTS). Students who have studied full-time for two years or more at a college or university where the sole language of instruction is English and in a country where English is the primary spoken language may request a TOEFL waiver. Individual departments may specify additional prerequisites, which can be found in the chapter "Departments, Programs, & Course Offerings" on page 66.

An applicant who does not intend to earn an advanced degree at Duke but who wishes to take graduate courses may apply for nondegree admission. Such admission is granted in two different categories: (1) admission as a nondegree student affiliating with a particular department; or (2) admission through the Office of Continuing Studies as a nondegree student without departmental affiliation. Credits earned by nondegree students in graduate courses taken at Duke before full admission to The Graduate School may be carried over into a graduate degree program if (1) the action is recommended by the student's director of graduate studies and approved by the dean; (2) the coursework is not more than two years old; (3) the amount of such credit does not exceed one full-time semester; and (4) the coursework received grades of B or better.

A student who has discontinued a program of graduate degree work and who wishes to reenroll must send a written request for readmission to The Graduate School's Office of Academic Affairs. The dean of The Graduate School will make the final decision regarding all requests for readmission.

A student who enters The Graduate School in a master's program must submit a new application to be considered for a doctoral program.

Applicants holding PhDs or their equivalent are generally not eligible for admission to Duke University for a second PhD. The dean of The Graduate School will consider exceptions only if the department or program demonstrates that the proposed field of study is unrelated to the field of the first PhD, and that the educational experience afforded by the proposed doctoral field is essential for the applicant's long-term research objectives. Please note that applicants who have not yet had the opportunity to benefit from a doctoral education will be prioritized in the admissions and financial aid process.

Application Procedures

This chapter is a brief summary of information available from The Graduate School admissions website: https://gradschool.duke.edu/admissions. *This website should be consulted for more comprehensive information on all aspects of the application, admission, and award process.*

A person seeking admission to The Graduate School may access application and program information online at https://gradschool.duke.edu/admissions. All parts of the application form must be filled out completely and submitted to The Graduate School admissions office with the application fee. The necessary supporting documents must also be included as part of the submission of the online application. The application fee is $95.[1] The required supporting documents are: (1) one copy of a transcript from each undergraduate or graduate institution attended; (2) three letters of recommendation; (3) official Graduate Record Examination (GRE) General Test scores for applicants to most programs[2]; and (4) official scores on the GRE Subject Tests for applicants to certain specified departments.

If an applicant accepts an offer of admission, he or she must send an official, confidential transcript to The Graduate School for each institution listed in the application. The Graduate School reserves the right to revoke any offer of admission in the case of a discrepancy between the transcript included in the application and the official transcript.

Materials submitted in support of an application are not released for other purposes and cannot be returned to the applicant.

Those applying for admission should take the GRE in time for official scores to reach The Graduate School by the appropriate application deadline. Information on the dates and locations of the Graduate Record Examinations can be obtained from the applicant's educational institution or the Educational Testing Service GRE website at https://www.ets.org/gre.

TOEFL/IELTS Policy for International Applicants. If an applicant's first language is not English, the applicant must submit certification of English proficiency demonstrated by official test scores from the International English Language Testing Service (IELTS) (https://www.ielts.org) or the Test of English as a Foreign Language (TOEFL) (https://www.ets.org/toefl).

TOEFL/IELTS Waiver Policy. To be eligible for a TOEFL/IELTS waiver, students must have studied full-time for two years or more at a college or university where the sole language of instruction is English and in a country where English is the primary spoken language. The two years of study must be completed prior to application submission.

1 All fees are based on current charges and are subject to change without notice.

2 Applicants to the master of arts in liberal studies (MALS) and the master of fine arts in experimental and documentary arts (MFAEDA) programs are not required to submit standardized test scores. Applicants to the master of science in global health (MScGH) and the master of arts in bioethics and science policy programs can submit either MCAT or GRE scores. Applicants to the doctor of philosophy (PhD) in business administration program can submit either GMAT or GRE scores.

English Language Requirements for International Students. In addition to submitting an IELTS or TOEFL score, international students whose first language is not English must demonstrate proficiency in academic English by taking oral and written exams upon their arrival at Duke. Depending on their exam results, students are either exempted from or placed into one or more English for International Students (EIS) courses. Students with EIS requirements must begin these courses in their first year of study.

Part-Time Graduate Study. Very few graduate departments will consider applications from applicants wishing to pursue degree study on a part-time basis. Contact your department of interest to determine whether they accept part-time students. Admission requirements, procedures, and deadlines are the same for part-time study as for full-time study. Visa restrictions do not allow international students to pursue graduate study on a part-time basis.

Continuing Studies Procedures. An applicant seeking admission as a nondegree continuing studies graduate student at Duke must have received a bachelor's degree from a regionally accredited college or university. More information regarding continuing studies at Duke is available on the Duke University Continuing Studies website at https://learnmore.duke.edu.

Review of Application and Notification of Status. All applications are considered without regard to race, color, religion, national origin, disability, veteran status, sexual orientation, gender identity, sex, or age.

Application files are assembled in The Graduate School admissions office, where all official record-keeping is maintained. A departmental admissions committee, usually headed by the director of graduate studies, reviews the applications and makes recommendations to the dean of The Graduate School. All offers of formal admission to The Graduate School are made by the dean. The process of admission is not complete until the student accepts the offer online through the Applicant Status Page in the Application Management System.

Deferrals. Requests for deferral are rarely approved by The Graduate School. Valid reasons for a deferral are health issues, visa issues which are beyond the student's control, or military service.

Immunizations. North Carolina Statute G.S.: 130A-155.1 states that no person shall attend a college or university, public, private, or religious, excluding students attending night classes only and students matriculating in off-campus courses, unless a certificate of immunizations against diphtheria, tetanus, whooping cough, poliomyelitis, red measles (rubeola), and rubella is presented to the college or university. The required forms and instructions are provided to students after their acceptance of the offer of admission.

Deadlines for Application

It is the applicant's responsibility to make certain that The Graduate School admissions office has received all required materials by the appropriate application deadlines. Only complete applications can be considered. To ensure that the admissions office will have adequate time to assemble all items submitted on an applicant's behalf, application materials should be submitted at least two weeks before the stated deadlines.

Consult The Graduate School's website (https://gradschool.duke.edu/admissions/application-deadlines) for a more detailed explanation of deadlines and their enforcement.

Fall Semester

Fall application deadlines vary by program and are listed on The Graduate School's website (https://gradschool.duke.edu/admissions/application-deadlines). Applications submitted by these dates are guaranteed a review by the departmental admissions committees. Applications submitted after these dates are not guaranteed consideration but will be considered for admission if all spaces have not been filled, and for financial aid, if funds are still available. All PhD applicants seeking fall admission should meet the stated deadlines, since it is likely that enrollment in many departments will be filled soon after the deadlines.

Spring Semester

October 1. Deadline for submission of applications for the spring semester, space permitting. Very few departments accept new students for the spring semester, and financial aid is not readily available for spring matriculants. Please visit the Programs and Degrees page of The Graduate School website (https://gradschool.duke.edu/academics/programs-degrees) to determine which departments accept spring matriculants.

Summer Session

Those seeking admission to The Graduate School for the summer session should apply in accordance with the fall deadline schedule. There are two summer sessions, one running from mid-May to late June, the other from early July to mid-August. Very few departments accept new students for the summer session. With the exception of applicants to the master of arts in teaching program (which begins in the summer), applicants who wish to apply for summer admission must obtain special permission from the department of interest and The Graduate School.

Bill Snead

Financial Information

Bill Snead

Tuition and Fees

Although many students will receive financial assistance for their graduate education, students are responsible for ensuring that they have the means to support themselves, and the ability to pay tuition, and fees due the university. Below is a summary of expected costs. The figures are estimates for 2020-2021 and are subject to change.

PhD Tuition

PhD tuition is charged on a per semester basis. For 2019-2020, the tuition charge for PhD students in their first three years of study is $28,950 per academic semester. Upon approval of the dean, one semester of credit may be granted for PhD candidates entering with a previous graduate degree or for one semester of nondegree graduate-level work done at Duke prior to matriculation. Students in their fourth year of study and beyond are charged a reduced tuition rate of $4,000 per academic term. All PhD students, regardless of year of study, will be charged the tuition rate of $4,000 for the summer 2021 term.

Master's Tuition

Master's tuition for full-time study is charged on a per semester basis. For 2020-2021, the tuition charge for full-time master's students is $28,950 per academic semester. Master's students are required to enroll in and pay tuition for three full-time semesters of study, or the part-time equivalent thereof. Upon meeting the three-semester requirement, master's students may convert to part-time academic status and will be charged a per credit rate for all remaining credits. For the 2020-2021 academic year, the per credit rate is $3, 360. Master's students are also charged a part-time rate for summer coursework, not to exceed half the full-time rate for each summer term. Incoming students who are approved to attend on a part-time basis are also charged the current per credit rate.

Student Health Fee

All full-time students and part-time degree candidates are assessed a fee each semester for the use of the Student Health Service. For fall and spring, the fee is estimated at $858 ($429 per semester). For summer 2021, the fee is estimated at $302. This fee is distinct from health insurance and does not provide major medical coverage.

Recreation Fee

Graduate students will be charged a recreation fee for the use of on-campus facilities. The 2020-2021 fee is $162.75 per semester. Use of the recreational facilities and payment of the fee is optional for PhD students in their sixth or later years.

Student Activity and Student Services Fees

All graduate students will be charged student activity fees of $18.25 and student services fees of $10, per academic semester.

Transcript Fee

All entering students will be charged a one-time mandatory fee of $120 for transcripts. This fee entitles the student to an unlimited number of Duke transcripts. Requests for transcripts of academic records can be made via DukeHub, Duke's online student records system, which can be accessed at https://dukehub.duke.edu/.

For additional information about trancripts, visit the following page on the Office of the University Registrar's website: https://registrar.duke.edu/student-records-resources/transcripts-and-verifications.

Other Miscellaneous Fees

Marine Laboratory Fee

For Marine Laboratory investigators' research table fee, please contact the Nicholas School of the Environment.

Audit Fee

Auditing classes is permitted on a space available basis with the consent of the instructor. Degree-seeking students may audit courses without charge during the fall and spring terms. An audit fee will be charged for all nondegree students in any term, and may be charged for degree-seeking students during the summer term, depending on the course.

Parking Fee

Students should contact the University Parking and Transportation Services Office regarding parking fees.

Living Expenses

Health Insurance

Students will be charged for enrollment in the Duke Student Medical Insurance Plan (Duke SMIP) in the fall semester, unless proof of other comparable health insurance is provided to the Student Health Center no later than their communicated deadline. For current Duke SMIP rates, please visit the Student Health website, https://studentaffairs.duke.edu/studenthealth.

Books and Supplies

Books and supplies for 2020-2021 are estimated at $936 for twelve months.

General Living Expenses

For detailed information on the complete cost of attendance for PhD and master's students, visit The Graduate School Cost to Attend webpage, https://gradschool.duke.edu/financial-support/cost-attend.

Payment Policies

The bursar's office emails statements to registered graduate students for tuition, fees, and other charges approximately four to six weeks prior to the beginning of classes each semester. The amount due on the statement is payable by the due date listed on the statement. Student account statements are also available online. Inquiries regarding statements can be directed to the bursar's office at bursar@duke.edu or (919) 684-3531.

As part of the admission agreement to Duke University, students are required to pay all statements as presented. If full payment is not received, a late payment penalty charge on the past due amount is charged on the subsequent statement. The past due amount is defined as the amount due from the previous statement minus payments, financial aid, loans, and other credits received prior to the due date listed on the prior statement.

Failure to receive an invoice does not warrant exemption from the payment of tuition and fees nor from the penalties and restrictions. Nonregistered students will be required to make payment for tuition, fees, and other charges at the time of registration.

In addition to late payment charges, students with accounts in default may be subject to the following restrictions:

- blocked from registering for future terms
- not eligible to receive compensatory or fellowship stipend
- blocked from access to copies of transcript of academic records
- not able to have academic credits certified
- not be permitted to go on leave of absence
- not eligible to receive a diploma at graduation
- subject to withdrawal from the university
- subject to having the past due student account referred to a collection agency and credit bureaus

Refund Policies

Refunds for Withdrawal from School during Fall and Spring Semesters. In the event of death, refund of full tuition and fees for the term will be granted. In all other cases of withdrawal from the university, students may have tuition refunded according to the following schedule:

- Withdrawal before classes begin: full refund, including fees
- Withdrawal during the first or second week of classes: 80 percent refund*
- Withdrawal during the third, fourth, or fifth week of classes: 60 percent refund*
- Withdrawal during the sixth week of classes: 20 percent refund*
- Withdrawal after the sixth week: no refund

*Fees are not refunded after the start of the term.

If a student has to drop a course for which no alternate registration is available, drops special fee courses (music, golf, etc.), or drops a paid audit during the first two weeks of the drop/add period, a full refund may be granted with the approval of the dean. The student health fee will not be refunded.

PhD Funding

The contributions of graduate students are highly valued in the university and Duke has a strong commitment to fully fund the PhD students it selects for graduate study for five consecutive years. The Graduate School and its graduate programs offer a wide array of financial support. Funding is available from annually allocated fellowship awards funds, instruction, endowed fellowships, foundation and other private support, as well as federal and privately sponsored research grants, training grants, and fellowships. PhD students are also encouraged to independently seek out external funding as these opportunities often provide valuable recognition of a student's academic potential and promise.

Students admitted to a PhD program are typically supported for a period of five years, provided that satisfactory academic progress

is being made. Standard support packages for PhD students may include a scholarship that covers all or a portion of tuition and fees, health insurance, and a fellowship and/or assistantship stipend to help defray cost of living expenses. Students with funding questions specific to their studies are encouraged to communicate with their graduate program.

Duke also provides tuition scholarships to PhD students in their sixth year who do not have tuition support from external or other institutional sources. Sixth-year PhD students are eligible to apply for a tuition scholarship if they have applied for and failed to obtain external tuition funding or competitive Graduate School tuition funding for the sixth year of study.

Department and Program Fellowships and Assistantships

Tuition and fee scholarships for study toward a PhD are provided by The Graduate School. For information about fellowship and/or assistantship stipends in a specific department or program, students should contact the director of graduate studies for their program. In general, a student's support package may be composed of several different types of funding, including:

- **Full or partial scholarships** to cover tuition, mandatory fees, and health insurance.
- **Fellowship stipends** are awarded by the department or program. Many departments also offer endowed fellowships.
- **Training grant appointments** for US citizens and permanent residents participating in federally funded training programs.
- **Research assistantships** are available for graduate students whose training enables them to assist individual faculty members in certain departments.
- **Teaching assistantships**, which are opportunities offered to graduate students for instructional training, offer roles such as preceptors and section leaders, tutors, and graders.

Some master's programs utilize, when possible, the federal work study program to help provide financial support. As a result, some departments may require or request that students complete the Free Application for Federal Student Aid so that eligibility for work study funds can be determined. This form can be completed online at the Free Application for Federal Student Aid website, https://studentaid.ed.gov/sa/fafsa.

Interdisciplinary Programs and Centers

In addition to the departmentally-based awards, several interdisciplinary programs and centers offer fellowship and assistantship awards to both incoming and continuing students interested in the program areas. These include programs in documentary studies, medieval and Renaissance studies, women's studies, Latin American and Caribbean studies, visual studies, and in centers such as the Kenan Institute for Ethics, the Innovation & Entrepreneurship Initiative, and the John Hope Franklin Center for Interdisciplinary and International Studies.

Fellowships for Incoming and Continuing Students

The Graduate School funds several competitive fellowships for incoming and continuing PhD students. For incoming students, selection is based on departmental nomination during The Graduate School application process. Continuing students interested in applying for Graduate School fellowships should follow the application procedures listed on The Graduate School Financial Support website. Selection of award recipients is made on the basis of academic merit and departmental recommendations.

Most fellowships for incoming and continuing students will provide a full tuition and mandatory fee scholarship, payment of student's health insurance premium, and stipend support. Some awards also provide stipend supplements to the standard departmental stipend, research and/ or travel expense funding.

A comprehensive list of all available fellowships offered through The Graduate School can be found on the Financial Support website, as well as a funding database to assist in identifying funding opportunities. In addition to fellowships, The Graduate School also works to secure funding for advanced students who need to conduct research overseas in order to complete their dissertation projects. Additional information regarding these opportunities are also available through the school's Find Funding database. For more information, visit https://gradschool.duke.edu/financial-support/find-funding.

National, Regional, and Foundation Awards

In addition to those awards available through the university, applicants are urged to compete for national and foundation awards available for graduate study. The Duke University Office of Research Support website, https://ors.duke.edu/, lists awards available from a variety of federal and private sources, as well as awards funded by the university. External awards, which are prestigious and a valuable acknowledgement of a student's intellectual capability and academic promise, typically replace departmental or The Graduate School fellowship awards.

Payment and Taxation of Awards

Students must be enrolled in The Graduate School in order to receive fellowship or assistantship support. Tuition and fee scholarships and health insurance payments are posted directly to a student's bursar account by The Graduate School Office of Budgets and Finance.

Payments for both fellowships and assistantships are generally managed by students' departments for distribution. It is highly recommended, however, that students sign up to receive stipend payments through direct deposit to their bank account. Under the Tax Reform Act of 1986, both fellowship stipends and assistantships are taxable.

For US Citizens: Fellowship stipends may be reduced, for tax purposes, by the amounts paid for tuition, mandatory fees (other than the health and recreation fees) and required books, supplies, and equipment. For general information about the taxability of scholarships and fellowships, students should see IRS publication 970, which can be found on the Internal Revenue website.

For International Citizens: Stipend payments are subject to withholding of federal and state income taxes, unless there is an existing tax treaty between the student's country and the United States stating otherwise. Information concerning tax treaties by country can also be found on the Internal Revenue Service website. In addition there is an IRS requirement that tuition payments for foreign

students must be reported to the federal government. More information on taxation of foreign nationals and current tax treaties is available on the Corporate Payroll website.

Students have ultimate responsibility for ensuring that their tuition and fees are paid. Students should review statements received from the bursar's office regularly and quickly resolve payment problems or issues that arise. Students with questions about their bursar accounts should contact the assistant to the director of graduate studies in their department, the bursar's office, or The Graduate School Office of Budgets and Finance.

Payment of Awards

It is the policy of The Graduate School that full-time students may not complete more than 19.9 hours per week in non-dissertation-related research appointments, teaching assistantships or other instructional positions, or other financial support sources (both on and off campus).

Payment of graduate student scholarship, fellowship, and assistantship support are subject to the following policies:

- Registration policy: Students must be registered in The Graduate School in order to receive fellowship or assistantship support.
- Satisfactory academic progress
- Payment of bursar accounts for fall, and spring, and summer
- Refunds for withdrawal from school during fall and spring semesters

Financial Aid

In addition to the information shown below, students should also review the Duke University Bursar's FAQs. If students have additional questions about financial support, they should contact grad-finaid@duke.edu.

For students pursuing a master's degree in The Graduate School, some limited funds for tuition scholarships may be available within individual departments and programs. Master's students who are US citizens are also eligible for federal financial aid and federal work study. Master's applicants should indicate their need for financial support on their application for admission, and US citizens should complete the online Free Application for Federal Student Aid. Graduate students are required to make satisfactory academic progress in their programs in order to remain enrolled in The Graduate School and to receive financial aid.

Loans

Students who plan to supplement their financial resources through loans or federal work-study employment must complete the above mentioned FAFSA. Students are encouraged to complete the FAFSA online. In order for The Graduate School to obtain the information electronically, Duke's school code (002920) must be indicated on the form.

Students who are enrolled at least half time, who are US citizens or permanent residents, and who meet the federal criteria for need are eligible for loans.

Student Loans

Duke University offers the William D. Ford Federal Direct Loan Programs for graduate students, including Direct Unsubsidized Loan and Direct PLUS Loan. Each of these loans has different terms and conditions, but they are generally deferrable until after graduation or until the student is enrolled for less than half-time.

These federal loans are available only to United States citizens and, generally, only to master's students, because PhD scholarships and fellowships typically exceed the cost of attendance. Visit the Duke Financial Aid website for more information and application procedures for student loans.

Duke Credit Union Graduate Student Assistance Program (GSAP)

The Duke Credit Union has partnered with The Graduate School to provide a short-term loan package for PhD students who occasionally find themselves in need of funds on a short-term basis in order to settle into a new home when they begin their PhD program at Duke, purchase a computer, or address an unexpected emergency. GSAP offers qualified PhD student loans of up to $2,500 for up to 12 months at competitive interest rates. Payroll deduction is available. See the Duke Credit Union website for details and to apply.

Helen & Gordon McKinney Emergency Loan Fund

The Helen & Gordon McKinney Emergency Loan Fund provides short-term, low-interest loans to PhD students for general expenses such as settling into a new home, purchasing a computer, or addressing unexpected emergencies. The maximum loan amount is $1,000 with a repayment term no longer than 12 months at a 3.5% interest rate. Interest begins after the second month following loan disbursement. Students must possess the ability to repay the loan while they are enrolled as there is no deferment period. Students cannot have more than one loan outstanding at any point in time, and may only request three loans during their academic career. Applicants with outstanding federal aid will be subject to the federal cost of attendance regulations.

Inquiries should be sent to grad-finaid@duke.edu.

Work-Study Program Employment

Limited funds are available for graduate students through the federal work-study program. A student who wishes to apply for federal work-study must complete a FAFSA. Students considering the possibility of federal work-study for the fall should submit FAFSA forms prior to January 31. Eligibility requirements are similar to those of the federal loan programs. Awards are based on the assignment, eligibility of the student, and availability of funds. In addition to departmental opportunities, the Duke University Career Center maintains a listing of opportunities for students.

Jonathan Lee

Registration

Les Todd

Registration Requirements

All students must register each fall and spring semester and pay the requisite tuition and fees for each semester until all degree requirements are completed, including graduation. The only exception to this requirement is an approved leave of absence granted by The Graduate School's associate dean of academic affairs (hereafter referred to as the academic dean). Failure to maintain continuous registration each fall and spring semester will result in administrative withdrawal from the university.

Leave of Absence

Students in good academic standing may apply for a total of two semesters of leave. Those who have been on a leave of absence and who intend to resume a degree program must give the department and the academic dean notice of this intention one month before the first day of the semester of their return. A request for a medical leave of absence must be supported by a letter stating the necessity for leave from the student's current treating medical practitioner.

Doctoral Students

All doctoral students must register for a total of six semesters of full tuition. After the six semesters of full tuition, doctoral students will be charged a reduced tuition. Those PhD students with an earned graduate degree may petition to reduce the number of semesters of full tuition required for the degree to five semesters. Specific course requirements for doctoral students are set by the degree-granting programs and departments. Doctoral students may enroll in up to fifteen credit units per term and should seek permission from their director of graduate studies (DGS) for any additional credits. Students must be registered during the terms when they take qualifying, preliminary, and final examinations, when they submit dissertations in final form to ProQuest and DukeSpace, and when they graduate. These milestone examinations may occur during breaks between terms for students registered in the term immediately before and immediately after the break.

Master's Students

Full-time master's candidates must register for at least three semesters of enrollment, at a full load of at least nine credit units per term, until a minimum of thirty units of degree credit have been achieved (some programs require more than thirty units to obtain a degree). Full-time students can enroll for fewer than nine units only during the final semester when they are completing the required degree credits in their program. An academic load of more than fifteen credits in a given term must be approved by the student's DGS. Approved transfer coursework into a master's program will not reduce the minimum registration of thirty units for a master's degree at Duke University. Students must be registered during the terms when they take final examinations, submit their theses and graduate. The thesis examination may occur between terms if the student is registered for both the term before and after the break when the exam occurs.

Registration Periods

All students who are enrolled in The Graduate School and who have not been granted a current leave of absence by the academic dean must register each fall and spring until all degree requirements are completed. New students will register immediately prior to the first day of classes in either term; continuing students register during the announced registration periods (set by the Office of the University Registrar) in November and April.

In fall and spring semesters, all continuing PhD students are registered automatically for continuation (CTN 1-01), unless there are registration blocks on their accounts, such as those resulting from unpaid bursar balances. Students must take necessary action to resolve registration blocks, wait for the blocks to be removed from their accounts in DukeHub, and then manually register for continuation or courses as appropriate.

Late Registration

All students are expected to register at the times specified by the university. A late registration fee is charged to any student registering late, including a current student who delays registering until the registration date for new students.

Auditing Courses

Any PhD or master's degree candidate enrolled full-time may audit graduate and undergraduate courses without charge during the fall and spring semesters, if this is acceptable to the faculty teaching these courses. Students should obtain faculty permission prior to registering to audit the class. If the student is not a graduate degree student, an audit fee is charged. There is a fee associated with auditing courses during the summer session.

Withdrawal

Graduate students may withdraw from courses up to the last day of graduate classes by filing a course withdrawal request signed by the student, instructor, and DGS. For courses taken for credit, this will result in a W notation on their transcript for that course; for an audited course, the notation is WA. Students who wish to withdraw from their programs must notify the academic dean of their intent in writing. In the case of involuntary withdrawal, the academic dean will notify the student. Students who are withdrawn from The Graduate School, whether voluntarily or involuntarily, during a term in which they are registered, will be charged a pro-rated tuition for the term that depends on the number of weeks that had transpired before the withdrawal notice.

Summer Registration

Students who are in residence at Duke University during the spring and who plan to enroll in courses in the summer session should have their course programs approved by their DGS. Summer session students should register at announced times beginning with the February registration period and up to the Wednesday preceding the start of the appropriate term. There may be charges associated with taking summer courses. PhD students who are conducting sponsored research related to their degree and/or are receiving support through university fellowships during the summer session, but are not enrolled in any courses, must be registered for summer but are charged a reduced continuation tuition.

Summer session students may add a course or courses before or during the first three days of the term. Courses may also be dropped before and during the first three days, but a 20 percent tuition fee will be charged (1) if the course is not dropped before the first day, and (2) the dropped course(s) results in a total tuition reduction. Courses dropped after the third day of classes are not eligible for tuition refund.

Chris Hildreth

Regulations

Bill Snead

General Academic Regulations

Credits

The following regulations pertain to credits earned outside of The Graduate School:

Graduate Credit Earned before the Bachelor's Degree Is Granted. Ordinarily no credit will be allowed for graduate courses taken before a student has been awarded a baccalaureate degree from an accredited college or university. However, an exception is made specifically for Duke University undergraduates who have been admitted provisionally to an approved accelerated undergraduate/graduate master's degree program. Course credits for designated, pre-approved graduate-level courses taken during the senior year and prior to the baccalaureate may be used toward the master's degree course requirement, per the specific program's agreement with The Graduate School and with Trinity or Pratt. The counting of such credits toward the master's degree must be approved in advance by the academic dean of The Graduate School.

Transfer of Graduate Credits. For master's programs, up to six units of graduate credit may be requested to be transferred toward the master's degree after at least twelve credit units have been completed in the student's Duke graduate degree program. Such credit must be graded and at a mark of B or better and be no more than six years old at the time of graduation from Duke. The transfer of graduate credit does not reduce the required minimum registration of thirty units for a master's degree at Duke or the requirement of three or more terms of registration. For PhD students, up to one semester of full-time tuition credit (but not course credit) may be given if the student has completed a relevant graduate degree at another institution. No transfer credits toward a master's degree will be awarded to those students who wish to receive a master's degree en route to the PhD. Financial credit for the above programs will be given only after the student has completed one full-time semester in a degree-granting graduate program. For PhD students, departments may consider previous coursework in determining further course requirements for the student. In any case, academic credit is distinct from financial credit or registration requirements for the PhD.

Grades and Academic Standing

Grades in The Graduate School are as follows: A, B, C, F, and I. One of these final grades must be assigned in all cases promptly upon the end of a graded course. An I (Incomplete) indicates that some portion of the student's work is lacking, for reasons such as illness or emergency absence, at the time the grades are reported. For students enrolled in The Graduate School, the instructor who gives an I for a course specifies, via a written agreement with the student, the date by which the student must make up the deficiency and a permanent grade recorded. However, if a course is not completed within one calendar year from the date the course ended, the grade of I becomes permanent and may not be removed from the student's record in the event the work is subsequently completed. The grade of Z indicates satisfactory progress at the end of the first semester of a two-semester course. For nondegree graduate students enrolled in the summer session, a temporary I for a course may be assigned after the student has submitted a written request. If the request is approved by the instructor of the course, then the student must satisfactorily complete the work prior to the last day of classes of the subsequent summer term.

In order to be certified as making satisfactory progress toward the degree, and in order to receive their degrees, graduate students must maintain at least a 3.0 (B) cumulative grade point average. Students falling below this average, or who receive a C- or two C's in a given term, will be placed on academic probation. To remain in good academic standing in a program, a student must also demonstrate satisfactory progress in research and related activities beyond coursework, as certified annually by the student's director of graduate studies. For master's students to be making satisfactory progress to degree, at least two thirds of the credits attempted in any given term must be completed with a satisfactory grade (Credit in the case of Credit/No Credit courses, or a grade better than F for a graded course). Degree programs may establish additional criteria that students must meet to remain in good academic standing. A failure to attain good academic standing, for whatever reason, results in probation for one semester. Two consecutive semesters on academic probation will normally result in academic withdrawal from the university. The university reserves the right to request the withdrawal of any student whose academic performance at any time is not satisfactory to the university. Matriculation by the student is a concession to this right. A grade of F in a major course occasions dismissal from a student's degree program, except in extenuating circumstances and at the discretion of the academic dean.

Reciprocal or Interinstitutional Agreements with In-State Universities

Under a plan of cooperation among Duke University, The University of North Carolina at Chapel Hill, North Carolina Central University, North Carolina State University, the University of North Carolina-Greensboro, and the University of North Carolina-Charlotte, full-time students properly enrolled in The Graduate School of Duke University during the regular academic year, and paying full tuition to this institution, may be admitted to a maximum of two courses per semester at one of the other institutions in the cooperative plan. Under the same arrangement, students in the graduate schools in the neighboring institutions may be admitted to coursework at Duke University. Credit so earned is not defined as transfer credit. Such courses cannot be taken on an audit or Pass/Fail basis. To take advantage of this arrangement during either summer session term, the student registers for three units of credit at the home institution and three units of credit at the other institution, for a total of six units. All inter-institutional registrations involving extra-fee courses or special fees required of all students will be made at the expense of the student and will not be considered a part of the Duke University tuition coverage. This reciprocal agreement does not apply to inter-university joint degree programs or contract programs such as the American Dance Festival.

Identification Cards

Graduate students are issued identification cards that they should carry at all times. The card is a means of identification for library privileges, athletic events, and other university functions or services open to university students. It may also provide access to certain buildings, parking lots, or other locations for which student entry is approved. Students will be expected to present their cards on request to any university official or employee. The card is not transferable, and fraudulent use may result in loss of student privileges or dismissal from The Graduate School. A lost card must be reported immediately to the DukeCard Office.

Courses Primarily for Undergraduates

Courses below the 500 level may not be applied toward the required credits needed for a post-baccalaureate degree. With the approval of their director of graduate studies and the academic dean, graduate students may enroll in lower-level courses, but these courses will not count toward full-time enrollment or any graduation requirement and will not be included in a student's GPA calculation.

Selected graduate-level courses are offered concurrently with their undergraduate-level counterparts. Graduate students enrolled in these courses are required to complete the requirements and meet the rigor delineated on the graduate-level syllabi, which must be distinct from—and more rigorous than—the requirements for undergraduate credit. For additional information, please contact the university registrar and/or the director of graduate studies.

Withdrawal from a Course

For permissible changes during the Drop/Add period of the fall or spring semester and during the first three days of summer session term, see the chapter "Registration" on page 4647." If a course is dropped after the Drop/Add period during the fall or spring or after the first three days of classes during the summer, a Withdrew (W) will be noted on the permanent record. Course withdrawals are allowed up through the last day of graduate classes in any given term.

Interruption of Program and Withdrawal from The Graduate School

Students are expected to meet academic requirements and financial obligations, as specified elsewhere in this bulletin, in order to remain in good standing. Certain nonacademic rules and regulations must be observed also, such as the Duke Community Standard. Failure to meet these requirements may result in summary dismissal by the academic dean of The Graduate School. The university reserves the right, and matriculation by the student is a concession to this right, to request the withdrawal of any student whose academic performance at any time is not satisfactory to the university. A student who wishes for any reason to withdraw from The Graduate School during the fall, spring, or summer session must notify in writing both the DGS in the major department and the academic dean prior to the date of the expected withdrawal and no later than the published last day of graduate classes for that semester or summer session. International students on visas should be aware that withdrawal has immediate implications for their legal status in the United States and should contact Duke Visa Services for guidance. If students wish to withdraw from courses in the summer session, they must consult both the director of graduate studies in the major department and the director of the summer session. To learn about the policies on tuition refunds upon withdrawal, see the chapter "Financial Information" on page 40.

After completion of at least one semester of graduate study in good academic standing, a student who must withdraw before completion of a graduate program may, with the approval of the major department, request the dean to issue a certificate of graduate study.

Leave of Absence

A leave of absence for no more than two semesters may be granted because of medical conditions, full-time employment relevant to completing the degree, receipt of an external research award, or other acceptable reasons as judged by the academic dean of The Graduate School. A request for a leave of absence should be originated by the student, endorsed by the student's DGS, and submitted to the academic dean for consideration prior to the beginning of the semester for which the leave is requested. A student is eligible to request a leave of absence only if s/he is in good academic standing and has completed at least one semester in the current graduate degree program at Duke. No more than two semesters of leave, in total, may be granted throughout a student's degree program. Requests for medical leaves of absence must be supported by a letter to the academic dean from a treating medical practitioner. Return from such leave must be similarly supported by evidence, such as a letter from a treating practitioner, that the student is ready to return to the rigors of graduate study. If an emergency medical leave must be taken once a semester has begun, it would be retroactive to the start of the term. Formal leaves of absence are not applicable to summer term.

Time limitations that pertain to the various degrees and requirements, and the completion of courses on which a grade of Incomplete (I) was earned, are not waived during leaves of absence, other than those of medical necessity and as approved by the academic dean.

Students contemplating leaves of absence should be aware that, for financial purposes, all guarantees of financial support are calculated from the date of initial matriculation. For example, if a graduate program has stated that a student will be supported through the fifth year of graduate study and the student subsequently takes a leave of absence for one of those years, the student would forfeit a year of institutional support. Departments and programs are encouraged, but not required, to offer a deferral of funding to a subsequent term in the case of medical leaves of absence. Foreign students on visas should consult Duke Visa Services for the implications of a leave of absence on their legal status in this country.

English Proficiency for International Students

All international students whose first language is not English must enroll in appropriate sections of English for International Students (EIS) during their initial year at Duke, unless formally waived from this requirement by The Graduate School upon certification of competency in English. The determination and assignment of the necessary course sections is made by the EIS staff based on test results. The lower level EIS courses must be taken in the first year; in any case, all required courses should be taken as early as possible

in the student's course of study at Duke. Completion of all EIS courses into which a student places is a requirement for graduation. International MSc and PhD students in the Pratt School of Engineering are subject to the same requirements, but the placement testing and course instruction will be provided directly by Pratt. Duke Kunshan University MSc degree candidates are also subject to these requirements and will receive training in English proficiency at that campus

Library Privileges

Graduate students have full library privileges and are entitled to carrels only if registered as full-time students. Only PhD students who have attained candidacy (passed the preliminary examination) are eligible for closed carrels.

Student Health and Insurance

The Student Health Fee covers most of the services offered at Duke Student Health if medically indicated and rendered by a Student Health Provider. The health fee should not be confused with the supplementary Duke Student Medical Insurance Plan, which covers a large number of medical costs above and beyond the treatment available through the University Student Health Program. Full-time students who are entitled to coverage by the student health program are also eligible for the supplementary insurance policy.

All students enrolled in programs that require payment of the health fee must also have adequate medical insurance. The university requires all students to be responsible for health costs over and above what is covered by the student health fee. Students will automatically be enrolled in the Duke Student Medical Insurance Plan unless they submit a waiver indicating that they are covered by a comparable plan. Students indicate their health insurance decision through DukeHub as part of the online registration process. For international students holding J-1 or F-1 visas, participation in the Duke Student Medical Insurance Plan is mandatory.

The Graduate Faculty

Bylaws

The following are the bylaws of the Graduate Faculty, approved on May 3, 2016 by the Executive Committee of the Graduate Faculty:

The Duke University Graduate Faculty is composed of full and term members, who together advise graduate students and serve on their milestone examination committees. Membership is contingent upon adherence to the Duke Community Standard. Full Graduate Faculty membership is of an unlimited duration as long as a full-time Duke faculty appointment is active and responsibilities are met. These include the following:

- Appropriate oversight and assistance to all students on whose committee a member serves.
- Attentive advisory support of all students for whom a Graduate Faculty member serves as supervisor, chair or primary advisor.
- Active engagement in development and delivery of the graduate program.

Full Graduate Faculty membership confers the following privileges:

- To chair graduate master's or doctoral committees in the departments or units in which one serves as a full member.
- To act as the primary advisor of a doctoral candidate or supervisor of graduate student's dissertation research.
- To participate in designing degree requirements for departments or programs in which she/he is a member.

Term membership on the Graduate Faculty is for a defined period of service on student milestone committee(s), and may or may not involve an ongoing advisory role in a student's research on whose committee a term member may serve. A Graduate Faculty appointment is not necessary to act as instructor to a graduate student in a course.

Qualifications for Graduate Faculty Membership

Nominal prerequisites for admission to the Graduate Faculty as a full member include possession of a terminal degree in the relevant discipline, and a current faculty appointment at Duke University. In addition, the candidate must have a tenure track faculty appointment at Duke, or another regular-rank, full-time Duke faculty appointment and the experience and distinction of current full Graduate Faculty in the nominating unit. Nominating departments may set additional requirements if they choose or, in special cases, request that the dean waive one of these prerequisites (as in the case of joint degree programs with other universities, or programs at Duke Kunshan University). Only departments with approved graduate degrees are eligible to nominate members of their own primary or secondary faculty as full members of the Graduate Faculty. In rare exceptions made by the dean, non-departmental doctoral degree programs can nominate for full faculty membership, but only in the case of programs that can demonstrate the financial resources to support students for a minimum of five years. Secondary faculty may chair committees only if approved to do so by the primary, full Graduate Faculty of the host department.

Term appointments to the Graduate Faculty are available for service on specific student milestone committees. Term faculty members must have demonstrable scholarly or research expertise in the broad field of the degree candidate on whose committee the term member would serve. Term members may be nominated by any academic unit with an approved Graduate School degree program, for service on its milestone committees. Candidates may be appointed for a renewable limited term of up to five years. Duke faculty who are term members and experienced in graduate education, with service on four or more previous milestone committees at Duke, may be nominated by the program's DGS to chair master's examination committees. Term members may chair dissertation committees only in the case of joint doctoral programs with other universities, and only when explicitly approved to do so by the responsible academic deans of both universities.

Nomination Process

Nomination for appointment to full membership in the Graduate Faculty must be voted on by the full Graduate Faculty members of the nominating department, with a majority in favor. Nominations subsequently forwarded to the academic dean must include: a) an official request from the director of graduate studies (DGS) and the department chair; b) documentation that there has been a majority vote cast by the full members of the Graduate Faculty in the academic unit; and c) a current curriculum vitae. In addition, for secondary

faculty from clinical departments, the nomination must include a letter of support for the Graduate Faculty appointment from the candidate's department chair or division chief. Nominations for term membership must be approved and recommended by the DGS of the degree-sponsoring unit, with the nomination form accompanied by a current curriculum vitae. The dean reserves the right of effective review of each request.

Faculty Review

Full Graduate Faculty status ends when a member ceases full-time, active employment as a Duke faculty member; such members may be re-nominated as term faculty. With Graduate School oversight, nominating departments are also responsible for reviewing the effectiveness of their graduate faculty, and are expected to recommend removal from the Graduate Faculty of any of their faculty members who fail to maintain an appropriate level of scholarship, engagement in student advising, or other essential participation in graduate training and education. In addition, departments nominating secondary faculty are responsible for assuring that home departments/institutes allow the requisite level of participation in graduate training by those faculty.

Executive Committee of the Graduate Faculty (ECGF)

Full members of the Graduate Faculty elect representatives to serve on the ECGF, with a designated and consistent number of members elected from each graduate academic division: Humanities, Social Sciences, Physical Sciences and Engineering, and Biological and Biomedical Sciences. Members are elected such that they have staggered two-year terms. A chair and vice chair are elected annually from and by the previous academic year's ECGF membership. Ex officio, non-voting members include senior TGS deans, a Graduate and Professional Student Council member, and a representative of the University Library. The academic dean manages the committee and schedules items for the committee's agenda in consultation with the chair and dean.

The ECGF advises the dean of The Graduate School on policy matters related to graduate education and support, considers external reviews of relevant programs and departments, and reviews graduate program proposals. Approval by ECGF is necessary for development of a new graduate degree or certificate program, and is the first step in the faculty governance process for the creation of a new graduate degree program.

Degree Regulations: The Master's Degrees

Master of Arts/Master of Science

Prerequisites

For graduate study in master's degree programs, applicants must have completed a baccalaureate degree program at an accredited institution and have met the academic prerequisites and other admissions criteria of the program. Students should read carefully the special requirements listed by their major departments in the chapter "Departments, Programs, & Course Offerings" on page 66. If special master's requirements are not specified in this chapter and there is a question about prerequisites, prospective students should write directly to the appropriate director of graduate studies.

Language Requirements

The Graduate School requires no foreign language for the master's degree. Certain departments, however, do have language requirements, and these must be satisfied before the master's examination can be taken. See the departmental listings in the chapter "Departments, Programs, & Course Offerings" on page 66.

All master's theses must be written in English. The only exception is that short passages and quotations may be written in another language in the research chapter(s) if deemed appropriate by a student's thesis examination committee.

Major and Related Subjects

Thirty course credits at Duke constitutes minimum enrollment for the completion of most master of arts and master of science degrees. Students must present acceptable grades for a minimum of 24 course credits of graded coursework, at least twelve of which must be in the major subject. Master's students must complete additional coursework up to at least 30 credit units, as well as six hours of approved Responsible Conduct of Research training. Some master's programs require additional course credits beyond the minimum of at least 24 graded and 30 overall course credits, as approved by The Graduate School. Individual programs and departments decide whether any given MA, MS, or MFA program of study may be completed by submission of an approved thesis or by other academic exercises in lieu of the thesis, as previously approved by The Graduate School for a given degree program (see requirements listed in the chapter "Departments, Programs, & Course Offerings" on page 66). In either case, a maximum of 6 course credits may be earned by the completion exercises (such as thesis research) and the final examination.

Thesis Requirements

The master's thesis should demonstrate the student's ability to collect, arrange, interpret, and report pertinent material on a research problem. The thesis must be written in an acceptable style for the disciplinary field and should exhibit the student's competence in scholarly procedures. Requirements of form are set forth in the Duke University *Guide for Electronic Submission of Thesis and Dissertations,* which is available on The Graduate School/Academics/Theses and Dissertations website. The thesis advisor must examine and approve the master's thesis prior to submission to The Graduate School, as indicated by a letter stating this approval. The thesis must be submitted electronically in an approved form to ProQuest two weeks prior to defense (see deadlines for submission and defense posted on The Graduate School/Academics/Preparing to Graduate/Graduation Deadlines website. Electronic copies of the thesis will be distributed by the student, at least two weeks before the final examination, to the members of the examining committee (three or more). Deadlines for submission are posted on The Graduate School website and must be respected if the student wishes to receive the degree in the semester when the intention to graduate has been declared. If a student misses deadlines for completion of all requirements

during a term, including submission of an approved and correctly formatted thesis document, then the student must register and pay for a subsequent term in which s/he will receive the degree. All master's theses must be submitted electronically to ProQuest in Ann Arbor, Michigan, and to DukeSpace in the Duke Libraries, where they are openly and publicly accessible online after any approved embargo period. See The Graduate School/Academics/Theses and Dissertations website for information about electronic submission and procedures for obtaining a copyright.

The Master's Examining Committee and the Examination

In consultation with a student and his/her major advisor, the program or department's director of graduate studies recommends an examining committee composed of at least three members of the Duke Graduate Faculty. Membership for service on a student milestone committee requires a degree that is at least the same level for which the student is a degree candidate (e.g., a master's degree for a master's committee). Any request for an exception by the academic dean must be based on the research expertise and necessity of adding another member without such a degree. A majority of the committee, including the chair, must be a faculty member of the degree-sponsoring department or program, or, in the case of interdisciplinary programs, a faculty member of a participating department. Another member (the minor area representative) must be from a research or scholarly area that is relevant to, but distinct from, the topic of the student's thesis research. Normally only full graduate faculty members may chair master's examination committees, unless a term member has received explicit approval from the academic dean of The Graduate School for this role. The committee and its chair must be approved by the academic dean of The Graduate School at least thirty days before the student takes the final examination. A student must be registered in the term during which he or she takes the final examination. However, the examination may also occur during breaks between terms if the student is registered for the term on either side of the break when the exam is to occur.

Master's examinations take several forms within The Graduate School. The thesis examination is an oral defense of the written thesis that has been read and evaluated by the student's examining committee. The most common non-thesis examinations are written or oral exams on a prescribed reading list or body of material; oral exams on a paper or a set of papers submitted by the student; or an oral exam on a research project or memorandum. The doctoral preliminary examination may also serve as the final examination for the master's degree when it is in the same field and department, with the approval of the examining committee and DGS.

The master's committee will conduct the examination and certify the student's success or failure by signing an examination certificate provided by The Graduate School office. Each member of the approved committee must participate in the examination and must vote as to whether the student passed or failed the exam. With the express approval of the academic dean in advance of the exam, committee members may be allowed to participate via teleconference or video conference as long as a majority of the committee, including the chair, is physically present for the exam and signs the exam card (remote members document their votes separately).

Successful completion of the master's examination requires at least three affirmative votes and no more than one negative vote. The sole exception to this policy is that a negative vote cast by the chair or co-chair of the examining committee will mean a failure on the examination. The committee may vote to extend to the student the privilege of taking the examination a second time, in a subsequent term, in case of failure. The action of the committee to pass or fail the student is confirmed by the DGS, who also must sign the exam certificate, which must then be submitted to The Graduate School. If the student passes the examination, the signed certificate indicates completion of the final examination and program requirements for the degree. If a thesis is presented, the committee members also sign the title page and abstract page of the thesis, which the candidate then returns to The Graduate School along with the signed exam certificate. Any required changes to the thesis must be incorporated in correct format and the final document successfully uploaded to ProQuest before the relevant deadline (see *Guide for Electronic Submission of Thesis and Dissertations*).

Master of Arts in Teaching

See page 246 for a description of the MAT Program.

Master of Arts in Liberal Studies

See page 221 for a description of the MALS Program.

Master of Fine Arts in Experimental and Documentary Arts

See page 248 for a description of the MFA Program.

Additional Master's Regulations

Applying to Graduate

On or before January 25 for a May degree, on or before June 15 for a September degree, on or before October 15 for a December degree, and at least one month prior to the final examination, students must apply for graduation electronically by going to their student record in DukeHub. The declaration of intention to graduate presents the title of the thesis or specifies approved alternative academic exercises on which the degree candidate will be examined. A separate application to graduate must be submitted for each degree or certificate a student will earn. The application is not valid for more than one semester—a new application in DukeHub will need to be submitted for completion of any degree or certificate in a subsequent term.

Transfer of Credits from Another School

A maximum of six course credits of graduate credit may be transferred for graduate courses completed at other schools after the bachelor's degree has been conferred. Such credits will be transferred only if the student has received a grade of B (or its equivalent) or better. The transfer of graduate credit does not reduce the required minimum registration of 30 course credits for a master's degree at Duke, even though it may relieve the student of specific courses otherwise required by the major department. Requests for transfer should be submitted on the approved graduate school form.

Nondegree Students

Credit for graduate courses taken at Duke by a post-baccalaureate student before formal degree admission to The Graduate School or while registered as a nondegree student through Duke Continuing Studies or The Graduate School may be carried over into a graduate degree program if (1) the action is recommended by the student's DGS and approved by the academic dean, (2) the amount of such credit does not exceed 12 course credits, (3) the work has received grades of B or better, (4) the work is not more than two years old, and (5) the student applies for and is granted formal admission into a degree program.

Time Limits for Completion of Master's Degrees

Master's degree candidates who are in residence for consecutive academic years normally complete all requirements for the degree within two calendar years from the date of their first registration in The Graduate School. Candidates enrolled in full-time programs of study must complete all requirements within four calendar years of their first registration. Part-time students must complete all requirements within six calendar years of their first registration.

To be awarded a degree in May, the recording of transfer credit must be completed by the first day of the final examination period. If a thesis is one of the requirements, it must be submitted to The Graduate School by the deadline posted on The Graduate School website. Candidates desiring to have their degrees conferred in September must have completed all requirements, including the recording of transfer of credit, by the last weekday of the Duke University summer session. Candidates completing degree requirements after that date and during the fall will have their degrees conferred in January.

Training in Academic and Research Integrity

Incoming master's students enrolled in all degree programs of The Graduate School must complete a training course in academic integrity and responsible conduct of research. This will consist of a four-hour session at the start of the term, offered by The Graduate School staff and associates, and an additional two-hour RCR forum later in their studies. Completion of this training is a requirement for graduation. The training for Duke Kunshan University master of science candidates is customized and offered for them at the Kunshan campus but is also an absolute degree requirement.

Master's Degree En Route to a PhD

Doctoral students in Duke PhD programs may obtain one master's degree en route to the PhD without additional tuition charges beyond those of the PhD. This master's degree may be in the same department, if the department permits this, or may be in a different department, if approved by the second department and the academic dean of The Graduate School. In either case, the student must complete all requirements for the relevant master's degree. A master's degree in a different department or field en route to the PhD will be awarded only concomitant with the PhD. If, for whatever reason, the student does not complete the PhD, and would like to receive the master's degree nonetheless, tuition will be charged for the terms during which the master's degree was pursued. Tuition and any other balances due must be paid to receive the degree.

Degree Regulations: The Doctoral Degree

Requirements

The formal requirements for the PhD are as follows: (1) payment of six semesters of full-time tuition (or five if credit for a previous graduate degree has been approved), (2) major and related courses as determined by the degree program, (3) the fulfillment of foreign language(s) requirements in many departments, (4) required training in the Responsible Conduct of Research, (5) a supervisory committee for the student's program of study, (6) residence of at least one year, (7) passing the preliminary examination, (8) completing the dissertation, (9) passing the final examination, and (10) final dissertation submission to ProQuest and DukeSpace for eventual public access.

Major and Related Work

The student's plan of study normally demands substantial concentration on courses in the major degree program, plus coursework in related minor fields as determined by individual programs. The programs may specify courses that are required for the degree in that particular program. If there are deficiencies in a student's undergraduate preparation, degree programs may also require certain prerequisite courses to be taken. In all cases, the student's DGS, in consultation with the student's advisory committee, will determine if the student must meet requirements above the minimum.

Foreign Languages

The Graduate School has no foreign language requirement for the PhD, but individual departments may have such requirements. For specific departmental language requirements, see the chapter "Departments, Programs, & Course Offerings" on page 66 or contact the appropriate DGS.

The Graduate School requires that all dissertations and theses be written in English. The sole exception is when there are compelling scholarly or professional reasons to write the research portions of a doctoral dissertation in another language, if that language is recognized by the student's examination committee as the primary language of the student's research within a foreign language studies PhD program in which the student is a degree candidate. To write a dissertation in a language other than English, the student must submit a request for an exception at the time the prospectus is submitted. The request must be approved by the student's examination committee and by The Graduate School's academic dean. If granted an exception, the student may write the dissertation's research chapters, introduction, and conclusion in another language. In all cases, the title, abstract, copyright notice, committee signature pages, and table of contents of dissertations must be written in English. The entirety of master's theses must be in English, except short quotations as judged appropriate by the thesis examination committee.

English Language Proficiency

All international PhD students are subject to the requirement described above (see "English Proficiency for International Students").

Responsible Conduct of Research

All PhD students at Duke University are required to complete a series of training sessions in the Responsible Conduct of Research (RCR). These sessions consist of two components: the first is a full-day orientation workshop given at the beginning of each academic year for all new incoming students. All students in the biomedical sciences will attend a general introductory workshop provided by the School of Medicine; students in the humanities and social sciences will attend a similar introductory workshop at a conference facility in Durham, as will students in nonmedical biological sciences, physical sciences, and engineering programs. All PhD students will subsequently attend a mandatory minimum number of RCR forums or other training experiences (including workshops and courses) scheduled throughout the academic year on individual topics related to responsible conduct of research. The number and content, as well as the semester's schedule of such forums, courses, or workshops will be published at the beginning of each semester on The Graduate School website.

Milestone Examination Committee

The obligatory milestone examinations for PhD students are the preliminary and dissertation examinations. Membership for service on a student milestone committee requires a degree that is at least the same level for which the student is a degree candidate (e.g., a doctoral degree for a doctoral committee). Any request for an exception by the academic dean must be based on the research expertise and necessity of adding another member without such a degree. The requirements for the composition of the committee are the same, regardless of the examination, though its individual members may change over time. This committee also typically serves as an advisory committee to the student during his or her studies, and should be appointed to reflect research expertise that is helpful in guiding and evaluating the student's research project. As early in a student's course of study as is practicable, and not later than one month (thirty days) before the preliminary examination, the DGS in the degree program will nominate for the approval of the academic dean a milestone committee consisting of at least four members of the Graduate Faculty, with one member designated as chair. The chair must be a full member of the Graduate Faculty and hold a faculty appointment in the degree-sponsoring program. Individual programs may specify whether the chair can or cannot be the primary research advisor. In all cases, this committee must include at least three Graduate Faculty members from the major field of study, and at least one from a minor area, being from outside the degree program or from a clearly differentiated subfield within the degree program. At least two members of the committee, including the chair, must be faculty in the degree-sponsoring department or program. A majority of the committee must be Duke University faculty members, except in the case of joint PhD programs with other universities. This committee, with all members participating, will determine a program of study and administer the preliminary examination. The student's milestone committee, either the same or with some or all members replaced as needed, will also examine the dissertation and administer the final examination.

Progress toward Degree

Beginning with their second year of study, all PhD students must file an annual progress report, prepared in consultation with their research advisor, to their DGS summarizing their progress toward the degree. For students who have passed the preliminary examination and are working on their dissertations, this progress summary is also to be given to their doctoral committees, who will evaluate the student's status. Departments determine whether the progress report is a written report only or also requires a live presentation to the committee. The DGS in turn prepares an annual summary report on all the program's students for the academic dean's review, reporting any student who has failed to demonstrate satisfactory progress. Failure on the part of a student to submit an annual progress report will preclude The Graduate School's ability to certify satisfactory progress toward the degree and thus will jeopardize both the student's academic standing and eligibility for continued financial support. For federal financial aid eligibility, doctoral students must complete at least two thirds of the course credits they attempt in any given term.

Residence

The minimum residence requirement is one academic year of full-time physical presence at Duke's campus in Durham, concurrent with one year of continuous registration in The Graduate School (that is, two consecutive semesters of full-time tuition). The only exceptions to this are for joint degree programs with other universities, for which residency requirements will be made known to each such program's students.

Time Limits

A student registered for full-time study must pass the preliminary examination by the end of the third academic year, unless granted permission to delay the examination by the academic dean. Endorsed requests for a delay must be made by the DGS in the major department, explaining the justification for the delay and setting a specific date for the examination in the following term of registration. Except under highly unusual circumstances (e.g. severe illness), extensions will not be granted beyond the middle of the fourth year. Note that leaves of absence do not delay this timetable. Students who have not passed their preliminary examination by the deadline, whether original or extended, will be withdrawn. The preliminary examination milestone expires after five years and may not be renewed.

Credit is not allowed for graduate courses (including transfers) or foreign language examinations that are more than six years old at the date of the preliminary examination. In cases of exceptional merit, however, the academic dean may extend a specific time limit. Should this limit be exceeded, the student's department must submit to the academic dean specific requirements for revalidating credits or examinations.

The dissertation is expected to have been submitted, examined and accepted within four calendar years after the preliminary examination, or seven years after entry to the PhD program. In the event that this timeline is not met, the candidate may, with the approval of the advisory committee and the DGS, petition the academic dean for an extension of up to one year. If this extension is granted and the dissertation is not submitted and successfully examined by the new deadline, the student will be withdrawn from candidacy. Credit will not be allowed for a preliminary examination that is more than five years old at the date of the final examination. Only in extraordinary cases, such as severe and prolonged illness or military deployment, will the academic dean consider any extension to this maximum timetable of eight years.

Preliminary Examination

A student is not accepted as a candidate for the PhD until the preliminary examination has been passed. The examination ordinarily covers both the major field and related work, although some degree programs cover such field expertise in a separate qualifying examination. Please consult the chapter "Departments, Programs, & Course Offerings" on page 66 or the degree program website

for individual department or program procedures. The preliminary examination must be scheduled, with an approved committee, at least thirty days in advance. A student must be registered in the term during which he or she takes the preliminary examination. The examination may occur during the break between terms if the student is registered for the terms before and after the break.

Successful completion of the preliminary examination requires at least four affirmative votes and no more than one negative vote. The sole exception to this policy is that a negative vote cast by the chair or co-chair of the examining committee will mean a failure on the examination. A student who fails the preliminary examination may apply, with the unanimous consent of the examination committee and the DGS, for the privilege of a second examination to be taken between three and six months after the date of the first. Successful completion of the second examination requires the affirmative vote of all original committee members. Failure on the second examination makes a student ineligible to continue a program for the PhD at Duke University.

The qualifying and/or preliminary examination may also be used as the completion exercise for awarding a master's degree for a terminal master's or, where appropriate, for awarding a master's degree en route to the PhD.

The Dissertation

The dissertation is expected to be a mature and competent piece of the student's own writing, embodying the results of significant and original research. The dissertation must include a scholarly introduction that sets the context and importance of the research questions addressed in the study, separate chapter(s) presenting the research itself, and a final overview chapter summarizing the findings, conclusions, and significance of the dissertation project. Though the writing is expected to be the student's own, many dissertation projects involve collaborative work; the contributions made by other researchers must be identified fully and specifically for each chapter in a preface to the relevant chapter. One month before the dissertation is presented and no later than January 25 for a May commencement, June 15 for a September degree, and October 15 for a December degree, students must apply for graduation electronically by following the appropriate procedure in their student account on DukeHub. This application indicates the title of the dissertation, which must be approved by both the DGS of the student's degree program and the professor who directs the dissertation.

The basic requirements for preparing the dissertation are prescribed in the *Guide for Electronic Submission of Theses and Dissertations*, which is available on The Graduate School/Academics/Theses and Dissertations website. The dissertation must be completed to the satisfaction of the professor who directs the dissertation (dissertation advisor), members of the student's milestone committee, and the academic dean of The Graduate School. The dissertation advisor must examine and approve that the dissertation is ready for defense prior to submission to The Graduate School, as indicated by a letter to The Graduate School stating this approval. An electronic copy of the approved dissertation must be uploaded to ProQuest for review and approval by The Graduate School at least two weeks prior to the defense. Deadlines for dissertation submission are posted on The Graduate School website and must be respected if the student wishes to receive the degree in the semester when the intention to graduate has been formally declared; if the deadlines are missed, the student must register and reapply to graduate in a subsequent term, and pay continuation tuition accordingly. Final doctoral dissertations are scholarly products of Duke University, and must become publicly available for reading, though they may be embargoed for a specified period before becoming publicly accessible. Dissertations must be submitted electronically to ProQuest in Ann Arbor, Michigan, and to DukeSpace in the Duke Libraries, where they are openly accessible online after any embargo. See The Graduate School/Academics/Theses and Dissertations website for information about electronic submission and about procedures for obtaining a copyright, and the possibility of a temporary embargo before public accessibility. Abstracts are published in *Dissertation Abstracts International*.

Final Examination (Dissertation Defense)

The final examination is administered by a milestone examination committee of at least four qualified members of the graduate faculty, who must have at least two weeks to read and review the completed dissertation before the final examination (the dissertation defense). Many programs require a public seminar to present the dissertation's content, in addition to the formal examination itself. An oral examination by the committee, of at least 90 minutes in duration, shall be focused primarily on the dissertation; however, any question may be asked in the candidate's major field. The student must be physically present for the oral examination, together with a majority of the committee and its chair.

Successful completion of the final examination, taking into account the dissertation itself and its oral defense, requires at least four affirmative votes and no more than one negative vote. The sole exception to this policy is that a negative vote cast by the chair or co-chair of the examining committee will mean a failure on the examination. A student who fails the final examination may be allowed to take it a second time, but no earlier than six months from the date of the first examination. Permission to take the second examination must be obtained from the professor who directed the dissertation and the other examining committee members, as well as from the DGS and academic dean. The second examination must be administered by the same committee that conducted the first examination, and all votes must be positive to pass. A second failure renders the student ineligible to continue work for the PhD at Duke University.

A student must be registered during the term when he or she takes the final examination. The examination may occur during the break between terms if the student is registered for the terms before and after the break.

Deposit of the Dissertation

After passing the examination and making any minor changes requested by the committee, candidates must upload the final electronic version of the dissertation to ProQuest and thus DukeSpace prior to the relevant deadline for public access. A student who misses the deadline must apply to graduate in the next term and pay corresponding tuition. A student must be registered during the term when he or she submits the final version of the dissertation and graduates.

Graduate Certificates

Specialized Certificate of Graduate Study

Some academic programs offer a specialized Certificate of Graduate Study to students who complete a designated amount of coursework and co-curricular requirements in a particular scholarly area. Eligible students are active post-baccalaureate degree candidates

enrolled at Duke University, who must apply to and be accepted by the certificate program(s) of interest. The Office of Academic Affairs monitors these applications, as well as notifies the university registrar when the student has completed all requirements for the certificate. Awarding of the specialized certificate must be concurrent with the awarding of the Duke degree and is indicated on the student's final transcript. Check with program directors for full information about the requirements of various graduate certificate programs.

Approval of Certificate Programs

All certificate programs must be approved by the Executive Committee of the Graduate Faculty and the Dean. The procedures for requesting such approval follow the same guidelines as those used for new degree programs.

Notification of Completion of Certificate Requirements

Certificate candidates must apply to graduate with their certificate(s) separately from applying to graduate with their degree. Certificate granting programs must, each semester, notify the relevant staff member in Academic Affairs, in writing, of graduating students successfully meeting the requirements for certification. After receiving notification, the Office of Academic Affairs will subsequently request that the awarding of the certificate be listed on the student's official transcript. There is generally not a paper copy of the certificate award.

General Certificate of Graduate Study

The student who must withdraw prior to completion of a graduate degree program, but after successfully completing a minimum of one semester's graduate study, may, with DGS approval, request that the academic dean issue the student a general Certificate of Graduate Study.

Commencement and Diplomas

Commencement exercises are held once a year, in May, when degrees are conferred and diplomas are issued to those students who have completed requirements by the end of the spring semester. Those who complete degree requirements by the end of the fall semester or by the end of a summer term receive diplomas dated in January and September, respectively, and receive those diplomas by mail. The May commencement also includes a PhD hooding ceremony. Doctoral students who graduated earlier in the academic year are encouraged to attend the May ceremonies, despite having already received their degrees. The doctoral hooding ceremony does not include master's students or PhD students who have not fully completed their degree requirements. Diplomas and final transcripts will not be issued until all balances due to the bursar have been paid in full. All degree recipients graduating in a given year are permitted and encouraged to attend the year's culminating commencement ceremonies.

The Duke Community Standard

Duke University is a community dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Citizens of this community commit to reflect upon and uphold these principles in all academic and nonacademic endeavors, and to protect and promote a culture of integrity.

To uphold the Duke Community Standard:

- I will not lie, cheat, or steal in my academic endeavors;
- I will conduct myself honorably in all my endeavors; and
- I will act if the Standard is compromised.

Standards of Conduct

Graduate students at Duke University freely choose to join a community of scholarship predicated on the open exchange of ideas and original research. At Duke University, students assume the responsibility to foster intellectual honesty, tolerance, and generosity and to encourage respectful debate and creative research. By accepting admission to Duke University, graduate students pledge to uphold the intellectual and ethical standards of the university, as expressed in the Duke Community Standard, to respect the rights of their colleagues, to abide by university regulations, and to obey local, state, and federal laws.

Failure of a graduate student to adhere to the Duke Community Standard is likely to result in dismissal from Duke University. The Graduate School and the university specifically prohibit the following:

1. **Lying:** Knowing misrepresentations to gain illicit benefit or to cause harm to others. This incudes, but is not limited to, communicating a falsehood in order to gain an academic, professional, or personal advantage that has an impact on students, faculty, or administration of the university.
2. **Cheating:** A dishonest or unfair action to advantage an individual's academic work or research. Such dishonesty would include the falsification of data; plagiarism or otherwise representing someone else's work as your own; and tampering with another person's documents or research materials.
3. **Theft:** Misappropriation of property, services, credentials, or documents. Theft includes the misuse or willful damage of university property, equipment, services, funds, library materials, or electronic networks.
4. **Harassment:** The creation of a hostile or intimidating environment based, for example, on age, color, disability, national origin, sex, gender identity, gender expression, race, religion, class, institutional status, sexual orientation, or on some other basis, in which unwelcome verbal or physical conduct, because of its severity, pervasiveness, and/or persistence, unreasonably and significantly interferes with an individual's work or education, or affects adversely an individual's living conditions. Duke University is committed to protecting academic freedom for all members of the university community. This policy against harassment is, therefore, applied so as to protect the rights of all parties to a complaint. Academic freedom and freedom of

expression include, but are not limited, to the expression of ideas, however controversial, in the classroom, residence hall, and, in keeping with different responsibilities, in workplaces elsewhere in the university community. University policy also prohibits domestic violence, dating violence, and stalking.

5. **Sexual harassment:** The creation of a hostile or intimidating environment through unwelcome conduct of a sexual nature that, because of its severity, pervasiveness, and/or persistence, unreasonably and significantly interferes with an individual's work or education, or adversely affects an individual's living conditions. Sexual harassment also includes verbal or written threats, unwanted sexual solicitation, stalking, and the use of a position of authority to intimidate or coerce others (e.g., where submission to conduct of a sexual nature is used as a basis for decisions affecting an individual's education or employment). Duke teaching personnel, employees, and graduate students are expected to report consensual sexual relationships between individuals in a supervisory or teaching relationship to their superiors under the Consensual Relationship Policy and Appendix Z of the Faculty Handbook. Examples of such supervisory/teaching relationships include: instructor and student; advisor and student; and supervisor and staff member.
6. **Assault:** An attack on another person resulting in either physical or psychological injury.
7. **Possession of illicit drugs on university property or as part of any university activity:** Students are prohibited to manufacture, sell, deliver, possess, or use a controlled substance without legal authorization. The North Carolina Controlled Substances Act defines a controlled substance as any drug, substance or immediate precursor, including but not limited to opiates, barbiturates, amphetamines, marijuana, and hallucinogens. Possession of drug paraphernalia is also prohibited under North Carolina law and university policy. Drug paraphernalia includes all equipment, products and material of any kind that are used to facilitate, or intended or designed to facilitate, violations of the North Carolina Controlled Substances Act.
8. **Refusal to comply with the directions of a university police officer.** Students must comply with the lawful directions of the university police. In addition, interference with the proper operation of safety or security devices**,** including emergency telephones, door locks, fire alarms, smoke detectors or any other safety device is prohibited.
9. **Trespassing:** Students may not enter university property to which access is prohibited.
10. **Possession of explosives, incendiary devices, or firearms on university property**.

Failure to meet these requirements and to abide by the rules and regulations of Duke University may result in summary dismissal by the dean or academic dean of The Graduate School. In accepting admission, students indicate their willingness to subscribe to and be governed by these rules and regulations and acknowledge the right of the university to take disciplinary action, including suspension and/or expulsion, as may be deemed appropriate for failure to abide by such rules and regulations or for conduct adjudged unsatisfactory or detrimental to the university. In addition, students must meet academic requirements and financial obligations, as specified elsewhere in this bulletin, in order to remain in good standing.

Student Grievance Procedures

The Graduate School is committed to a fair hearing and resolution of any student grievance. Graduate students with grievances may wish to consult their DGS, who can inform them of the appropriate channels to address a student grievance.

Students who wish to appeal a grade should do so by request of the instructor of the course in question. The instructor may change the grade if he or she determines the original grade was given in error. If, after review by the instructor, the student still wishes to appeal the grade, the student should do so in writing directly to the department chair or program director of the unit that sponsors the course. This official will review the circumstances of the grade and advise the instructor and student as to whether the grade was appropriate or not. Only the instructor can change the grade itself.

Complaints of discrimination, harassment (including sexual harassment), domestic violence, dating violence, and stalking committed by students, employees, and third parties (e.g., vendors, contractors, and visitors) are addressed under the university's Student Sexual Misconduct Policy, and/or Policy on Prohibited Discrimination Harassment and Related Misconduct, as appropriate. Such complaints are considered by central university offices and staff, such as the Office of Student Conduct and the Office for Institutional Equity. Students may consult these offices or The Graduate School for guidance on how to file complaints of this general nature.

In other circumstances, such as academic status or financial complaints, the DGS is generally the first to hear the substance of a complaint. If the complaint cannot be resolved satisfactorily at this level, or if the student is not comfortable discussing the grievance with the DGS, the student may ask the grievance be considered by the program chair, or by a faculty committee within the program appointed by the chair. Students or program faculty who are unable to resolve grievances at the level of the degree program may contact the relevant associate dean of The Graduate School (https://gradschool.duke.edu/about/staff-directory). For academic matters, the contact is the associate dean for academic affairs; for financial concerns, the contact is the associate dean for finance and administration; for grievances related to student life, the contact is the associate dean for graduate student affairs; for admissions complaints, the contact is the associate dean for admissions. The relevant associate dean will consider all the evidence and circumstances as well as interview the student with the grievance, and ultimately make a decision to resolve the grievance. If necessary, as the final avenue of appeal, the student may ask subsequently for the grievance to be considered by the dean of The Graduate School. Any grievance or appeal must be filed in writing with the next appropriate university officer within ten days after a decision has been formally rendered by any of the university officers mentioned above.

The DGS will inform the relevant associate dean of any student grievances and their resolution in the annual report of the program. The deans will keep confidential records of all student grievances filed with them, the process by which they were considered, and their resolution.

Judicial Code and Appeals Procedure

In the spring of 1971, The Graduate School community ratified and adopted an official judicial code and procedures. These procedures were subsequently amended in November 1998 and in May 2007.

I. Graduate School Judicial Code and Procedures

a. A student, by accepting admission to The Graduate School of Duke University, thereby indicates willingness to subscribe to and be governed by the rules and regulations of the university as currently are in effect or, from time to time, are put into effect by the appropriate authorities of the university, and indicates willingness to accept disciplinary action, if behavior is adjudged to be in violation of those rules or in some way unacceptable or detrimental to the university. However, a student's position of responsibility to the authorities and the regulations of the university in no way alters or modifies responsibilities in relation to civil authorities and laws.
b. A graduate student at Duke University stands in a primary and unique relation of responsibility to the faculty in the major department, the faculty upon whose recommendation a graduate degree will or will not be awarded to the student. In matters which involve or may affect the student's intellectual or professional life, the student is directly responsible to this department and its representatives, and such matters should primarily be handled by the department.
c. Actions which appear to conflict with university-wide rules and regulations will fall under the jurisdiction of the University Judicial Board.
d. At the final level of appeal, a student may elect to have the dean of The Graduate School hear matters related to the student's conduct, or may elect to have such matters reviewed and judged by a Judicial Board of faculty and students appointed by the dean of The Graduate School. (The constitution and procedure of the judicial board are detailed below.)
e. The director of graduate studies or the chair in the student's degree program or major department may request that a student's actions be reviewed by the Judicial Board or by the dean of The Graduate School.

II. The Graduate School Judicial Board

a. Composition. The Graduate School Judicial Board shall have five members, serving on an ad hoc basis or for a period of two years, at the discretion of the dean: two graduate students appointed from the student body by the dean of The Graduate School with the advice of the Graduate and Professional Student Council, two members of the graduate faculty appointed by the Executive Committee of the Graduate Faculty, and one associate or assistant dean appointed by the dean of The Graduate School. The board shall elect one of its members as chair. The board shall have at its service a recording secretary to keep minutes of the hearings and of the board's actions in a permanent, confidential record book. The Board will be constituted in order to hear cases in which the accused is a student currently enrolled in The Graduate School and in cases in which the accused is a former student but which arise out of activities of the accused while a student enrolled in The Graduate School, and which have been referred to it by the director of graduate studies or the chair of the student's department, by the dean of The Graduate School, or by the student.

b. Preliminary Procedures. If a student requests a hearing by the Judicial Board it must be done in writing, allowing the dean at least one week to assemble or notify the board. In addition, the chairman shall not convene the board until at least one week after being asked to convene the board. It is the responsibility of the chair of the Judicial Board fully to inform its members concerning the case and the reasons the case has been referred to the board; and to prepare a written summary of this information for the board, the dean, and the student.

c. Procedural Safeguards for the Hearing. The accused has the right to challenge any member of the Judicial Board on grounds of prejudice. If the board decides to excuse one or more of its members for reasons given by the accused, it shall consult with the dean about the need for replacements. The accused may choose an advisor to assist in the hearing. The advisor must be a current Duke student, a current Duke faculty member, or a current Duke employee. The role of the advisor is to assist and support the student through the disciplinary process. The advisor may not address the hearing panel or any witness during the hearing. The accused may also produce witnesses (including no more than two character witnesses), introduce documents, and offer testimony. A person having direct knowledge relevant to a case being heard by the board is a material witness. The Judicial Board may request the appearance of material witnesses. The board shall also request, upon written request of the complainant or the accused, the appearance of material witnesses. Witnesses shall be notified of the time, place, and purpose of their appearance. The accused has the right to examine the written statement of any witness relevant to the case at least seventy-two hours before the hearing. The accused has the right to be faced with any witness who has given a statement relevant to the case at the hearing if the witness's attendance can be secured. The hearing will be conducted in private unless the accused requests an open hearing. However, any such a hearing must still operate within the context of federal regulations (FERPA: https://www.ed.gov/policy/gen/guid/fpco/ferpa/index.html). If any objection is raised to conducting an open hearing in any particular case, the Judicial Board shall decide the issue by majority vote. If the decision is made not to hold an open hearing, the accused shall be informed in writing of the reasons for the decision. The Judicial Board shall consider only the report of the chair, documents submitted into evidence, and the testimony of witnesses at the hearing in reaching its decisions.

d. Conduct of the Hearing. The hearing of any case shall begin with a reading of the charge by the chairman in the presence of the accused. The accused shall then plead guilty or not guilty or move to terminate or postpone the hearing. The accused may qualify a plea, admitting guilt in part and denying it in part. The accused may not be questioned for more than one hour without recess. At any time during the hearing, the accused or the Judicial Board may move to terminate or to postpone the hearing or to qualify the plea or to modify its charge. Pending verdict on charges (including appeal) against the accused, status as a student shall not be changed, nor the right to be on campus or to attend classes suspended, except that the provost may impose an interim suspension upon any member of the university community who demonstrates, by conduct, that continued presence on the campus constitutes an immediate threat to the physical well-being or property of members of the university community or the property or orderly functioning of the university.

e. Sanctions and the Verdict. The Graduate School Judicial Board shall have the power to impose the following penalties: expulsion (dismissal from the university with the recommendation that the person never be readmitted); suspension (dismissal from the university and from participation in all university activities for a specified period of time, after which the student may apply for readmission); disciplinary probation (placing the student on a probationary status for a specified period of time, during which conviction for violation of any regulation may result in more serious disciplinary action); restitution (payment

for all, or a portion of property damage caused during the commission of an offense). Restitution may be imposed by itself or in addition to any of the other penalties. In the case of a student who is not currently at Duke or who has already graduated, such sanctions could include revocation of the degree. The judgment shall consist of a finding of guilty or not guilty of the charge and, when the accused is found guilty, a statement of the punishment assessed. On all questions, including the verdict and the finding of guilty or not guilty, the board shall be governed by a majority vote. The Judicial Board may decide to rehear a case in which significant new evidence can be introduced. In addition, the defendant may request an appeal. An appeal shall be granted on the following grounds: procedural error substantially affecting the rights of the accused; incompatibility of the verdict with the evidence; excessive penalty not in accord with "current community standards;" new evidence of a character directly to affect the judgment but on which the original tribunal had refused a new hearing.

f. Appeals. The appellant may submit to the dean a written statement containing the grounds for a final appeal and arguments. In such cases, the dean should determine if the appeal should be granted, and the dean can hear the case, or refer it to the appropriate faculty in the student's department or to the Judicial Board.

III. Amendment and Construction

This Judicial code and procedure and this constitution and procedure for The Graduate School Judicial Board may be amended at any time with due notice or publication by consent of the dean, the Executive Committee of the Graduate Faculty, and the graduate student representatives of the Graduate and Professional Student Council. Questions and problems not answered or anticipated by the foregoing may be resolved by the use of other existing institutions or by amendment.

Graduate Student Affairs

Jared Lazarus

Core Objectives

The core objectives of Graduate Student Affairs (GSA) are to assess student needs, build student support and resources, and identify, recruit, and retain a diverse student population. This is accomplished through comprehensive programming developed after evaluating students' needs, partnering with student groups, and actively recruiting and preparing underrepresented students to be fully engaged as Duke graduate students. GSA staff combines these program components with innovative outreach, high levels of communication, and advocacy to enhance the quality of graduate student life.

Program Components

GSA hosts various programs that mark students' progress throughout their graduate careers.

- New Student Orientation aids students in their transition to Duke by providing information about the academic community, policies, and resources.
- The Graduate Student Resource Fair takes place during New Student Orientation and features representatives from various university offices and the local community.
- A Milestone Recognition Reception for PhD candidates honors those who pass preliminary examinations each year.
- During Commencement weekend, GSA hosts the PhD Hooding Ceremony and Reception, which celebrates the culmination of doctoral study.

Professional Development Programs

GSA provides strategic leadership to ensure that Graduate School students can identify the full range of career options available to them and develop the transferable skills to succeed in those careers. The Graduate School sponsors and partners with groups and offices across campus to provide programs, resources, and professional development events to help students with every step along the way—from identifying potential career paths, to developing skills to compete for them, to managing their career. These offerings help prepare students for successful careers in academia, business, entrepreneurship, government, and nonprofits. For more information, visit The Graduate School's professional development website, https://gradschool.duke.edu/professional-development.

Mentoring

GSA recognizes that mentoring is vital to graduate students' success, and The Graduate School is committed to cultivating a culture of mentoring in graduate education at Duke. Students with strong mentoring relationships are more productive, more involved in the campus community, and more satisfied with their graduate school experience. Mentoring support ensures that students will be well trained, successfully complete their degrees, and obtain promising job opportunities. A dedicated mentoring resources website (https://gradschool.duke.edu/professional-development/cultivating-culture-mentoring) ensures that graduate students and the university community have the necessary tools to succeed.

Social Programs

GSA coordinates activities designed specifically to encourage social interaction among graduate students. Several events during New Student Orientation Week help new students become acquainted with fellow students and Duke faculty. Graduate Student Appreciation Week recognizes graduate students' contributions to Duke's academic climate with a roster of enjoyable social events, practical and professional development workshops on student life issues. To provide regular networking opportunities for graduate students with children, GSA also hosts several GradParent Group events each year. Other social programming includes, but is not limited to, the annual Homecoming Celebration, a reception for LGBTQ and Allies, and a reception for faculty and students of color.

Diversity and Inclusion

The Graduate School is dedicated to and benefits from a student population diverse in background, culture, socioeconomic status, race, ethnicity, and work and life experiences that contribute to a fuller representation of perspectives within the academic life of the university. The Graduate School encourages applications from all those sectors of society, including prospective students whose life experiences may include the challenge of access due to a disability.

As part of Duke's long-standing commitment to increase the diversity and quality of its graduate student body, The Graduate School works to:

- increase enrollment of students from traditionally underrepresented groups,
- provide students with sufficient funding to complete their graduate studies in a timely manner, and
- promote an academic and social environment where these scholars can flourish.

A key mission of the Office of Graduate Student Affairs is to coordinate, supplement, and expand the recruiting efforts of graduate departments and programs. Targeted recruiting strategies are vital to these efforts, and the involvement of Duke's graduate faculty is central to these strategies. Each year, GSA staff and faculty participates in recruitment

fairs across the country that enable us to meet potential graduate students and to answer any questions they might have about Duke's graduate programs. Other mechanisms The Graduate School employs in the recruitment of students from diverse backgrounds include participation in national consortia designed to promote graduate education and targeted recruitment visits to institutions that serve students from historically underrepresented groups. GSA also supports the Summer Research Opportunities Program (SROP) that identifies potential graduate students in the biomedical sciences in their undergraduate years. Visit https://gradschool.duke.edu/about/commitment-diversity for more information on The Graduate School's commitment to diversity and inclusion.

Program Support

GSA's programs are developed, supported, and enhanced through four program support elements: advocacy, communications, student group support, and program evaluation. These elements ensure that GSA develops its programs and resources in such a way that they are accessible, inviting, and responsive to the needs of all segments of the graduate community. GSA is committed to giving students access to resources needed to achieve their scholarly, personal, and professional goals by recognizing the importance of student well-being, students with families, and student groups.

Advocacy

GSA makes every attempt to assess and to respond to the concerns of Duke graduate students. The Child Care Subsidy, and efforts to recognize and promote best practices in graduate student mentoring, are examples of initiatives that arose from GSA's response to students' expressed needs and concerns. In many instances, GSA is the initial point of contact for graduate students, offering informal counseling, advising, and follow-up.

Furthermore, GSA acts as the liaison between The Graduate School and the Career Center; Counseling and Psychological Services (CAPS); Duke Reach; the Office for Institutional Equity; the Disability Management Office; the central university Office of Student Affairs; and other campus offices. The Office of Graduate Student Affairs collaborates with Duke's graduate departments and the university administration. In addition, GSA representatives are members of national committees, graduate consortia, and professional associations concerned with issues related to graduate student life.

Communications

GSA works directly with The Graduate School's senior public affairs officer to ensure cohesive communication within the graduate community and the university. GSA staff members serve on a variety of committees that explore and evaluate new models of communication with students.

GSA also uses a number of online resources to foster ongoing communication among graduate students, faculty, and staff:

- The Graduate School's listserv and social-media platforms deliver timely, targeted, and relevant information to keep students informed about GSA events and other university programs.
- The Graduate School's e-newsletter shares relevant and current information with students, alumni, faculty, and staff.
- The e-newsletter highlights student issues, features student profiles, and identifies useful resources. To subscribe to the e-newsletter, visit https://gradschool.duke.edu/about/e-newsletter.
- The online Student Handbook and Student Resources sections of The Graduate School website help students quickly find the information they need.

Student Group Support

GSA advises and assists a number of graduate student organizations, including but not limited to: the Black Graduate and Professional Student Association, the Bouchet Society, Duke Chinese Students and Scholars Association, DukeOUT, the Hurston-James Society, the Graduate and Professional Student Council, GradParents Group, Duke F1RSTS, the Society for the Advancement of Chicanos Native Americans in Science, the Society of Duke Fellows, and Women in Science and Engineering. Graduate student groups help GSA invest its resources into programming that addresses specific needs of various segments of the graduate community that may not be addressed within academic disciplines.

Program Evaluation

Developing formal and informal procedures for program evaluation is crucial in assessing the effectiveness of GSA services and in instituting new programs. Formal evaluation of GSA's programs is carried out through surveys of major activities, followed by analysis and progress reports. Assessment of GSA's effectiveness is also supported by collaborating with other Graduate School offices throughout the admissions process and to prepare retention data. Informal evaluations of GSA events are conducted with individual students, student groups, and graduate faculty. Additionally, GSA regularly seeks feedback from its Graduate Student Affairs Advisory Committee (GSAAC). Composed of faculty, students, and staff representing each broad disciplinary area in The Graduate School, GSAAC's role is to serve as an evaluative resource in program development and to help in adopting specific strategies to meet program goals.

Julie Schoonmaker

Departments, Programs, & Course Offerings

Meghan Mendenhall

Course Enrollment

Courses numbered 500-699 are sometimes open to qualified undergraduate students who have received permission of the instructor and the director of graduate studies. Undergraduate students are not permitted in any courses above 700.

Double numbers separated by a hyphen indicate that credit is contingent upon completion of both courses. Double numbers separated by a comma indicate that although the course is a year-long course, credit may be received for either course or both courses.

C-L: denotes a course that is cross-listed or a program under which a course is listed.

The following symbols are included as suffixes to course numbers:

A	Courses that are taught away from Duke's Durham campus, e.g., study abroad or domestic away programs.
D	Course has a discussion section (for a larger class)
L	Course includes laboratory experience.
P	Preceptorial (small class)
S	Seminar (small class)
T	Tutorial (small class)

Certificate Programs

The Graduate School offers graduate certificate programs (most of which are interdisciplinary or multidisciplinary) that draw upon the unique strengths of Duke's research institutes and faculty. Certificate programs are designed to provide graduate students with advanced training in interdisciplinary or emerging fields of knowledge by taking advantage of the distinctive resources available at Duke or in the Research Triangle Park area.

The certificate is a formal statement of the interdisciplinary coursework a student has completed, and it has proven to be a useful, professional credential to students seeking positions after graduation. The student's official Duke University transcript notes the awarding of the certificate. These certificates are not standalone and cannot be earned independent of the student's degree. (Additional information for each certificate program is available on the certificate's website.)

Further descriptions, information, and requirements for all certificate programs are to be found in this chapter. Use the below links to navigate to individual certificate program listings.

Departments, Programs, and Course Offerings

Advanced Quantitative Methods in the Social Sciences

A certificate is available in this program.

The central mission of the graduate certificate in advanced quantitative methods in the social sciences is to provide interested doctoral students with a coherent and integrated understanding of quantitative approaches in the social sciences. The program is intended for doctoral students from any department or school who have interests in research in the social sciences. The goal is to provide advanced training in quantitative methods in an interdisciplinary context to facilitate research without regard to discipline and communication across disciplinary boundaries. Applications are typically made late in the second year or in the third year.

Requirements

- **Four graduate-level, interdisciplinary courses in social sciences.**
  - **Mathematics and Mathematical Statistics:** All candidates must demonstrate competence in basic mathematics, equivalent to completion of a basic course or series of courses in multivariate calculus, linear algebra, and probability theory through Statistics 611 or Economics 703.
  - **Research Design:** All candidates must have the equivalent of a course in the fundamental principles of research design, typically acquired through training within the home department, such as Political Science 731 or 732, Psychology 718S, or Sociology 702 and 720S.
  - **Formal Modeling and Derivation of Hypotheses:** All candidates must achieve competence in formal modeling. The expectation is that the student will have training at least at the equivalent of a micro-economics course in economics. The most preferred course is Economics 705 depending on the applicant's objectives (e.g., Political Science 631L, Psychology 749/750, Sociology 702, or Business Administration 513).
  - **Hypothesis Testing:** All candidates must achieve competence in the testing of hypotheses. This can be satisfied by successful completion of Statistics 601 or 831. In addition, applicants may ask that the board accept a disciplinary equivalent (currently taught examples include Economics 707, Political Science 630, Psychology 720, and Sociology 723).
- **Advanced, Interdisciplinary Knowledge:** A minimum of two courses—the equivalent of a year-long training—in one or more advanced, interdisciplinary topics of special interest to the student (all courses being outside the individual's own department and ordinarily unavailable within it), plus the Program for Advanced Research in the Social Sciences capstone course.

For additional information, visit the program's website at https://ssri.duke.edu/.

African & African American Studies

Professor Neal, *Chair*; Associate Professor of the Practice Shapiro, *Director of Graduate Studies*; Professors Baker, Bonilla-Silva, Burton, Crichlow, Darity, DeFrantz, Dubois, French, Holloway, Matory, Piot, and Powell; Associate Professors Cobb, Glymph, Hall, Haynie, Jaji, Lentz-Smith, Lubiano, Makhulu, and Royal; Assistant Professors Aidoo, Daly, and Winters; Professor of the Practice Smith; Associate Professor of the Practice Shapiro

A certificate is available in this department.

The Department of African & African American Studies (AAAS) offers a certificate in African and African American studies. Students enrolled in doctoral and master's programs are eligible and may work concurrently with their departments to satisfy the requirements for a certificate in African and African American studies. The curricular format is a trifold course of study that includes coursework, teaching, and research. The award of a graduate certificate is carried on the student's official transcript upon completion of the program. Students enrolled in the graduate program are eligible to apply for AAAS-sponsored teaching assistantships for undergraduate courses.

Graduate study leading to the certificate in African and African American studies encourages research and scholarship in all dimensions of the African and African American thought and experience. The graduate program is designed to provide access for students and scholars to a broad range of information and research from the humanities and social sciences, and the arts and professions, while taking advantage of the university's distinctive resources in each of these areas of study. Graduate students enrolled in the program are encouraged to participate in all African and African American studies events, and to audit the lecture series and symposia.

For further information regarding application and enrollment in the graduate certificate Program in African and African American Studies, contact the department's director of graduate studies or visit https://aaas.duke.edu/graduate-certificate.

Requirements for PhD Students

- Must take the gateway graduate seminar.
- Must take three additional graduate-level courses, two of which must be taught by AAAS core faculty. The third course must originate in, or be cross-listed with African and African American studies.
- Must either complete a teaching assistantship (or instructorship) in an AAAS-related undergraduate course under the sponsorship/supervision of an AAAS core or secondary faculty member; or take a fifth course, approved by the director of graduate studies, and submit a course proposal with syllabus for a related African and African American studies undergraduate course. In this case, the proposal and syllabus must be submitted prior to the dissertation defense and approved by an AAAS core faculty member.
- Write a dissertation in an African and African American studies area with core or secondary faculty represented on the dissertation committee.

Requirements for Master's Students

- Must take the gateway graduate seminar.
- Must take two additional graduate-level courses taught by core or secondary faculty.
- Must complete an independent study (MALS students may complete Liberal Studies 890) developed in association with an AAAS core or secondary faculty member.
- A final thesis/project (MALS students may complete Liberal Studies 850), approved in advance by the AAAS director of graduate studies, that addresses an aspect of the program's scholarly mission. An AAAS faculty member must serve as a final reader of the thesis/project, or as an examiner in its final review.

Courses in African & African American Studies (AAAS)

503S. The Black Radical Tradition: COVID-19, #JusticeForGeorgeFloyd, and the Movement for Black Lives. Black Studies is "essential work!" This course introduces students to a series of thinkers connected by a set of moments and locations that demand Black radical theorizing. Conjoining Black radical traditions in the US and South Africa, students explore contemporary political struggles in the anti-racism protests, campus struggles, COVID-19, and the Movement for Black Lives. Instructor: Makhulu. 3 units. C-L: Religion 503S, Cultural Anthropology 503S, Political Science 589S, International Comparative Studies 504S

510S. Global Africa. 3 units. C-L: see Cultural Anthropology 561S; also C-L: History 561S, Political Science 527S, International Comparative Studies 510S

512S. The Fetish: The Role of Things in Spiritual, Economic, and Sexual Life. This course explores the social relationships produced by debates over the value and agency of material things ranging from the cross and the Eucharist to black leather, fur, dildos and even the more mundane commodities through which capitalism and socialism have defined their rivalry. Thus we will examine the highly charged role of things in religion, economics, and spiritualized erotic relationships, as well as the centrality of the fetish concept in the mutual transformation of modern Africa and the West. Instructor: Matory. 3 units. C-L: Cultural Anthropology 511S, Religion 511S

515S. Race, Class, and Gender: A Social History of Modern (1750-present) Britain. 3 units. C-L: see History 505S; also C-L: Gender, Sexuality, and Feminist Studies 509S

520S. Harlem Renaissance. 3 units. C-L: see Art History 554S

530S. Third Cinema. 3 units. C-L: see Literature 613S; also C-L: International Comparative Studies 613S, Latin American Studies 613S, Visual and Media Studies 611S

531S. Black Camera: Still and Moving Images. 3 units. C-L: see Art History 650S

539. Black Camera: Still and Moving Images. 3 units. C-L: see Art History 539

540S. Seminar in Asian and Middle Eastern Cultural Studies. 3 units. C-L: see Asian & Middle Eastern Studies 505S; also C-L: Literature 530S

541S. Monuments and Memory: Public Policy and Remembrance of Racial Histories. 3 units. C-L: see Public Policy 562S

544S. Race and American Politics. 3 units. C-L: see Political Science 525S; also C-L: Public Policy 526S

545S. Race, Racism, and Democracy. 3 units. C-L: see Cultural Anthropology 535S

548S. Poverty, Inequality, and Health. 3 units. C-L: see Public Policy 644S

549S. Schooling and Social Stratification. 3 units. C-L: see Public Policy 542S; also C-L: Education 542S

551S. Race and Ethnicity. 3 units. C-L: see Public Policy 529S; also C-L: International Comparative Studies 529S

569. Understanding Sickle Cell Disease: A Biopsychosocial Approach. 3 units. C-L: see Nursing 569; also C-L: Global Health 569

575. Justice, Law, and Commerce in Islam. 3 units. C-L: see Religion 660; also C-L: Medieval and Renaissance Studies 659

589S. Black Visual Theory. 3 units. C-L: see Visual and Media Studies 555S

590S-5. Topics in African Art. 3 units. C-L: see Art History 590S-5

594S. Cultural (Con)Fusions of Asians and Africans. This course examines how people lay claims to belonging as citizens of nation-states. Focusing primarily on African and Indian descended populations in the Caribbean and the Pacific, we investigate how these populations invoke colonial constructions to reinvent themselves and work to negotiate their racialized identities in these shared communities. We will consider the construction of histories and explore the general cultural politics that sustain and bolster claims of authenticity and belonging and unbelonging within these national spaces. What sorts of sociocultural and political strategies are deployed by such people to exclude others even as they connect across these troubling divides? Instructor: Crichlow. 3 units. C-L: Cultural Anthropology 594S, Latin American Studies 594S, Sociology 594S

610S. Africa, Cuba, Brazil: Great Powers of the Black Atlantic. Explores shared cultural history of three great populations separated by oceans but linked by slave trade. Course will offer lively, mutually transformative dialogue in religion, music, and political ideas. This case study in the Africanization of the Americas and the Americanization of Africa challenges a range of conventional assumptions about transnationalism, race, class, gender, and their artistic expression. Instructor: Matory. 3 units. C-L: Cultural Anthropology 610S, History 610S, Romance Studies 522S

620S. AfroFuturism. Explores Afrofuturism, a literary and cultural aesthetic imagining how people of color project themselves into narratives of the future. Investigation of Science fiction, fantasy literature, music, artworks, music videos, and dance to trace the concept of an Afrofuturist point of view. Creation of Afrofuturist media and performances. Artists considered include writers Samuel R. Delany and Andrea Hairston; musicians Parliament-Funkadelic and Sun Ra; filmmaker Hype Williams; performers Janelle Monae and Flying

Lotus. Instructor: DeFrantz. 3 units. C-L: Dance 535S, Theater Studies 535S, Visual and Media Studies 524S

621S. Black Performance Theory. Exploration of methods and research approaches relevant to the construction of black performance theory. Performance Studies methodologies undergird ways of seeing and modes of analysis relevant to considerations of black art, including dance, sound and music, drama, visual art, and aesthetics of popular culture. Instructor consent required. Instructor: DeFrantz. 3 units. C-L: Dance 645S, Visual and Media Studies 621S

622S. Black Sonic Culture—Analog to Digital. The course will examine the production, reproduction and distribution Black (African Diasporic) "Sound"--inclusive of, but not exclusive of various musical cultures--in the creation of Black Sonic Culture(s) that were in conversation with and counter to Black Literary Culture, Black Visual Culture and Black Performance traditions. The course, in particular, will examine the impact on the transition from analog sound to digital sound. Instructor: Neal. 3 units. C-L: English 691S, Literature 691S, Music 691S

640S. African Cities. If the predominant mode of development in African cities is informal and unplanned giving rise to new modes of life, livelihood, and leisure beyond the organizing infrastructures of formal architecture and design in reality, the new African urbanism seems to give rise to two distinct conditions of life--the one crisis and the other ingenuity. This course is concerned to think through the paradox of rapid urban growth across the continent--from Lagos and Cairo to Johannesburg and Cape Town--and the fact that such rapid urban growth is taking place without the conventional facilities, infrastructures and technologies. Instructor: Makhulu. 3 units. C-L: Cultural Anthropology 562S

641S. Citizen and Subject in a Neoliberal Age. Explores studies of citizenship, quests to belong to a place, and institutional mechanisms people deem sacred, and others, profane and dispensable. Focuses on the ways African, Caribbean and Pacific peoples have adapted identitarian constructions to develop narratives of home. Case studies using ethnographic, historical, sociological and visual methods are used to investigate how particular claims are pursued in clamoring for citizenship in various communities. Instructor: Crichlow. 3 units. C-L: Sociology 645S, Cultural Anthropology 641S

642S. Global Inequality Research Seminar. 3 units. C-L: see Public Policy 645S; also C-L: Economics 541S, Sociology 642S, Political Science 642S, Human Rights Program-Franklin Humanities Institute 642S

643S. Black Women, Black Freedom. Examination of struggles for freedom, from nineteenth century through twenty-first, particularly through the lives of black women. Drawing on women's history, literature, art, performance and critical theory, students interrogate meaning of various freedoms, including civic and sexual. Objective is to discern a working definition for "black freedom" by centering women in struggles for black liberation. Instructor: Cobb. 3 units. C-L: Art History 643S

645S. African Modernities. Encounters between African societies and global forces, including colonialism, capitalism, development initiatives. Instructor: Staff. 3 units. C-L: Cultural Anthropology 560S

646. Surviving Globalization: The Global South and the Development Imagination. Global Change entails a multiplicity of environmental, social, economic, political and cultural factors that create challenges for development. The Global South, a vital area of the world, has been entangled in this vortex of global change as both catalyst and conductor of an emergent globalizing modernity. The progress of globalization seems beset by multiple stressors, ranging from financial crises and global recession, to climate change, state and non-state conflicts, free ranging terrorist aggression, and global health scares. What are the odds then of surviving globalization? What role do our imaginations of development play in either creating crises or effectively responding to them? This course is the same as African & African American Studies 409 but with additional graduate level work. Instructor: Crichlow. 3 units. C-L: International Comparative Studies 647, Sociology 647

660. Health in the African Diaspora. Exposes and explores the individual and joint contributions of biological and non-biological factors to health and wellbeing in peoples from various regions and countries of the African Diaspora. The course draws on a variety of disciplines, modes of inquiry, and health problems in comparative analyses of genetic, historical, political, and sociocultural dimensions of the African Diaspora. Course content is not limited to the transatlantic African Diaspora; it spans multiple African Diaspora streams. Instructor: Royal. 3 units. C-L: Cultural Anthropology 660, Global Health 672

690. Special Topics. Topics vary from semester to semester. Instructor: Staff. 3 units.

690S. Special Topics. Seminar version of African & African American Studies 690. Instructor: Staff. 3 units. C-L: Science & Society 590S-1

699S. Gateway/Proseminar. The proseminar is the required gateway course in the AAAS Certificate Program. It is designed to introduce students to the broad interdisciplinary scope of advanced scholarship in black diasporic studies globally. Students will learn interdisciplinary and cross disciplinary research methods, including awareness of archival, bibliographic, and qualitative/quantitative methods. The history of the field and its unique influence on the production of humanistic and social scientific knowledge are also significant concerns in the course. Instructor: Staff. 3 units.

720S. Outsiders and Insiders. 3 units. C-L: see Art History 715S

735. The History of Hip-Hop. Co-taught by Grammy Award-winning producer 9th Wonder (Patrick Douthit) and Mark Anthony Neal, a noted scholar of black cultural studies, the course will examine the organic social, cultural and economic foundations of hip-hop culture. Students will examine the impact of fifteen recordings released during the foundational years of the culture (1973-1993) that exemplify the foundational tensions of culture vs. commerce and spirituality vs. secularism. In addition to a midterm project (producing an audio documentary) and a final exam, students will be expected to produce a review essay based on assigned readings and curriculum outline for teaching hip-hop studies for secondary education. Instructor: Neal. 3 units. C-L: English 735, Music 735, Visual and Media Studies 735

740S. Racial and Ethnic Minorities in American Politics. 3 units. C-L: see Political Science 703S; also C-L: Public Policy 845S

741S. Globalization. 3 units. C-L: see Cultural Anthropology 741S

747S. Visual Culture of Black Appalachia: Race, Place and Resilience. 3 units. C-L: see Documentary Studies 747S; also C-L: Art History 747S

767. How Blackness Thinks. 3 units. C-L: see Religion 767; also C-L: English 767, Christian Theology 774

780S. Teaching Race, Teaching Gender. Interdisciplinary analyses of the problematics of teaching about social hierarchies, especially those of race, class, and gender. Curricular content and its interaction with the social constructions of students and teachers. Instructor: Lubiano. 3 units. C-L: Gender, Sexuality, and Feminist Studies 780S, History 780S, Literature 780S

890. Special Topics. Topics vary from semester to semester. Instructor: Staff. 3 units.

890S. Special Topics. Topics will vary from semester to semester. Instructor: Staff. 3 units.

891. Special Readings. Consent of instructor required. Instructor: Staff. 3 units.

900. African American Religion Through the Literary Imagination. 3 units. C-L: see Religion 900; also C-L: English 900

Analytical Political Economy

Associate Professor Leventoglu and Professor Kuran, *Directors of Graduate Studies*

Faculty in Political Science: Professor Vanberg, *Chair*; Associate Professor Leventoglu, *Associate Chair and Director of Graduate Studies (Master's)*; Professor Beardsley, *Director of Graduate Studies (PhD)*; Professors Aldrich, Beardsley, Beramendi, de Marchi, Feaver, Gillespie, Grieco, Hillygus, Kitschelt, Knight, Kuran, Malesky, Manion, McClain, McCubbins, Munger, Niou, Price, Remmer, Rohde, Siegel, Vanberg, and Wibbels; Associate Professors Haynie, Johnston, Kirshner, Leventoglu, Stegmueller, and White; Assistant Professors Fresh, Jardina, Rousseliere, and Schubiger; Associate Professor of the Practice Maghraoui; Professors Emeriti Fish, Grant, Holsti, Hough, Horowitz (law), Johns, McKean, Paletz, Spragens, and Ward; Research Professors Emeriti Brennan, Keech, and Soskice; *Secondary Appointments*: Professors Hacohen (History), Jentleson (Public Policy), Kelley (Public Policy), Krishna (Public Policy), Rosenberg (Philosophy), N. Siegel (Law), and Vaisey (Sociology); Associate Professors Atkins (Classical Studies), Bermeo (Public Policy), Carnes (Public Policy), Goss (Public Policy), and Mullin (Environment); Assistant Professors Barnes (Public Policy), Johnson (Public Policy), and Rose (Public Policy); Adjunct Professors Lawrence, Liu (Asian & Middle Eastern Studies), MacKuen, and Stimson; Associate Professor of the Practice Charney (Public Policy); Professor Emeritus Mickiewicz (Public Policy)

Faculty in Economics: Professor Burnside, *Chair*; Associate Professor Bugni, *Director of Graduate Studies (PhD)*; Professors Abdulkadiroglu, Adler, Ambrus, Anton, Arcidiacono, Ariely, Bansal, Bayer, Bollerslev, Clotfelter, Cohen, Coleman, Collard-Wexler, Conitzer, Darity, Field, Frakes, Frankenberg, Hoover, Hotz, Hsieh, Kimbrough, Kramer, Kranton, Kuran, Lewis, Lopomo, Marx, McAdams, McElroy, Munger, Nechyba, Newell, Pattanayak, Patton, Peretto, Petters, Pfaff, Pizer, Rampini, Ridley, Rosen, Sanders, Sarver, Smith, Tauchen, Taylor, Thomas, Timmins, Tower, Viswanathan, Xu, and Yildirim; Associate Professors Ananat, Bennear, Berger, Bianchi, Conrad, Daley, Dix-Carneiro, Ilut, Leventoglu, Li, Mohanan, Roberts, Sadowski, and Suarez Serrato; Assistant Professors Bardhi, Garlick, Harding, Jurado, Kehrig, Komisarow, Lanteri, Macartney, Masten, Maurel, Rangel, Sexton, Sidibe, Wang, and Weller; Professors Emeriti Burmeister, Cook, De Marchi, Grabowski, Graham, Ladd, Sloan, Toniolo, Wallace, and Weintraub; Research Professors Becker, Caldwell, and Medema; Associate Research Professors Boyd and Zanalda; Professors of the Practice Connolly, Fullenkamp, Leachman, Leven, Rasiel, and Ridley; Associate Professor of the Practice Kim; Assistant Professor of the Practice Levonmaa

A master's degree is available in this program.

The Master's Program in Analytical Political Economy is a joint program between the departments of political science and economics. Students preparing to enter this program will find an undergraduate background in political science, economics, statistics, or mathematics to be helpful. It is designed to train and develop economic, political modeling, game theory, and statistical technique skills linked to political economy, and related areas to prepare graduates for PhD studies or related professions. Students complete coursework in both political science and economics. Graduates are awarded an MA in analytical political economy as their degree.

Students must complete a minimum of 30 course credits: 12 course credits in political science courses numbering 500 or above, or substitutes approved by the MAPE directors; 12 course credits in select economics courses (Economics 601, 602, 605, 606, 608D, 612, 613, 652, 656, 701, 702, 703, 705, 706, 707, or approved substitutes, with no more than 6 course credits from any one of the subfields of Microeconomics, Macroeconomics, and Econometrics); and 6 additional credits in graded graduate courses in economics or political science. The final category may include approved independent study with economics and/or political science faculty advisors. Courses in other relevant disciplines also may be counted toward the degree, subject to approval by the MAPE directors. Effective Fall 2018, undergraduate courses (499 or lower) do not count toward the MAPE degree or a student's GPA. Undergraduate courses taken before Fall 2018 do count toward the MAPE degree (given a grade of B- or better) and GPA. A graduate-level course paired with an undergraduate-level course may count toward the MAPE degree and a student's GPA only if the graduate-level version has a separate, more rigorous syllabus for graduate students. It is the student's responsibility to verify that this is the case before enrolling in any paired courses.

Students must pass both a portfolio review and a qualifying exam. The student's portfolio includes the final outputs of learning and research activities carried out during their master's studies. These outputs consist of final versions of all papers that received a grade of B+ or above (with the grade indicated); the accompanying slides from any oral or written presentations; and any other research product produced under the program. The portfolio also includes an up-to-date résumé or curriculum vitae; a self-assessment of the student's experiences in the MAPE Program; and a statement on the student's long-term plans. The qualifying exam, which is administered by the Department of Political Science, assesses whether the student has attained a firm command of the political economy literature.

Political Science Courses (POLSCI)

522S. Comparative Party Politics. 3 units.
632. Computational Political Economy. 3 units.
644S. The Political Economy of Inequality. 3 units.
645S. Political Economy of Growth, Stabilization, and Distribution. 3 units.
646S. The Politics of European Integration. 3 units.
705S. Political Economy of Macroeconomics. 3 units.

715. Core in Political Institutions. 3 units.
730. Formal Modeling in Political Science (C-E). 3 units.
745. Core in Political Economy. 3 units.
762. The Political Economy of Institutions. 3 units.

Economics Courses (ECON)

601. Micro economics. 3 units.
602. Macroeconomic Theory. 3 units.
605. Advanced Microeconomic Analysis. 3 units.
606. Advanced Macroeconomics II. 3 units.
608D. Introduction to Econometrics. 3 units.
612. Time Series Econometrics. 3 units.
613. Applied Econometrics in Microeconomics. 3 units.
652. Economic Growth. 3 units.
656. International Monetary Economics. 3 units.
701. Microeconomic Analysis I. 3 units.
705. Microeconomic Analysis II. 3 units.
702. Macroeconomic Analysis I. 3 units.
706. Macroeconomic Analysis II. 3 units.
703. Econometrics I. 3 units.
707. Econometrics II. 3 units.

Anthropology and History

A certificate is available in this program.

For several decades, historians have been turning to cultural anthropology, and anthropologists to history, for methodological guidance. By now a relatively large number of historians and anthropologists work within a shared framework, asking similar questions, and seeking answers to these questions from similar kinds of evidence. In both disciplines it is widely understood that cultural diversity and cultural change cannot be accounted for either by the traditional narrative techniques of historians or by the traditional ethnographic descriptions of anthropologists. Instead, historians realize they must look beyond action, intention, and event, to underlying patterns, unspoken presuppositions, institutional, and discursive structures. Anthropologists realize that kinship, ritual, social role, discourse, and belief are all subject to improvisation, contestation, politicization, and thus to change. Scholars in both disciplines have looked to practice theory, as developed by Bourdieu, Giddens, Ortner, and Sewell; to postcolonial studies, as developed by Stoler, Dirks, Spivak, Das, and Burton; to performance theory, as developed by Sahlins, Butler, Sedgwick; and to other, related approaches.

Drawing on these streams of theory, anthropologists and historians strive to come to grips with the full implications of cultural diversity and change. The challenge is to understand what all actors in a given context consciously know and intend as well as what they unconsciously take for granted, what they do on purpose and what they do without reflection, and to see how action and conflict have both intended and unintended consequences. One goal of such research is a new kind of total history, of the kind the Comaroffs have attempted for South Africa. Another goal is the recovery of forgotten or suppressed pathways to meaning of the kind rescued from oblivion by recent work on indigenous sexuality in colonial Mexico or Spanish judicial repression in colonial Peru. Still another is the exploration of historical change in "affect," the seemingly automatic responses to situations that often encode cultural assumptions and set the parameters of meaning and action. Still another is the extension of ethnographic understandings to the materials of Western history, and the history of anthropology itself.

Collaboration between faculty of the history and cultural anthropology departments at Duke has been active since the 1980s. Numerous cross-listed graduate seminars and joint work on graduate preliminary examination committees and dissertation defense committees have testified to the vital role of this collaboration for graduate training over the years.

This collaboration has now been formalized with a certificate program to ensure that students who wish to draw on the other discipline gain familiarity with the joint methods of both disciplines in a more systematic way. Students will also receive a tangible token in recognition of their accomplishments.

Students enrolled in the PhD programs of either cultural anthropology or history wishing to earn a certificate in anthropology and history must designate a mentor from among the affiliated faculty of the certificate program. With their mentors, students will draw up a coherent program of study leading to the certificate.

Requirements

Student must designate a mentor from the affiliated faculty of the certificate program. With mentor, student must draw up a program of study that must include:

- Completion of a core graduate seminar:
  - with two-semester sequence beginning with required graduate-level History and Cultural Anthropology (Anthropology and History); and
  - concluding with—research seminar in which students prepare and present their own papers.
- Participation (while in residence) in an anthropology and history colloquium to be organized by the affiliated faculty and the students.
- One presentation of the student's own work at the colloquium, usually during the writing phase of the dissertation.
- At least two other courses in the nondegree department.
- Capstone research paper (if in history, this may be a part of the student's portfolio).
- Preliminary examination field in the nondegree discipline.

The director of graduate studies in each department, assisted by one member of the affiliated faculty from each department, will monitor the student's progress and review his/her dossier at least once annually.

PhD students in other Duke departments and programs may also earn a certificate in anthropology and history; for details, see https://history.duke.edu/graduate/anthropology-history-certificate.

Art, Art History & Visual Studies

Professor Dillon, *Chair*; Professor Jaskot, *Director of Graduate Studies*; Professors Antliff, Dillon, Forte, Hansen, Jaskot, Lasch, McWilliam, Morgan, Powell, Rankin, Seaman, Stiles, Van Miegroet, Weisenfeld, and Wharton; Associate Professors Abe, Cobb, Gabara, Galletti, and Szabo; Assistant Professors Olson, Caviglia, and Salvatella

A PhD is available in this department.

The Department of Art, Art History & Visual Studies offers graduate work leading to the PhD in art and art history. The doctoral program is competitive with the leading programs in the country. The department is committed to full and equal funding of its students during their time in residence at Duke. Admission to the program is limited to between four and six new students per year.

The PhD program is integrally connected with many interdisciplinary, theoretical, and international initiatives in the humanities at Duke. The doctoral program is distinguished by its flexibility and cross-disciplinarity. It requires a thorough grounding in the form and meaning of objects and sites, as well as in their theoretical and historical contexts. Coursework has been designed to prepare students for careers in art and architectural criticism, research and teaching in the academy, museum, and art gallery. Faculty in the program are expert in a broad range of areas of art history, as well as in a variety of media, from architecture, sculpture and painting to video and cybernetics.

For further information on the PhD program, prospective applicants may visit the department's website at https://aahvs.duke.edu, or write to the director of graduate studies.

The department also offers a master's degree in digital art history/computational media (formerly historical and cultural visualization). The eighteen-month program integrates historical disciplines and the study of cultural artifacts with digital visualization techniques for the analysis and presentation of research. The program requires ten courses over three semesters in addition to summer research. Students affiliate with an existing faculty research initiative, from which they will develop their own independent research project for the MA thesis. Common themes that unite the various projects are the visualization of process, the representation of change over time, recontextualizing displaced objects and object biographies.

The department also offers a master of fine arts degree in experimental and documentary arts in collaboration with the Center for Documentary Studies and the Program in the Arts of the Moving Image. For information on the MFA in experimental and documentary arts, please visit https://aahvs.duke.edu/graduate/mfaeda.

The *Guidelines for Graduate Students in the Doctoral Program in Art History* fully describe these and additional requirements and the detailed steps in the student's graduate career.

Courses in Art History (ARTHIST)

501S. Greek Art and Society: Archaic to Classical. Main categories of buildings, monuments, and images most characteristic of ancient city life in fifth and fourth centuries BCE. Range of material studied: city plans, temples, statues, reliefs, painted pottery. Emphasis on archaeological and historical contexts; questions and themes concern relation of new forms of public building and representation to changing historical circumstances. Fifth century made decisive break with archaic visual modes; area of special investigation is swift emergence and consolidation of revolutionary way of seeing and representing known as 'classical art'. Instructor: Dillon. 3 units. C-L: Classical Studies 541S

502S. Greek Art: Hellenistic to Roman. Seminar explores art of Greek East from 300 B.C.E to 300 C.E.; emphasis on understanding and analyzing production, style, materials, functions. Sculpture made for Hellenistic kings and cities, and changes in sculptural production with Roman conquest and imperial rule. Main categories of evidence: funerary monuments, portrait statues, heroic groups in baroque style, Dionysiac-themed decorative sculpture. Issues of stylistic categories, periodization, meaning and interpretation, theoretical perspectives expressed in ancient literary texts, and current scholarly debates and trends in study of Hellenistic and Roman art in a Greek context form an integral part of the seminar. Instructor: Dillon. 3 units. C-L: Classical Studies 542S

503S. Ancient Spain and Portugal: The Roman Provinces of the Iberian Peninsula. 3 units. C-L: see Classical Studies 546S

504SL. Building Duke: An Architectural History of Duke Campus from 1924 to Today. Research seminar and laboratory on the architectural history of Duke Campus based on original archival materials (photos, blueprints, contracts, letters, and financial records) preserved in Duke Library collections. Explores the variety of interpretative lenses in the field of architecture history, including, but not limited to, issues of style, patronage, labor, class, gender, and race. Analyzes notions of cultural identity as construed by Duke founders and administrators, and as imprinted on Duke Campus by its architects and landscape designers. Original research projects based on primary materials and digital visualizations of changes in the physical fabric of Duke Campus through time. Instructor: Galletti. 3 units. C-L: Historical and Cultural Visualization 504SL

505S. Visual Studies from the Global South. This seminar shifts the geography of critical theory, introducing interdisciplinary approaches to visual culture and art formulated outside the northern academies of Europe and the United States. Diverse readings introduce how the visual is constituted in sites that have endured colonialism and globalization. Specific topics include: word and image; space, place, and site; media and new technologies; indigenous and Afro-diasporic philosophies; and the raced and gendered body. Instructor: Gabara. 3 units. C-L: Visual and Media Studies 505S, Romance Studies 505S

506A. History of Netherlandish Art and Visual Culture in a European Context. A contextual study of visual culture in the Greater Netherlands and its underlying historical and socioeconomic assumptions from the late medieval to early modern period, through immediate contact with urban cultures, such as Amsterdam, Leiden, Utrecht, Brussels, Ghent, Bruges, and Antwerp. Includes daily visits to major museums, buildings, and sites; hands-on research in various collections; discussion sessions with leading scholars

in the field; and a critical introduction to various research strategies. (Taught in the Netherlands.) Not open to students who have taken Art History 262A-263A. Course credit contingent upon completion of Art History 507A. Instructor: Van Miegroet. 3 units. C-L: Medieval and Renaissance Studies 504A, Visual and Media Studies 506A

507A. History of Netherlandish Art and Visual Culture in a European Context. Second half of Art History 506A-507A; required for credit for 506A. (Taught in the Netherlands.) Not open to students who have taken Art History 262A-263A. Instructor: Van Miegroet. 3 units. C-L: Medieval and Renaissance Studies 505A, Visual and Media Studies 507A

508S. Art and Markets. Cross-disciplinary art history-visual culture-economics seminar. Analytical and applied historical exploration of cultural production and local art markets, and their emergence throughout Europe, Asia, and the Americas. Criteria for valuation of imagery or what makes art as a commodity desirable or fashionable. Visual taste formation, consumer behavior, and the role of art dealers as cross-cultural negotiants. Consent of instructor required. Instructor: Van Miegroet. 3 units. C-L: Visual and Media Studies 567S, Economics 321S

509S. Mimesis in Theory, Embodied Practice, and Literary Arts. 3 units. C-L: see French 507S; also C-L: English 581S, Literature 507S

515S. Representing Architecture: Means and Methods. Projects- and skills-based studio course. Exploration of the historical and contemporary techniques and technologies used to visualize, communicate and document, built/historic, proposed or hypothesized architecture and its construction. Focus on its application for art, architectural history and the humanities, as well as architectural design training. Topics covered include hand sketching, ortho/perspective representation, 2d CAD, 3d modeling and potential explorations of 3d immersion/VR or 3d printing/model-making. Presented in a series of short, topic-based studio exercises culminating in a final project, which may relate to the student's research interests. Instructor consent required. Instructor: Staff. 3 units. C-L: Visual Arts 515S, Historical and Cultural Visualization 515S

520S. Roman Provincial Archaeology: The West. 3 units. C-L: see Classical Studies 547S

522S. Curatorial Practices in a Global Context. History and critical theories of all experimental art from conceptual, performance, and installation to video and multimedia, collectives, and ecological and bioart considered in a global context including international exhibitions, biennials, and new curatorial practices. Instructor: Stiles. 3 units. C-L: Visual and Media Studies 522S

535S. Camera Asia. Examines how the art and technology of photography have changed how we study and understand the historical past, with a focus on China, India, and Japan. Analyzes arrival of the camera as a historical event, along with photographers and studios. Evaluates ways in which the new technology was embraced, and considers how the camera reconfigured attitudes towards the body and gender relations, nation building, war, catastrophes and death. Instructor: Weisenfeld and Ramaswamy. 3 units. C-L: Visual and Media Studies 535S, History 530S, International Comparative Studies 531S

536S. Technology and New Media: Academic Practice. 3 units. C-L: see Information Science + Studies 540S; also C-L: Visual and Media Studies 562S

537S. Computational Media, Arts & Cultures Proseminar. 3 units. C-L: see Computational Media, Arts & Cultures 650S; also C-L: Information Science + Studies 650S, Literature 621S, Visual and Media Studies 561S

539. Black Camera: Still and Moving Images. This course interrogates still and moving images by and about people of African descent. Students enrolled in this course will consider film, photography, and media art. Together, we will examine documentary film, daguerreotype and archival photography, black cinema, and the cultural politics that render production, reception and circulation particular for black subjects. Instructor: Cobb. 3 units. C-L: Visual and Media Studies 545, African & African American Studies 539

540S. Topics in Nineteenth-Century Art. Focus on a major artist, movement, or trend in nineteenth-century art. Subject varies from year to year. Consent of instructor required. Instructor: McWilliam or staff. 3 units.

542S. Information Archeology: Studies in the Nature of Information and Artifact in the Digital Environment. 3 units. C-L: see Information Science + Studies 680S; also C-L: Visual and Media Studies 569S

543S. Methodology of Art History. Various theoretical perspectives that have shaped disciplinary perspectives and practices in art history. Introduction to particular types of methodologies (i.e. Marxism, feminism, race and gender, psychoanalysis, post-colonial theory, and deconstruction) as fields of inquiry through which the study of the visual arts and culture have been practiced. Historiography of the last two decades in art history; selected contemporary debates. Instructor: Staff. 3 units.

544S. Soviet Art after Stalin 1956-1991. 3 units. C-L: see Russian 561S

545S. The Archaeology of Death: Ritual and Social Structure in the Ancient World. 3 units. C-L: see Classical Studies 543S

546S. The American Artist. This course utilizes art-historical methodologies as tools for critical inquiry and scholarly research on one American artist (selected as per this seminar's scheduling every four years). Apart from a firm biographical and art-historical grasp of the specific American artist under investigation, the goal of this course is to develop visual literacy of American art through seeing and writing. An emphasis will be placed on improving various forms of written art discourse (i.e., descriptive, expository, interpretative, etc.) Instructor: Staff. 3 units.

547L. Introduction to Digital Archaeology. 3 units. C-L: see Classical Studies 544L; also C-L: Information Science + Studies 544L

548S. Japanese Design in a Global World. Japanese design encompasses everything from sushi to Hello Kitty—from Shiseido to Nintendo. This course examines the diverse and vibrant spheres of contemporary Japanese design culture across the globe. It is both an introduction to design practices and a forum for the critical evaluation of theoretical issues related to the larger field of design. Exploring the diverse fields of fashion, graphic design & packaging, industrial design, corporate branding, culinary culture, robotics, electronics, gaming, animation, and toys, the class will be introduced to the global impact of Japanese design on daily life around the world and the dynamic transnational culture in which it participates. Instructor: Weisenfeld. 3 units. C-L: Visual and Media Studies 548S

549S. Roman Coinage: The Materiality of the Roman Economy. 3 units. C-L: see Classical Studies 540S

551SL. Advanced Digital Art History: New Representational Technologies. Research and study in material culture and the visual arts expressed by using new visual technologies to record and communicate complex sets of visual and physical data from urban and/or archaeological sites. Introduces techniques for the presentation and interpretation of visual material through a series of interpretative and reconstructive technologies, including the development of web pages (HTML/Dreamweaver), Photoshop, Illustrator, Google Sketch-up, Google Maps, and Flash. To develop techniques of interpretation and representation. Consent of instructor required. Instructor: Dillon, Olson, or Szabo. 3 units. C-L: Visual and Media Studies 551SL, Information Science + Studies 551SL

552. Creative Industries and the Urban Environment. This Bass Connections course examines the relationship between urban development and cultural production in specific contemporary and historical contexts, past and present. Cultural industries generally include printing, publishing and multimedia art, audiovisual, phonographic and cinematographic productions, as well as art creation, marketing and design and local art markets in the urban environment. The aim is to analyze the impact of creative industries on the economic development of a city and what one can learn from historical and present-day examples through the analysis of data. Analytical methods, theories and practices will be interwoven throughout the course. Instructor consent required. Instructor: Van Miegroet. 3 units. C-L: Visual and Media Studies 542, Information Science + Studies 552

553S. Principles of Roman Archaeology. 3 units. C-L: see Classical Studies 551S

554S. Harlem Renaissance. The art and culture that was produced by and about African Americans (largely in the western metropoles) during the period roughly between the two world wars. Chronological overview, a focus on individual figures, and study of the criticism and creative writings of this period. Other topics include black migrations to urban centers, performance-as-a-visual-paradigm, racial and cultural primitivism, and an alternative, African American stream of early twentieth-century visual modernism. Instructor: Powell. 3 units. C-L: African & African American Studies 520S

555S. Art and the Holocaust: Architecture, Art, and Cultural Politics during the Nazi Period. This course will analyze the history of the genocide of the European Jews, and its connection to antisemitic art and cultural policy during the Nazi period. With a sound understanding of the development of oppressive policies against the Jews, and looking at a variety of media (painting, architecture, film, photography, design), the course will explore the complicated relationship between developing racist policies and the world war as they impacted and were in turn influenced by artists. Examines not only artists involved in the Nazi state, but also those who resisted in exile or were its victims. Instructor: Jaskot. 3 units. C-L: German 565S, Jewish Studies 555S, History 531S, Visual and Media Studies 525S

557S. Trauma in Art, Literature, Film, and Visual Culture. Theories of trauma applied to visual representations of violence, destruction, and pain in contemporary art, film, and literature, examining the topic through multiple subjects from the Holocaust, cults, gangs, racism, and sexual abuse to cultures of trauma. Theories of trauma examined from a variety of sources including clinical psychology, cultural and trauma studies, art, film, and literature, aiming to enable students to gain the visual acuity to identify, understand, and respond to traumatic images with empathy. Not open to students who have previously taken this course as Art History 295S. Instructor: Stiles. 3 units. C-L: Visual and Media Studies 557S

558S. Spatial Practices. How space works from medieval refectories to Starbucks, from Jerusalem to Las Vegas, from mikvaot to hot spring spas. Consideration of space through theoretical texts, including Lefebvre, Habermas, Eliade, Zizek, and mapped on specific historical landscapes. Consent of instructor required: preference given to students earning concentration in architecture. Instructor: Wharton. 3 units.

560SL. Roman Topography: Urban Life and Cityscapes in Ancient Rome. 3 units. C-L: see Classical Studies 556SL; also C-L: Visual and Media Studies 570SL

561. Etruscan Cities. 3 units. C-L: see Classical Studies 560

580S. Historical and Cultural Visualization Proseminar 1. Interactivity and online content management through databases, collaborative blogs, and other systems. Data visualization based on textual, image, and quantitative sources. Basic techniques for virtual reality, simulations, augmented reality, and game-based historical and cultural visualization project development. Mini-projects based on existing and new research data from the Smith Media Labs and other sources. Best practices for digital research project planning and collaboration. Theoretical topics include: critical digital heritage, virtuality and culture, information aesthetics, hypermedia information design. Instructor consent required. Instructor: Olson or Szabo. 3 units. C-L: Historical and Cultural Visualization 580S, Visual and Media Studies 580S, Information Science + Studies 580S, Computational Media, Arts & Cultures 580S

581S. Historical and Cultural Visualization Proseminar 2. 2D and 3D imaging, modeling; raster and vector graphics sources, laser scanners, photogrammetric software, basic database structures. Digital mapping and GIS. Presentation strategies and best practices for the web (standards-compliant HTML/CSS/Javascript), multimedia (audio/video/animation), scholarly annotation, intellectual property. Theoretical, ethical issues in field of new media and digital humanities. Epistemological issues re: mediation and visualization, ethics of intellectual property, politics of geospatial visualization, digital materiality, affordances of new media narrativity. Instructor consent required. Instructor: Olson or Szabo. 3 units. C-L: Historical and Cultural Visualization 581S, Visual and Media Studies 581S, Information Science + Studies 581S, Computational Media, Arts & Cultures 581S

590S. Special Topics. Subjects, areas, or themes that embrace a range of disciplines or art-historical areas. Instructor: Staff. 3 units.

590S-1. Special Topics in Greek Art. Problems and issues in a specific period or genre of Greek material culture. Instructor consent required. Instructor: Dillon. 3 units. C-L: Classical Studies 590S

590S-11. Special Topics in Greek Archaeology. 3 units. C-L: see Classical Studies 590S-1

590S-3. Topics in Romanesque and Gothic Art and Architecture. Analysis of an individual topic. Subject varies from year to year. Consent of instructor required. Instructor: Staff. 3 units. C-L: Medieval and Renaissance Studies 590S-1

590S-4. Topics in Italian Renaissance Art. Topics in art and/or architecture from c. 1300 to c. 1600. Subject varies from year to

year. Consent of instructor required. Instructor: Galletti. 3 units. C-L: Medieval and Renaissance Studies 590S-2

590S-5. Topics in African Art. Specific problems of iconography, style, connoisseurship, or a particular art tradition in African art. Subject varies from year to year. Consent of instructor required. Instructor: Powell. 3 units. C-L: African & African American Studies 590S-5

590S-6. Topics in Chinese Art. Problems and issues in a specific period or genre of Chinese art. Specific focus varies from year to year. Instructor: Abe. 3 units.

590S-7. Topics in Japanese Art. Problems and issues in a specific period or genre of Japanese art. Specific focus varies from year to year. Consent of instructor required. Instructor: Weisenfeld. 3 units.

590S-8. Topics in Modern Art. Selected themes in modern art before 1945, with emphasis on major movements or masters. Subject varies from year to year. Consent of instructor required. Instructor: Stiles. 3 units.

590S-9. Topics in Art since 1945. Historical and critical principles applied to present-day artists and/or movements in all media since World War II. Consent of instructor required. Instructor: Stiles. 3 units.

590SL. Special Topics in Roman Archaeology. 3 units. C-L: see Classical Studies 590SL

620S. Models: Premodern to Posthuman. Architectural models may be either powerful small-scale prototypes for buildings or weak copies of powerful archetypes. Consideration of variety of architectural models from urban projects to dollhouses allows historical and theoretical exploration of models' agency. Instructor consent required. Instructor: Wharton. 3 units. C-L: Visual and Media Studies 620S

630S. Phenomenology and Media. 3 units. C-L: see Literature 630S; also C-L: Information Science + Studies 630S, Visual and Media Studies 630S

632S. Whitehead, Bergson, James. 3 units. C-L: see Literature 632S; also C-L: Information Science + Studies 632S, Visual and Media Studies 632S

643S. Black Women, Black Freedom. 3 units. C-L: see African & African American Studies 643S

650S. Black Camera: Still and Moving Images. This course interrogates still and moving images by and about people of African descent. Graduate students enrolled in this course will consider film, photography, and media art. Together, we will examine documentary film, daguerreotype and archival photography, black cinema, and the cultural politics that render production, reception and circulation particular for black subjects. Instructor: Cobb. 3 units. C-L: Visual and Media Studies 650S, African & African American Studies 531S

691. Independent Study. Directed reading in a field of special interest, under the supervision of a faculty member, resulting in a substantive paper or report. Open to qualified students by consent of instructor and director of undergraduate studies. Instructor: Staff. 3 units.

700S. Museum Studies. Introduction to the organization and functions of the museum in preparation for the presentation of a student-organized exhibition. Most of the semester spent in independent study researching scholarly, critical essays for the catalog. Instructor: Museum Staff. 3 units.

701S. Museum Studies. Completion of research and preparation of the catalog. Students actively participate in catalog design and production, and will be responsible for planning and installing the exhibition as well as interpreting it to the public through lectures and tours. Instructor: Museum Staff. 3 units.

702S. Critical Approaches to Exhibitions and Museums. The historical context and critical analysis of exhibition theory and practices from curiosity cabinets to ethnological museums to postmodern spectacles with special attention to the development of the fine art museum as a distinctive site of visual display and consumption. Instructor: Abe. 3 units.

703S. Goya and David: Enlightenment and Unreason. A comparative study exploring the artists' contrasting responses to contemporary currents in art, philosophy and politics; examination of Goya and David as historiographical subjects; exploration and critique of biographical strategies in art history. Instructor: McWilliam. 3 units.

704S. Nationalism and Visual Culture Since 1789. Theories of nationalism, national identity and nationhood; cultural expression as a medium for nationalism; historical study of nationalist theories from Taine to the present day. Art history and national essentialism. National myths and the representation of heroes; the representation of the military; national enemies and subject peoples. National symbols and popular culture; the invention of national traditions; historicism and the visual construction of collective identities. Regionalism, folk art and the cult of the land; the representation of place in conceptions of nationhood. Nostalgia, from "Merrie England" to the Wild West. Nations covered include Britain, France, Germany & America. Instructor: McWilliam. 3 units. C-L: Visual and Media Studies 704S, History 705S, Romance Studies 704S

705S. Death and Burial in the Middle Ages: The Impact on Architecture and Sculpture. Course will study attitudes towards the dead body and the fate of the soul in the middle ages, and the impact of changing approaches to burial on architecture and planning in the medieval city. Instructor: Bruzelius. 3 units.

706S. Primitivism, Art, and Culture. Seminar studies issues of primitivism in western culture, considering attitudes towards race and gender. Particular attention to the function of primitivism within modernist discourse—especially as regards such major figures as Gauguin, Matisse, and Picasso; and critical evaluations of the concept of primitivism in the fields of anthropology, literary criticism, cultural geography, and social history. Consent of instructor required. Instructor: Antliff. 3 units.

707S. British Modernism in the Early Twentieth Century. A seminar focusing on the development of modernism in England, from the creation of a British fauvist movement in 1910 to the advent of vorticism during World War I. Topics include Roger Fry and the Omega Workshops, J. D. Fergusson and the British fauvists, the vorticism of Wyndham Lewis, Jacob Epstein and Henri Gaudier-

Brzeska, and the criticism of vorticists T. E. Hulme and Ezra Pound. These movements studied in the light of political ideology, literary theory, and gender studies. Consent of instructor required. Instructor: Antliff. 3 units.

708S. Cubism and Cultural Politics. Seminar studies the cubist movement in pre-World War I Paris, considering art theory and production within the matrix of cultural politics and current critical debates in the field. Focus on significant figures including Georges Braque, Robert and Sonia Delaunay, Marcel Duchamp, Raymond Duchamp-Villon, Albert Gleizes, Juan Gris, Marie Laurenein, Henri Le Fauconnier, Fernand Lèger, Jean Metzinger, Pablo Picasso, and others. Consent of instructor required. Instructor: Antliff. 3 units.

709S. Art & Democracy: Madrid/Barcelona/Bilbao. 3 units. C-L: see Spanish 717S; also C-L: Literature 717S

710S. Modernism and Cultural Politics. Issues of politics and art of the modernist period in Europe, focusing on movements significantly involved with and influenced by political thought and activism—from anarchism and Marxism to nationalism, neocatholicism, royalism, and fascism—and/or subject to recent politicized art historical interpretation. Topics may include the neo-impressionism; symbolism; catalanisme and the early Picasso; fauvism; primitivism, cubism; futurism; purism; the Bauhaus; deStijl; Russian avant-gardism; dada; and surrealism. Consent of instructor required. Instructor: Antliff. 3 units.

711S. Art of the Courts in Thirteenth- and Fourteenth-Century Europe. Examination of the major courts of Europe in France, England, Germany, and Italy to study the development of court culture and the relationships and exchanges between the different courts through marriage alliances, exchanges of presents, and shifts in taste and style. Focus on the courts of Louis IX in France, Henry III and Edward II in England, and the court of Naples from 1266 onwards. Topics include patterns of spirituality, family relationships, and the role of women and books. Instructor: Bruzelius. 3 units.

712S. The Paris Salon: Artists, Critics, and Institutions 1815-1900. Approaches the major exhibition of contemporary French painting and sculpture from multiple perspectives, highlighting involvement of successive political regimes in regulating the artistic economy. Analysis of artists' relationship with-and attempts to modify-the Salon structure, the emergence of alternative exhibiting venues, and the growth of the commercial art market. Particular emphasis on contemporary critical responses to artworks, viewed in the light of wider changes in journalism and the literary market place. Crucial texts and controversies over particular works will be examined in depth. The implications of reception theory for art history will be explored. Instructor: McWilliam. 3 units.

713S. Jerusalem/Istanbul. Constantinople/Istanbul was a great imperial city from its foundation, first Byzantine and Christian and then Ottoman and Islamic. As a center of economic, religious and political power, it has also been the site of formidable struggle. Jerusalem, a city venerated by the world's three dominant monotheistic religions, has been a site of spiritual and military conflict from biblical times to the present. Both cities present models of contentious urban spaces elsewhere. Our seminar investigates the contribution of a city's physical topography and its built fabric to urban violence. Instructor: Wharton. 3 units. C-L: Religion 881S

714. Historical Geographic Information Systems (GIS). 3 units. C-L: see Information Science + Studies 715; also C-L: Computational Media, Arts & Cultures 715

715S. Outsiders and Insiders. An exploration of the phenomenon in Europe and the Americas during the nineteenth and twentieth centuries, when critics began to differentiate between art from learned, civilized communities and art from an uneducated, barbaric population. From the *Beaux-Arts* and *Völkerkunde*, to the debates surrounding primitivism, modernism, and popular culture. An examination of the idea of an art hierarchy and other concepts of artistic outsiders and insiders from a variety of positions, taking into account nationality, class, literacy, economics, race, and gender in the categorization and evaluation of art. Instructor: Powell. 3 units. C-L: African & African American Studies 720S

716S. Fascism East and West: The Visual Culture of Japan, Germany, and Italy. Through a close analysis of cultural production and aesthetics, this course examines the relationship between the politics of fascism and its symbolic practices; how forms of rituals, myths, and images played a crucial role in the formation of the fascist regime's self-identity, and the formation of the national fascist subject. Materials include painting, sculpture, architecture, photography, graphic design, mass media, film, and forms of public spectacle and pageantry. Instructor: Weisenfeld. 3 units.

717S. Art and Markets. New research that negotiates various possibilities in reuniting ideas, theories, and reception codes, different from those we currently identify. Various scenarios generated will focus on unexpected interplays between images and audiences within their local, timely, and particular socioeconomic frame. Instructor: De Marchi and Van Miegroet. 3 units.

718S. History of Conceptual Art. This seminar concerns ekphrasis, the problem of using verbal representation to describe visual representation. Study of the interrelation between artists' theoretical writings and visual productions. Students may work on art and texts in all traditional and experimental visual art media, as well as in photography, video, film, and electronic multimedia. Instructor: Stiles. 3 units.

719S. Fascism, Art, and Ideology. A study of the cultural politics of European fascism, from its origins in the synthesis of nationalism and socialism before World War I, to its final eclipse in 1945. Analysis of art and architecture in Britain, France, Italy, and Germany in terms of contemporary debates over what constituted a fascist aesthetic. Consideration of the art and writing of the symbolists, futurists, vorticists, La Corbusier, German expressionists, and various German and Italian realists in light of theories of fascism. Instructor: Antliff. 3 units.

720S. Art History and Representation. Seminar in the production of art history through various forms of representation, broadly construed, with special attention to issues of aesthetics, social context, historical location, and enunciative position. Consideration of practices of collecting, translation, display, and knowledge formation in order to explore the heterogeneous genealogy of art history. Instructor: Abe. 3 units.

721S. Spatial Practices. Space, once a vacuum in which action took place, is now broadly acknowledged as a formidable matrix that shapes agency. From medieval refectories to Starbucks, from Jerusalem to Las Vegas, from mikvaot to hot spring spas, space produced for human use has in turn managed human performance. How space works--as reassuring or threatening, as ordering or disordering--is the subject of this seminar. By reading selected theoretical texts (e.g. Lefebvre, Habermas, Eliade, Zizek) and mapping specific historical

landscapes, we will become more aware of the ways space has shaped history and informed the objects of our scholarly research. Instructor Wharton. 3 units.

722S. Curatorial Practices in a Global Context. History and critical theories of all experimental art from conceptual, performance, and installation to video and multimedia, collectives, and ecological and bioart considered in a global context including international exhibitions, biennials, and new curatorial practices. Instructor: Stiles. 3 units. C-L: Visual and Media Studies 722S

723S. Grant Writing and Prospectus. Seminar required of all 3rd year graduate students in art history and visual & media studies. Focus on how to develop dissertation research prospectus and related grant proposals. Analysis of parallel forms (prospectus, grant proposal, book proposal, book introduction) to understand these related structures and the important questions they answer for reader. Oral presentation of their own developing prospectus or grant proposal helps students engage these principles in their own scholarship and allows them to develop professional skills. Instructor: Staff. 3 units.

724S. Copies and Duplication. Historical examination of duplication in the visual arts from antiquity to the present and how copies produce meaning. Students consider in depth the concepts and practices of duplication and originality in relation to their own interests and research focus. Subjects might include classical sculpture, modern forgeries, Chinese painting, photographic reproduction, prints and editions, film and the cinema, and seriality in modern art and architecture. Instructor: Abe. 3 units.

725S. Women in Antiquity: An Intensive Methodological Introduction. Gaining methodological introduction to study of women in antiquity; students also practice three crucial skills: how to research, how to discuss research, how to teach using specialized research. Subject of women in antiquity ideal vehicle (or test case) for these skills, as subject is inherently interdisciplinary and unavoidably fraught: unrecognized biases affect ancient evidence and contemporary scholarship. Instructor: Dillon. 3 units. C-L: Classical Studies 725S

726. Museum Theory and Practice. Introduction to museum theory and the operation, with a particular focus on art museums. How theory and practice is negotiated in real world settings. Issues involve collecting practices, exhibition practices, and interpretive techniques, as well as legal and ethical issues. Taught at the Nasher Museum. Instructor: McHugh. 3 units.

727S. Greek Sculpture in Athens, Archaic to Roman. Sculptural remains from Athens are exceedingly rich and extremely important for history of Greek art; most of our knowledge about Greek sculpture is derived from Athenian evidence. Hellenistic sculptors of Athens well known throughout the Mediterranean, working in Delos, Pergamon, Rome. Abundant literary and epigraphic evidence provides wealth of contextual information to reconstruct historical, political, and ideological circumstances of production and display of public statuary in Athens in a way that is not possible for any other ancient city except perhaps imperial Rome. Thorough understanding of Athenian material essential foundation for study of Greek sculpture. Instructor consent required. Instructor: Dillon. 3 units. C-L: Classical Studies 754S

728S. Architectural Theory: Vitruvius to Palladio. Seminar focused on pre-modern architectural theory. Covers a wide temporal span between Vitruvius Pollio's *De architectura libri decem* (1st cent. BCE) and Andrea Palladio's *Quattro libri dell'architettura* (1570). Major treatises will be discussed as well as the relevant modern literature. Objective is to insure solid and broad knowledge of pre-modern architectural theory, related historiography, current debates and scholarship as well as to develop students' independent analytical and research skills. No textbook is adopted. Students will read the English translations of the treatises as well as a set of critical academic articles and books provided by the instructor. Instructor: Galletti. 3 units.

729S. The Museum Object: Art and Artifact on Display. Technical study focusing on the material properties of artifacts and the technologies of art-making. Collection, exhibition, care, storage, handling, preservation, and conservation of objects in context with anthropological theory and legal and ethical considerations. Graduate-level assignments expected, and an appropriate graduate project to be developed over the course of the semester in consultation with the professor. Instructor: Staff. 3 units.

730S. A Cultural and Spatial Analysis of the Ghetto: Venice, Nazi Occupied Europe, Chicago. This seminar explores the cultural and spatial history of the Ghetto. From its origins in Venice through the spread of ghettos in Nazi-occupied Europe to the segregation of African-American populations in Chicago, specific spaces have been designated as ghettos. This designation has had an impact on the social understanding of architectural form, but it has also generated many cultural responses in material culture, art, photography, film, and other media. The course will explore the cultural understanding of the ghetto with a specific emphasis on the Jewish ghettos in Nazi-occupied Europe but with a comparative look at Venice and Chicago. Instructor: Jaskot. 3 units. C-L: German 730S, Jewish Studies 730S, History 730S

731S. The Bauhaus: Architecture, Design, Politics. This seminar analyzes the history of the Bauhaus, from its roots in Weimar Germany to its impact on framing post World War II international Modernism. It covers major scholarship on Modernism, architecture, and design as well as central questions of twentieth-century art and politics. Grounded in the foundation and activity of the school in Germany after World War I, the seminar will also cover the spread of Bauhaus ideas, faculty, and students internationally including in Japan, Turkey, the United States, and on both sides of the Cold War. Instructor: Jaskot. 3 units. C-L: German 731S, Visual and Media Studies 731S

732S. Women in Art: Early Modern Women Artists, Patrons, and Networks. Course focuses on women artists in early modern Italy and Europe. Issues of education and training, practice, patronage, professional networks, and markets will be at the center of attention along with issues of historiography and feminist theory. Objectives are to ensure solid knowledge of the artistic practice of women in early modern Europe within the relevant social, legal, and financial contexts; mastery of the relevant theoretical frameworks, current debates, and scholarship; and development of students' independent analytical and research skills. No textbook is adopted. Students will read and discuss a set of critical books provided by the instructor. Instructor: Galletti. 3 units.

733L. Virtual Museums: Theories and Methods of Twenty-First-Century Museums. The future of museums will be one of immateriality and interaction. Course focuses on how the "Internet of Things," augmented reality technologies, new data analyses of artifacts will transform missions, roles, and goals of museums and collections. Core of course will be digital lab sessions focused on virtual reconstruction of lost heritage—e.g., museums and sites destroyed and damaged by ISIS and other conflicts in Iraq and the

Middle East (Hatra, Nineveh, Nimrud, Baghdad). Graduate students will be assigned additional critical readings and be expected to write a final research paper of 3000 words based on a topic related to their interests worked out with the professor. Instructor: Forte. 3 units. C-L: Visual Arts 733L, Computational Media, Arts & Cultures 733L, Information Science + Studies 733L, Classical Studies 733L

734S. Renaissance Architecture: Theories and Histories. Seminar on the theory and history of Renaissance architecture in Italy and Europe. Focuses on the fifteenth and sixteenth centuries but covers a wider chronological span (1300-1700) in order to frame notions of Renaissance with regard to categories such as Gothic, Baroque, and Classical. Readings include theoretical and/or historical works foundational to the field and subfield—such as Vasari's *Lives* (1568), Burckhardt's *Architecture of the Italian Renaissance* (1878), and Wo¨lfflin's *Renaissance and Baroque* (1888)—as well as modern classics such as Wittkower's *Architectural Principles* (1949), Carpo's *Architecture in the Age of Printing* (2001), and Tafuri's *Princes, Cities, Architects* (1992). Instructor: Galletti. 3 units.

741S. The Symbolist Movement in the Arts and European Thought. Investigates the relationship linking Symbolist aesthetics and practice with currents in European philosophy in the late nineteenth and early twentieth centuries. The reaction against Positivism; aesthetic idealism and the Platonic tradition; the influence of Schopenhauer and Nietzsche on artists and writers; Symbolism and mysticism (Theosophy, Rosicrucianism, the occult); Symbolism and the Catholic revival; Art nouveau and theories of psychology; the anarchist impulse. Emphasis on visual arts in France, England and Germany; focus on the relationship between word and image in Symbolist poetics. Instructor: McWilliam. 3 units. C-L: Literature 741S, Visual and Media Studies 741S

743S. Anthropology of Media and Mediation. 3 units. C-L: see Cultural Anthropology 743S; also C-L: Visual and Media Studies 743S

745S. Women in Visual Arts, 1400-1800: Theory and History. Through lectures, discussion and individual projects, this course considers the roles women played in the Early Modern art world as makers, buyers, patrons, donors, critics, and art collectors. It also takes up issues of gender, masculinity and femininity. A central theme of this class is how the so-called Woman Question, which was essentially an ongoing quarrel about the nature and social role of women, shaped the representations and experiences of women of different classes and conditions. We will focus on visual representations, as well as period writing of and by women. This course will offer students opportunities to understand how the past can help us to think about the present. Instructor: Caviglia. 3 units.

747S. Visual Culture of Black Appalachia: Race, Place and Resilience. 3 units. C-L: see Documentary Studies 747S; also C-L: African & African American Studies 747S

778S. Chinese Buddhist Art. Chinese sculpture, painting, and architecture in relation to Buddhist texts, practice, and ritual from the fourth through the ninth century CE. Introduction to precedents in Indian and Central Asian Buddhist art. Emphasis on the relationship between Buddhist and non-Buddhist imagery. Instructor: Abe. 3 units.

782. Art and Dissidence: Films of Tarkovsky, Kubrick, Kurosawa, and Lynch. 3 units. C-L: see Russian 782

790. Topics in Art History. In-depth consideration of a specific art historical problem of a formal, historical, or conceptual nature. Consent of instructor required. Instructor: Staff. 3 units.

790S. Special Topics in Art History. Topics vary by semester. Subjects, areas, or themes that embrace the arts and humanities areas. Instructor: Staff. 3 units.

790S-1. Topics in Japanese Art. Problems and issues in a specific period or genre of Japanese Art. Specific focus varies from year to year. Consent of instructor required. Instructor: Weisenfeld. 3 units.

791. Individual Research in Art History. Directed research and writing in areas unrepresented by regular course offerings. Consent of instructor required. Instructor: Staff. 3 units.

792. Individual Research in Art History. Directed research and writing in areas unrepresented by regular course offerings. Consent of instructor required. Instructor: Staff. 3 units.

844. Protestants and Pictures. 3 units. C-L: see Religion 844

859. Roman Catholic Visual Piety in the Modern Era. 3 units. C-L: see Religion 859; also C-L: Visual and Media Studies 859

911. Religious Material Culture in Theory and Practice. 3 units. C-L: see Religion 911

Courses in Visual Arts (ARTSVIS)

510S. (Neosentience) Body as Electrochemical Computer. Weekly discussions/lectures related to different disciplinary understandings of the body, exploring new computational and aesthetic paradigms for brain/mind/body/ environment relations, and working towards articulating bridging languages enabling researchers to talk across disciplines. Students required to participate in ongoing discussion, develop particular aspects of research and write a major research paper. Instructor: Seaman. 3 units. C-L: Visual and Media Studies 510S, Information Science + Studies 666S

515S. Representing Architecture: Means and Methods. Projects- and skills-based studio course. Exploration of the historical and contemporary techniques and technologies used to visualize, communicate and document, built/historic, proposed or hypothesized architecture and its construction. Focus on its application for art, architectural history and the humanities, as well as architectural design training. Topics covered include hand sketching, ortho/perspective representation, 2d CAD, 3d modeling and potential explorations of 3d immersion/VR or 3d printing/model-making. Presented in a series of short, topic-based studio exercises culminating in a final project, which may relate to the student's research interests. Instructor consent required. Instructor: Staff. 3 units. C-L: Art History 515S, Historical and Cultural Visualization 515S

554S. Experimental Communities. Interdisciplinary seminar examining visual culture and experimental social structures. Readings across academic spectrum focusing on alternative corporate models and workers' unions, early soviet social networks, neighborhood associations, anarchist communes, art collectives, minority alliances, reality TV, fan clubs and fundamentalist

organizations, encouraging students to fuse theories of social change with practice to produce new social structures. Class productions may include research papers, performances, experimental theater, social actions, new media works, as well as conventional art forms. Work will be judged by its formal sophistication or aesthetic merits, its social or political relevance, and its engagement with methods of ethical inquiry studied throughout the semester. Consent of instructor required. Instructor: Lasch. 3 units. C-L: Visual and Media Studies 554S, Sociology 636S

556S. Poverty and the Visual. Relationship between art, visual culture, and poverty from 1950s to present across cultures. Readings across broad range of texts in humanities and social sciences. Research, visual analyses, and student productions based on a broader understanding of poverty as a philosophical, economic, social, and cultural concept. Three-part definition of poverty includes: special focus on cultural contributions of grassroots social movements and impoverished sectors of global society, poverty as an intentional set of aesthetic or cultural constraints, and poverty as a critical term to understand historical and contemporary limitations of visuality. Instructor consent required. Instructor: Lasch. 3 units. C-L: Visual and Media Studies 570S, Sociology 556S

564S. Physical Computing. Seminar in physical computing, creative coding, and the emerging artistic possibilities of the Internet of Things. Emphasis on the medial physicality of computation, and exploration of interfaces to the computational that depart from the keyboard, mouse, and screen. Discussion of the social implications of "smart" objects. Hands-on development of individual and group projects using Arduino, an extension of C/C++, internet-enabled microprocessors, and an array of analog and digital sensors and actuators. Topics also include networking, communication protocols, circuit design, and physical prototyping. Instructor: Olson. 3 units. C-L: Information Science + Studies 555S, Visual and Media Studies 564S, Computational Media, Arts & Cultures 564S

571S. Art as Work: Valuing Labor in the Arts. 3 units. C-L: see Dance 561S; also C-L: Literature 525S, Visual and Media Studies 571S

575S. Generative Media Authorship - Music, Text & Image. Covers Generative Media in all its forms. Lectures, workshops, discussions, one semester-length project, shorter individual exercises and readings. Interdisciplinary Graduate Seminar with advanced undergraduates and MFA students with permission of instructor. Instructor: Seaman and Supko. 3 units. C-L: Visual and Media Studies 575S, Information Science + Studies 575S, Music 575S, Computational Media, Arts & Cultures 575S

590S. Special Topics in the Visual Arts. Subjects, areas, or themes that embrace a range of disciplines or visual art areas. Instructor: Staff. 3 units.

599. Bookmaking: The Hand Printed Book. Using printmaking and photography as a vehicle for the development of imagery, students will focus on the creation of a hand printed artist book throughout the semester. Information driving the imagery and/or text will be researched and displayed in bound, editioned copies of their book at the end of the semester. Prior bookmaking and printmaking coursework/experience is required, in addition to knowledge of Adobe Photoshop and Illustrator. Instructor consent required. Instructor: Staff. 3 units.

605. Intermediate Drawing. This course allows students to explore their artistic interests and biases through a series of self-directed projects. Both the directness and the flexibility of the medium of drawing are investigated. Instructor: Staff. 3 units.

630. Projections in Time: The Still and Moving Image. Project-based studio course exploring time through film, video, and still photography. Management, presentation and trace of time discussed in relation to various forms of art, augmented by examination of concepts of duration, aura, silence and thought as they pertain to still and moving images. Individual and group projects investigate various manifestations of stillness and movement in film, video, and photography, with and without sound. Slices of time in both media examined for their properties of continuity, discontinuity and fissure, with emphasis on rendering meaning in and through time and space. Prerequisite: Two 200-level or above photography or film production classes. Instructor consent required. Instructor: Staff. 3 units. C-L: Documentary Studies 630, Visual and Media Studies 629

640S. Expanded Cinema: Cinema Outside the Movie Theater. This project-based course will explore moving image installation practices beyond the movie theater including alternative public spaces, devices, museums, white cubes and back boxes. The course will simultaneously examine relevant artworks in the context of their diverse histories and attendant theories, from early cinema devices, through works termed as Expanded Cinema around the 1970s, to current new media manifestations. Students will focus on developing moving image installation projects of their own, to be realized at various campus locations. Open to seniors and graduate students. Prerequisite: Two 200-level or above photography or film production classes. Instructor: Kaul. 3 units. C-L: Visual and Media Studies 640S, Documentary Studies 640S, Literature 545S

641SL. Narrative Practice in Global Art Cinema. Advanced in-depth examination of alternative narrative and doc-fiction practices emerging from national cinemas around the world. Intended for advanced undergraduate and graduate students with prior production experience. Screenings and readings related to significant national cinema movements and practitioners will inform production exercises, writing assignments and a final moving image project. Instructor: Gibson. 3 units. C-L: Visual and Media Studies 641SL

655S. The Photographic Portfolio. Students identify photographic territory to explore and build a body of work. Images are extensively work-shopped for sequencing. Particular emphasis on the making of high quality prints. Semester culminates in the production of finished portfolios in three formats: print, digital, and exhibition or installation. Student's body of work to be informed by relevant precedents from history of photography, with an emphasis on identifying bodies of photographic work that communicate something larger than a single idea. Instructor consent required; this is the same course as Visual Arts 455, with additional graduate level work required. Instructor: Staff. 3 units.

690S. Special Topics in the Visual Arts. Subject varies from year to year. Instructor: Staff. 3 units.

693. Individual Research Independent Study. Advanced research in Visual Arts practice. Consent of instructor required. Instructor: Staff. 3 units.

694. Individual Research Independent Study in the Visual Arts. Advanced research in Visual Arts Practice. Instructor consent

required. Instructor: Staff. 3 units.

706. Digital Imaging. Photoshop and Illustrator used to introduce single and serial images for print and web output. Graduate students required to create an intensive portfolio of work investigating a relevant research topic. Graduate section offered in conjunction with undergraduate course Visual and Media Studies/Visual Arts 206. Instructor consent required. Instructor: Salvatella de Prada. 3 units. C-L: Visual and Media Studies 706, Computational Media, Arts & Cultures 706

710. Sculpture. This course provides the opportunity for a program of self-directed graduate-level work in sculptural principles, processes, and issues introduced through lectures, readings, studio assignments, individual projects, and discussion. Ongoing reflection on contemporary sculpture is core to this class, through discussion and/or critical writing. Regular individual and group critiques monitor the progress of each independent project, and field trips. Instructor: Staff. 3 units.

720. Intermediate Painting. Studio in intermediate oil painting techniques: brushwork, blending, wet-on-wet vs. dry brush, glazes and washes. Work from observation and learn how to see and mix color independently. Develop original conceptual ideas and translate them into a visual language. Seeking to both establish and extend their vernacular, students create paintings with visual narratives as well as abstraction. Course may be repeated for credit. Course assumes prior experience in painting. Development of specific graduate-level work in consultation with the instructor expected. Instructor: McIver. 3 units.

721. Intermediate Sculpture. Graduate studio practice in sculpture at the intermediate level. Explore the possibilities of sculpture as an expressive medium through the creative use of material, shape, mass, movement, edge, texture, space, place, and repetition. Group and individual discussion and critique. Students explore new media and practice safe operation of machines and tools. Students required to create three sculptures that revolve around the theme of their graduate thesis and to write a one-page concept for each work. Students also research two artists who work in like themes to understand how to strategize and execute their work and concept. Prerequisite: Visual Arts 710 or consent of instructor. Instructor: Staff. 3 units.

733L. Virtual Museums: Theories and Methods of Twenty-First-Century Museums. The future of museums will be one of immateriality and interaction. Course focuses on how the "Internet of Things," augmented reality technologies, new data analyses of artifacts will transform missions, roles, and goals of museums and collections. Core of course will be digital lab sessions focused on virtual reconstruction of lost heritage—e.g., museums and sites destroyed and damaged by ISIS and other conflicts in Iraq and the Middle East (Hatra, Nineveh, Nimrud, Baghdad). Graduate students will be assigned additional critical readings and be expected to write a final research paper of 3000 words based on a topic related to their interests worked out with the professor. Instructor: Forte. 3 units. C-L: Art History 733L, Computational Media, Arts & Cultures 733L, Information Science + Studies 733L, Classical Studies 733L

740S. Producing Docu-Fiction. Investigation of hybrid, genre-defying films that question traditional definitions of documentary and fiction. Emphasis on experimental forms, documentary reenactment, mockumentary and dramatized "true stories." Exploration of both documentary and fiction production techniques, culminating in the production of a final video. Graduate-level assignments and advanced project work expected and developed in consultation with the professor. Instructor: Gibson. 3 units. C-L: Visual and Media Studies 740S

767S. Advanced Visual Practice. Students work on independent visual arts projects in a group situation. Students meet weekly with professor teaching course to discuss progress and monthly with full Visual Arts and Visual and Media Studies faculty for critiques. Graduate students will additionally submit a short paper. Instructor consent required. Instructor: Staff. 3 units.

790S. Special Topics in Visual Arts. Subject varies from year to year. Instructor: Staff. 3 units.

794L. Interactive Graphics: Critical Code. 3 units. C-L: see Information Science + Studies 794L; also C-L: Visual and Media Studies 794L

850S. Deleuze: Cinema and Philosophy. 3 units. C-L: see Literature 850S; also C-L: Visual and Media Studies 850S, English 860S, Romance Studies 850S, Computational Media, Arts & Cultures 85, Documentary Studies 850S

Courses in Historical and Cultural Visualization (HCVIS)

504SL. Building Duke: An Architectural History of Duke Campus from 1924 to Today. Research seminar and laboratory on the architectural history of Duke Campus based on original archival materials (photos, blueprints, contracts, letters, and financial records) preserved in Duke Library collections. Explores the variety of interpretative lenses in the field of architecture history, including, but not limited to, issues of style, patronage, labor, class, gender, and race. Analyzes notions of cultural identity as construed by Duke founders and administrators, and as imprinted on Duke Campus by its architects and landscape designers. Original research projects based on primary materials and digital visualizations of changes in the physical fabric of Duke Campus through time. Instructor: Galletti. 3 units. C-L: Art History 504SL

515S. Representing Architecture: Means and Methods. Projects- and skills-based studio course. Exploration of the historical and contemporary techniques and technologies used to visualize, communicate and document, built/historic, proposed or hypothesized architecture and its construction. Focus on its application for art, architectural history and the humanities, as well as architectural design training. Topics covered include hand sketching, ortho/perspective representation, 2d CAD, 3d modeling and potential explorations of 3d immersion/VR or 3d printing/model-making. Presented in a series of short, topic-based studio exercises culminating in a final project, which may relate to the student's research interests. Instructor consent required. Instructor: Staff. 3 units. C-L: Visual Arts 515S, Art History 515S

580S. Historical and Cultural Visualization Proseminar 1. Interactivity and online content management through databases, collaborative blogs, and other systems. Data visualization based on textual, image, and quantitative sources. Basic techniques for virtual reality, simulations, augmented reality, and game-based historical and cultural visualization project development. Mini-projects based on existing and new research data from the Smith Media Labs and other sources. Best practices for digital research project planning and collaboration. Theoretical topics include: critical digital heritage, virtuality and culture, information aesthetics, hypermedia information

design. Instructor consent required. Instructor: Olson or Szabo. 3 units. C-L: Visual and Media Studies 580S, Information Science + Studies 580S, Art History 580S, Computational Media, Arts & Cultures 580S

581S. Historical and Cultural Visualization Proseminar 2. 2D and 3D imaging, modeling; raster and vector graphics sources, laser scanners, photogrammetric software, basic database structures. Digital mapping and GIS. Presentation strategies and best practices for the web (standards-compliant HTML/CSS/Javascript), multimedia (audio/video/animation), scholarly annotation, intellectual property. Theoretical, ethical issues in field of new media and digital humanities. Epistemological issues re: mediation and visualization, ethics of intellectual property, politics of geospatial visualization, digital materiality, affordances of new media narrativity. Instructor consent required. Instructor: Olson or Szabo. 3 units. C-L: Visual and Media Studies 581S, Information Science + Studies 581S, Art History 581S, Computational Media, Arts & Cultures 581S

613S. Computational Media Studio in Advanced Digital Practice. Advanced digital practicum in interactive computational media as vehicle for creative and critical expression. Opportunity to synthesize previous course work in multimedia practice, web/graphic/motion design, 3D modeling/gaming, computer programming. In-depth exploration of computational media production as artistic practice through exercises, projects, and critiques. Acquisition and refinement of expertise in procedural and object-oriented programming, two- and three-dimensional graphics, data visualization, physical computing, AR/VR, and other emergent computational platforms. Sustained engagement with computational ethics. Instructor: Olson, Szabo, Wendell. 3 units. C-L: Visual and Media Studies 613S, Information Science + Studies 613S, Computational Media, Arts & Cultures 613S

791. Individual Thesis Research In Historical and Cultural Visualization. Directed research and writing in Historical and Cultural Visualization. Consent of instructor required. Instructor: Staff. 3 units.

792. Individual Thesis Research In Historical and Cultural Visualization II. Directed research and writing in Historical and Cultural Visualization. Consent of department required. Instructor: Staff. 3 units.

796L. Media, Arts & Cultures Research Practicum I. 3 units. C-L: see Computational Media, Arts & Cultures 796L; also C-L: Visual and Media Studies 796L, Information Science + Studies 796L

797L. Media, Arts & Cultures Research Practicum II. 3 units. C-L: see Computational Media, Arts & Cultures 797L; also C-L: Visual and Media Studies 797L, Information Science + Studies 797L

798L. Media, Arts & Cultures Research Practicum III. 3 units. C-L: see Computational Media, Arts & Cultures 798L; also C-L: Visual and Media Studies 798L, Information Science + Studies 798L

799L. Media, Arts & Cultures Research Practicum IV. 3 units. C-L: see Computational Media, Arts & Cultures 799L; also C-L: Visual and Media Studies 799L, Information Science + Studies 799L

Courses in Visual and Media Studies (VMS)

505S. Visual Studies from the Global South. This seminar shifts the geography of critical theory, introducing interdisciplinary approaches to visual culture and art formulated outside the northern academies of Europe and the United States. Diverse readings introduce how the visual is constituted in sites that have endured colonialism and globalization. Specific topics include: word and image; space, place, and site; media and new technologies; indigenous and Afro-diasporic philosophies; and the raced and gendered body. Instructor: Gabara. 3 units. C-L: Art History 505S, Romance Studies 505S

506A. History of Netherlandish Art and Visual Culture in a European Context. A contextual study of visual culture in the Greater Netherlands and its underlying historical and socioeconomic assumptions from the late medieval to early modern period, through immediate contact with urban cultures, such as Amsterdam, Leiden, Utrecht, Brussels, Ghent, Bruges, and Antwerp. Includes daily visits to major museums, buildings, and sites; hands-on research in various collections; discussion sessions with leading scholars in the field; and a critical introduction to various research strategies. (Taught in the Netherlands.) Not open to students who have taken Art History 262A-263A. Course credit contingent upon completion of Art History 507A. Instructor: Van Miegroet. 3 units. C-L: Art History 506A, Medieval and Renaissance Studies 504A

507A. History of Netherlandish Art and Visual Culture in a European Context. Second half of Art History 506A-507A; required for credit for 506A. (Taught in the Netherlands.) Not open to students who have taken Art History 262A-263A. Instructor: Van Miegroet. 3 units. C-L: Art History 507A, Medieval and Renaissance Studies 505A

510S. (Neosentience) Body as Electrochemical Computer. Weekly discussions/lectures related to different disciplinary understandings of the body, exploring new computational and aesthetic paradigms for brain/mind/body/ environment relations, and working towards articulating bridging languages enabling researchers to talk across disciplines. Students required to participate in ongoing discussion, develop particular aspects of research and write a major research paper. Instructor: Seaman. 3 units. C-L: Information Science + Studies 666S, Visual Arts 510S

512S. Performing Gender/Exhibiting Race. Studying intersections of race/gender in art since 1945 with host of visual subjects and methodological strategies. Examines works by e.g. Barkley L. Hendricks, David Hammons, Adrian Piper, Jean-Michel Basquiat, Faith Ringgold, Kara Walker. Traces theorizing gender/race through historical documents and contemporary writings. Focus on images in documentary and fine art photography; silent and sound film; broadcast television and video art past/present. Assorted critical writings on mass media imagery. Opportunities for introduction of artists, art works, issues external to syllabus. Instructor: Powell. 3 units. C-L: Literature 512S

515S. Interethnic Intimacies: Production and Consumption. 3 units. C-L: see Asian & Middle Eastern Studies 515S; also C-L: Literature 515S, International Comparative Studies 515S, Gender, Sexuality, and Feminist Studies 505S

520. Eco-Media: Studies in Planetary Futures. 3 units. C-L: see Cultural Anthropology 520; also C-L: Literature 522

520S. Eco-Media: Studies in Planetary Futures. 3 units. C-L: see Cultural Anthropology 520S; also C-L: Literature 522S

522S. Curatorial Practices in a Global Context. History and critical theories of all experimental art from conceptual, performance, and installation to video and multimedia, collectives, and ecological and bioart considered in a global context including international exhibitions, biennials, and new curatorial practices. Instructor: Stiles. 3 units. C-L: Art History 522S

523S. Imaging a Nation: Japanese Visual Culture 1868-1945. Focusing on various visual representations of Japanese national identity at home and abroad during the empire; contending interpretations of "Japaneseness" and changing discourses on Japanese aesthetics in relation to broader historical developments; examining cultural production, exhibition practices, patronage, nationalism, neo-traditionalism, Pan-Asianism, and the role of visual culture under imperialism. Instructor: Weisenfeld. 3 units. C-L: Asian & Middle Eastern Studies 566S

524S. AfroFuturism. 3 units. C-L: see African & African American Studies 620S; also C-L: Dance 535S, Theater Studies 535S

525S. Art and the Holocaust: Architecture, Art, and Cultural Politics during the Nazi Period. This course will analyze the history of the genocide of the European Jews, and its connection to antisemitic art and cultural policy during the Nazi period. With a sound understanding of the development of oppressive policies against the Jews, and looking at a variety of media (painting, architecture, film, photography, design), the course will explore the complicated relationship between developing racist policies and the world war as they impacted and were in turn influenced by artists. Examines not only artists involved in the Nazi state, but also those who resisted in exile or were its victims. Instructor: Jaskot. 3 units. C-L: Art History 555S, German 565S, Jewish Studies 555S, History 531S

533S. Live Images: Ancient and Medieval Representations of the Divine. The study of ancient and medieval works—speaking statues, miraculous icons, moving paintings. Seminar addresses questions of artistic and pictorial agency. Readings include theoretical texts, primary sources, and historical studies. Instructor: Wharton and Dillon. 3 units. C-L: Religion 552S, Classical Studies 558S, Medieval and Renaissance Studies 507S

535S. Camera Asia. Examines how the art and technology of photography have changed how we study and understand the historical past, with a focus on China, India, and Japan. Analyzes arrival of the camera as a historical event, along with photographers and studios. Evaluates ways in which the new technology was embraced, and considers how the camera reconfigured attitudes towards the body and gender relations, nation building, war, catastrophes and death. Instructor: Weisenfeld and Ramaswamy. 3 units. C-L: History 530S, International Comparative Studies 531S, Art History 535S

539S. Queer China. 3 units. C-L: see Asian & Middle Eastern Studies 539S; also C-L: Cultural Anthropology 539S, Gender, Sexuality, and Feminist Studies 502S, Literature 539S, Human Rights Program-Franklin Humanities Institute 539S

540S. Memory and Documentary Cinema in Latin America. 3 units. C-L: see Romance Studies 540S; also C-L: Documentary Studies 540S, Literature 544S, Latin American Studies 540S

541. Anime: Origins, Forms, Mutations. 3 units. C-L: see Asian & Middle Eastern Studies 561

542. Creative Industries and the Urban Environment. This Bass Connections course examines the relationship between urban development and cultural production in specific contemporary and historical contexts, past and present. Cultural industries generally include printing, publishing and multimedia art, audiovisual, phonographic and cinematographic productions, as well as art creation, marketing and design and local art markets in the urban environment. The aim is to analyze the impact of creative industries on the economic development of a city and what one can learn from historical and present-day examples through the analysis of data. Analytical methods, theories and practices will be interwoven throughout the course. Instructor consent required. Instructor: Van Miegroet. 3 units. C-L: Art History 552, Information Science + Studies 552

545. Black Camera: Still and Moving Images. This course interrogates still and moving images by and about people of African descent. Students enrolled in this course will consider film, photography, and media art. Together, we will examine documentary film, daguerreotype and archival photography, black cinema, and the cultural politics that render production, reception and circulation particular for black subjects. Instructor: Cobb. 3 units. C-L: African & African American Studies 539, Art History 539

548S. Japanese Design in a Global World. Japanese design encompasses everything from sushi to Hello Kitty—from Shiseido to Nintendo. This course examines the diverse and vibrant spheres of contemporary Japanese design culture across the globe. It is both an introduction to design practices and a forum for the critical evaluation of theoretical issues related to the larger field of design. Exploring the diverse fields of fashion, graphic design & packaging, industrial design, corporate branding, culinary culture, robotics, electronics, gaming, animation, and toys, the class will be introduced to the global impact of Japanese design on daily life around the world and the dynamic transnational culture in which it participates. Instructor: Weisenfeld. 3 units. C-L: Art History 548S

549S. Techno-Orientalism: Asian/America, (Post)Human and SF. 3 units. C-L: see Asian & Middle Eastern Studies 549S

550S. Debates in the Digital Humanities: Multi-Disciplinary Theory and Practice. 3 units. C-L: see Information Science + Studies 560S

551SL. Advanced Digital Art History: New Representational Technologies. Research and study in material culture and the visual arts expressed by using new visual technologies to record and communicate complex sets of visual and physical data from urban and/or archaeological sites. Introduces techniques for the presentation and interpretation of visual material through a series of interpretative and reconstructive technologies, including the development of web pages (HTML/Dreamweaver), Photoshop, Illustrator, Google Sketch-up, Google Maps, and Flash. To develop techniques of interpretation and representation. Consent of instructor required. Instructor: Dillon, Olson, or Szabo. 3 units. C-L: Art History 551SL, Information Science + Studies 551SL

552. Citizen Godard. 3 units. C-L: see French 510; also C-L: Literature 510

553S. From Caricature to Comic Strip. History of caricature as a medium for political critique and social comment from the eighteenth century to the present, focusing on England, France, Germany, and the United States. Languages of graphic satire in the context of specific historical moments, from the War of Independence to the war in Iraq; history of popular journalism and the comic press; censorship and agitation for press freedom; growth of specialized juvenile graphic magazines and the development of the strip

cartoon. Instructor: McWilliam. 3 units.

554S. Experimental Communities. Interdisciplinary seminar examining visual culture and experimental social structures. Readings across academic spectrum focusing on alternative corporate models and workers' unions, early soviet social networks, neighborhood associations, anarchist communes, art collectives, minority alliances, reality TV, fan clubs and fundamentalist organizations, encouraging students to fuse theories of social change with practice to produce new social structures. Class productions may include research papers, performances, experimental theater, social actions, new media works, as well as conventional art forms. Work will be judged by its formal sophistication or aesthetic merits, its social or political relevance, and its engagement with methods of ethical inquiry studied throughout the semester. Consent of instructor required. Instructor: Lasch. 3 units. C-L: Sociology 636S, Visual Arts 554S

555S. Black Visual Theory. Approaches to studying and theorizing of African diasporal arts and black subjectivity, with a special emphasis on art historiography, iconology, and criticism, and a particular focus on slavery, emancipation, freedom, and cultural nationalism, as pertaining to peoples of African descent and as manifested in such visual forms as paintings, sculptures, graphics, and media arts from the early modern period to the present, as well as the political edicts, philosophical tracts, autobiographies, and theoretical writings of individuals similarly preoccupied with these ideas. Consent of instructor required. Instructor: Powell. 3 units. C-L: African & African American Studies 589S

556S. Latin American Modernism and Visual Culture. Early twentieth-century modernist movements in Spanish America, Brazil, and the Caribbean. Topics include: race, primitivism, and indigenism; gender; theory of the avant-garde; peripheral modernity; and nationalism, regionalism, and cosmopolitanism. Instructor: Gabara. 3 units.

557S. Trauma in Art, Literature, Film, and Visual Culture. Theories of trauma applied to visual representations of violence, destruction, and pain in contemporary art, film, and literature, examining the topic through multiple subjects from the Holocaust, cults, gangs, racism, and sexual abuse to cultures of trauma. Theories of trauma examined from a variety of sources including clinical psychology, cultural and trauma studies, art, film, and literature, aiming to enable students to gain the visual acuity to identify, understand, and respond to traumatic images with empathy. Not open to students who have previously taken this course as Art History 295S. Instructor: Stiles. 3 units. C-L: Art History 557S

559S. Urbanism. Introduction to urbanism through considerations of the political, social and economic forces that model urban space. Assessment of the expression in urban topography of state power, disempowered communities, competing ethnicities, religious groups. Readings include canonical works of urban history (Vitruvius, Jacobs), theory (Benjamin, Lefebvre), novels and media (Visconti, Zola).] Instructor: Wharton. 3 units.

560S. Poverty of the Visual. Interdisciplinary seminar on the relationship between visuality and poverty from 1945 to the present. Theorizes visual culture through an examination of the forms of knowledge produced by impoverished populations. Uses philosophical and perceptual methods to explore the limits and limitations of visuality as it applies to science, ethics, the humanities, and the arts. Readings in the humanities and social sciences focus on issues related to lack, scarcity, absence, minimalism, and invisibility. Students encouraged to fuse theory and practice in research presentations and visual productions. Consent of instructor required. Instructor: Lasch. 3 units.

561S. Computational Media, Arts & Cultures Proseminar. 3 units. C-L: see Computational Media, Arts & Cultures 650S; also C-L: Information Science + Studies 650S, Literature 621S, Art History 537S

562S. Technology and New Media: Academic Practice. 3 units. C-L: see Information Science + Studies 540S; also C-L: Art History 536S

563. Media and Democracy. 3 units. C-L: see Public Policy 674

564S. Physical Computing. Seminar in physical computing, creative coding, and the emerging artistic possibilities of the Internet of Things. Emphasis on the medial physicality of computation, and exploration of interfaces to the computational that depart from the keyboard, mouse, and screen. Discussion of the social implications of "smart" objects. Hands-on development of individual and group projects using Arduino, an extension of C/C++, internet-enabled microprocessors, and an array of analog and digital sensors and actuators. Topics also include networking, communication protocols, circuit design, and physical prototyping. Instructor: Olson. 3 units. C-L: Information Science + Studies 555S, Visual Arts 564S, Computational Media, Arts & Cultures 564S

565S. New Media, Memory, and the Visual Archive. Explores impact of new media on the nature of archives as technologies of cultural memory and knowledge production. Sustained engagement with major theorists of the archive through the optics of "media specificity" and the analytical resources of visual studies. Themes include: storage capacity of media; database as cultural form; body as archive; new media and the documentation of "everyday life;" memory, counter-memory, and the politics of the archive; archival materiality and digital ephemerality. Primary focus on visual artifacts (image, moving image) with consideration of the role of other sensory modalities in the construction of individual, institutional and collective memory. Instructor: Olson. 3 units. C-L: Information Science + Studies 565S

566S. How They Got Game: History and Culture of Interactive Simulations and Video Games. 3 units. C-L: see Information Science + Studies 510S

567S. Art and Markets. Cross-disciplinary art history-visual culture-economics seminar. Analytical and applied historical exploration of cultural production and local art markets, and their emergence throughout Europe, Asia, and the Americas. Criteria for valuation of imagery or what makes art as a commodity desirable or fashionable. Visual taste formation, consumer behavior, and the role of art dealers as cross-cultural negotiants. Consent of instructor required. Instructor: Van Miegroet. 3 units. C-L: Art History 508S, Economics 321S

570S. Poverty and the Visual. Relationship between art, visual culture, and poverty from 1950s to present across cultures. Readings across broad range of texts in humanities and social sciences. Research, visual analyses, and student productions based on a broader

understanding of poverty as a philosophical, economic, social, and cultural concept. Three-part definition of poverty includes: special focus on cultural contributions of grassroots social movements and impoverished sectors of global society, poverty as an intentional set of aesthetic or cultural constraints, and poverty as a critical term to understand historical and contemporary limitations of visuality. Instructor consent required. Instructor: Lasch. 3 units. C-L: Visual Arts 556S, Sociology 556S

570SL. Roman Topography: Urban Life and Cityscapes in Ancient Rome. 3 units. C-L: see Classical Studies 556SL; also C-L: Art History 560SL

571S. Art as Work: Valuing Labor in the Arts. 3 units. C-L: see Dance 561S; also C-L: Literature 525S, Visual Arts 571S

575S. Generative Media Authorship - Music, Text & Image. Covers Generative Media in all its forms. Lectures, workshops, discussions, one semester-length project, shorter individual exercises and readings. Interdisciplinary Graduate Seminar with advanced undergraduates and MFA students with permission of instructor. Instructor: Seaman and Supko. 3 units. C-L: Information Science + Studies 575S, Music 575S, Visual Arts 575S, Computational Media, Arts & Cultures 575S

580S. Historical and Cultural Visualization Proseminar 1. Interactivity and online content management through databases, collaborative blogs, and other systems. Data visualization based on textual, image, and quantitative sources. Basic techniques for virtual reality, simulations, augmented reality, and game-based historical and cultural visualization project development. Mini-projects based on existing and new research data from the Smith Media Labs and other sources. Best practices for digital research project planning and collaboration. Theoretical topics include: critical digital heritage, virtuality and culture, information aesthetics, hypermedia information design. Instructor consent required. Instructor: Olson or Szabo. 3 units. C-L: Historical and Cultural Visualization 580S, Information Science + Studies 580S, Art History 580S, Computational Media, Arts & Cultures 580S

581S. Historical and Cultural Visualization Proseminar 2. 2D and 3D imaging, modeling; raster and vector graphics sources, laser scanners, photogrammetric software, basic database structures. Digital mapping and GIS. Presentation strategies and best practices for the web (standards-compliant HTML/CSS/Javascript), multimedia (audio/video/animation), scholarly annotation, intellectual property. Theoretical, ethical issues in field of new media and digital humanities. Epistemological issues re: mediation and visualization, ethics of intellectual property, politics of geospatial visualization, digital materiality, affordances of new media narrativity. Instructor consent required. Instructor: Olson or Szabo. 3 units. C-L: Historical and Cultural Visualization 581S, Information Science + Studies 581S, Art History 581S, Computational Media, Arts & Cultures 581S

590. Special Topics in Visual and Media Studies. Subjects, areas, or themes that embrace a range of disciplines related to visual and media studies. Instructor: Staff. 3 units.

590S. Special Topics in Visual Studies. Subjects, areas, or themes that embrace a range of disciplines related to visual studies. Instructor: Staff. 3 units.

610S. Basic Concepts in Cinema Studies. 3 units. C-L: see Literature 610S

611S. Third Cinema. 3 units. C-L: see Literature 613S; also C-L: African & African American Studies 530S, International Comparative Studies 613S, Latin American Studies 613S

612S. Theories of the Image: The Image in Walter Benjamin. 3 units. C-L: see Literature 612S; also C-L: German 512S, Romance Studies 612S

613S. Computational Media Studio in Advanced Digital Practice. Advanced digital practicum in interactive computational media as vehicle for creative and critical expression. Opportunity to synthesize previous course work in multimedia practice, web/graphic/motion design, 3D modeling/gaming, computer programming. In-depth exploration of computational media production as artistic practice through exercises, projects, and critiques. Acquisition and refinement of expertise in procedural and object-oriented programming, two- and three-dimensional graphics, data visualization, physical computing, AR/VR, and other emergent computational platforms. Sustained engagement with computational ethics. Instructor: Olson, Szabo, Wendell. 3 units. C-L: Historical and Cultural Visualization 613S, Information Science + Studies 613S, Computational Media, Arts & Cultures 613S

614S. Thinking Digital Cinema. 3 units. C-L: see Literature 614S; also C-L: Theater Studies 671S

615S. The #Selfie. 3 units. C-L: see Literature 615S; also C-L: Gender, Sexuality, and Feminist Studies 615S, International Comparative Studies 615S

620S. Models: Premodern to Posthuman. Architectural models may be either powerful small-scale prototypes for buildings or weak copies of powerful archetypes. Consideration of variety of architectural models from urban projects to dollhouses allows historical and theoretical exploration of models' agency. Instructor consent required. Instructor: Wharton. 3 units. C-L: Art History 620S

621S. Black Performance Theory. 3 units. C-L: see African & African American Studies 621S; also C-L: Dance 645S

622S. Film-philosophers/Film-makers. 3 units. C-L: see Literature 620S; also C-L: Theater Studies 620S, English 620S, Documentary Studies 620S

625S. Comparative Media Studies. 3 units. C-L: see Literature 625S; also C-L: Information Science + Studies 615S, Asian & Middle Eastern Studies 627S

629. Projections in Time: The Still and Moving Image. Project-based studio course exploring time through film, video, and still photography. Management, presentation and trace of time discussed in relation to various forms of art, augmented by examination of concepts of duration, aura, silence and thought as they pertain to still and moving images. Individual and group projects investigate various manifestations of stillness and movement in film, video, and photography, with and without sound. Slices of time in both media examined for their properties of continuity, discontinuity and fissure, with emphasis on rendering meaning in and through time and space. Prerequisite: Two 200-level or above photography or film production classes. Instructor consent required. Instructor: Staff. 3 units. C-L: Visual Arts 630, Documentary Studies 630

630S. Phenomenology and Media. 3 units. C-L: see Literature 630S; also C-L: Art History 630S, Information Science + Studies 630S

631S. Seminar on Modern Chinese Cinema. 3 units. C-L: see Asian & Middle Eastern Studies 631S; also C-L: Literature 631S

632. Questions of National Cinemas. 3 units. C-L: see Asian & Middle Eastern Studies 631; also C-L: Literature 632

632S. Whitehead, Bergson, James. 3 units. C-L: see Literature 632S; also C-L: Information Science + Studies 632S, Art History 632S

634S. Producing Docu-Fiction. Investigation of hybrid, genre-defying films that question traditional definitions of documentary and fiction. Emphasis on experimental forms, documentary reenactment, mockumentary and dramatized "true stories." Exploration of both documentary and fiction production techniques, culminating in the production of a final video project. Same as Visual and Media Studies 340S but with additional graduate level work. Instructor: Gibson. 3 units.

635S. 16mm Film Production. Hands-on experience with 16mm motion picture film and photography. In-depth exploration of the techniques and aesthetics of film production, including basic screen writing, lighting, story telling, and editing. Each student will produce an individual 16mm film. Same as Visual and Media Studies 362S but with additional graduate level work. Instructor: Staff. 3 units.

640S. Expanded Cinema: Cinema Outside the Movie Theater. This project-based course will explore moving image installation practices beyond the movie theater including alternative public spaces, devices, museums, white cubes and back boxes. The course will simultaneously examine relevant artworks in the context of their diverse histories and attendant theories, from early cinema devices, through works termed as Expanded Cinema around the 1970s, to current new media manifestations. Students will focus on developing moving image installation projects of their own, to be realized at various campus locations. Open to seniors and graduate students. Prerequisite: Two 200-level or above photography or film production classes. Instructor: Kaul. 3 units. C-L: Visual Arts 640S, Documentary Studies 640S, Literature 545S

641SL. Narrative Practice in Global Art Cinema. Advanced in-depth examination of alternative narrative and doc-fiction practices emerging from national cinemas around the world. Intended for advanced undergraduate and graduate students with prior production experience. Screenings and readings related to significant national cinema movements and practitioners will inform production exercises, writing assignments and a final moving image project. Instructor: Gibson. 3 units. C-L: Visual Arts 641SL

650S. Black Camera: Still and Moving Images. This course interrogates still and moving images by and about people of African descent. Graduate students enrolled in this course will consider film, photography, and media art. Together, we will examine documentary film, daguerreotype and archival photography, black cinema, and the cultural politics that render production, reception and circulation particular for black subjects. Instructor: Cobb. 3 units. C-L: African & African American Studies 531S, Art History 650S

660S. Digital Places and Spaces: Mirror, Hybrid, and Virtual Worlds. 3 units. C-L: see Information Science + Studies 660S

662S. Mapping Culture: Geographies of Space, Mind, and Power. 3 units. C-L: see Information Science + Studies 662S

685S. Visiting Filmmaker Master Course: Special Topics. Intensive production courses with visiting filmmaker. Topics vary by semester. May be taken twice. Instructor: Staff. 3 units.

690S. Special Topics in Visual and Media Studies. Subjects, areas, or themes that embrace a range of disciplines related to visual and media studies. Instructor: Staff. 3 units.

691. Independent Study. Directed reading in a field of special interest, under the supervision of a faculty member, resulting in a substantive paper or report. Consent of instructor and director of graduate studies required. Instructor: Staff. 3 units.

692. Independent Study. Directed reading in a field of special interest, under the supervision of a faculty member, resulting in a substantive paper or report. Consent of instructor and director of graduate studies required. Instructor: Staff. 3 units.

701. Book Art: Form and Function. Studio course examining all aspects of bookmaking, including theories of bookmaking, designing and planning, typography, computer design, illustration, and binding. Prerequisites: Consent of instructor. Instructor: Shatzman. 3 units. C-L: Visual Arts 701

704S. Nationalism and Visual Culture Since 1789. Theories of nationalism, national identity and nationhood; cultural expression as a medium for nationalism; historical study of nationalist theories from Taine to the present day. Art history and national essentialism. National myths and the representation of heroes; the representation of the military; national enemies and subject peoples. National symbols and popular culture; the invention of national traditions; historicism and the visual construction of collective identities. Regionalism, folk art and the cult of the land; the representation of place in conceptions of nationhood. Nostalgia, from "Merrie England" to the Wild West. Nations covered include Britain, France, Germany & America. Instructor: McWilliam. 3 units. C-L: Art History 704S, History 705S, Romance Studies 704S

706. Digital Imaging. Photoshop and Illustrator used to introduce single and serial images for print and web output. Graduate students required to create an intensive portfolio of work investigating a relevant research topic. Graduate section offered in conjunction with undergraduate course Visual and Media Studies/Visual Arts 206. Instructor consent required. Instructor: Salvatella de Prada. 3 units. C-L: Visual Arts 706, Computational Media, Arts & Cultures 706

709. Chinese Im/migration: Chinese Migrant Labor and Immigration to the US. 3 units. C-L: see Asian & Middle Eastern Studies 709

710S. Performance Art and Performativity: Theories and Methods. Examines critical discourses and theories in performance studies, including performativity, performance collectives, participation, and activism; corporeality and presence; identity and enactment of trauma; technological supplements to performance (from photography, film, and slide projection to television/video, virtual reality and digital and social media); biomedicine in the performance and alteration of gender and sexual roles; performance

in the post- or trans-human cyborg age of body enhancement and redesign, uploaded forms of consciousness, implant and wearable computers; and an array of other mental and physical technologies that increasingly render the body ambiguously human. Instructor: Stiles. 3 units.

719S. Russian Language and Culture through Film II. 3 units. C-L: see Russian 774S

720S. Art, Media, Technology/Histories, Theories, and Practices. Through trans-disciplinary theories, considers technological experiments and multi-disciplinary artistic exploration in post-WWII kinetics, cybernetics, computers, intermedia, expanded cinema, virtual reality, and new media with advent of technoculture, cyberspace, nano- and endo-culture, telematics, telepresence, bioart, artificial life, artificial intelligence, and emergent systems; and how media artists address the ways in which the global military, industrial, communications, computer, and information complex include mind control, surveillance, and infowar, and effect social interactions, and the environment and animals in the creation of the integrated spectacle. Instructor: Stiles. 3 units.

721S. Motion Graphics for Film and Video. An exploration of techniques and theoretical approaches to motion graphics, animation and post-production effects in film and video. Readings and screenings will lead to student-produced exercises through exposure to applications in the Adobe Creative Cloud and digital editing software. Graduate students enrolled in this course, will be asked to complete additional research either in the form of an paper or additional production assignment. Instructor: Staff. 3 units.

722S. Curatorial Practices in a Global Context. History and critical theories of all experimental art from conceptual, performance, and installation to video and multimedia, collectives, and ecological and bioart considered in a global context including international exhibitions, biennials, and new curatorial practices. Instructor: Stiles. 3 units. C-L: Art History 722S

729S. Experimental Filmmaking. Graduate level course covering the history of avant-garde in film and video combined with production exercises. This is a graduate level version of Experimental Filmmaking. The graduate students will be required to complete more advanced assignments and additional projects related to experimental filmmaking. Instructor: Staff. 3 units.

731S. The Bauhaus: Architecture, Design, Politics. This seminar analyzes the history of the Bauhaus, from its roots in Weimar Germany to its impact on framing post World War II international Modernism. It covers major scholarship on Modernism, architecture, and design as well as central questions of twentieth-century art and politics. Grounded in the foundation and activity of the school in Germany after World War I, the seminar will also cover the spread of Bauhaus ideas, faculty, and students internationally including in Japan, Turkey, the United States, and on both sides of the Cold War. Instructor: Jaskot. 3 units. C-L: Art History 731S, German 731S

735. The History of Hip-Hop. 3 units. C-L: see African & African American Studies 735; also C-L: English 735, Music 735

739S. Sound For Film and Video. Theory and practice of sound recording techniques and strategies for film and video. Focus on sound/image relationship, sound design and sound acquisition. Screenings and readings will reinforce practice exercises. Graduate level assignments and project. Instructor: Staff. 3 units.

740S. Producing Docu-Fiction. Investigation of hybrid, genre-defying films that question traditional definitions of documentary and fiction. Emphasis on experimental forms, documentary reenactment, mockumentary and dramatized "true stories." Exploration of both documentary and fiction production techniques, culminating in the production of a final video. Graduate-level assignments and advanced project work expected and developed in consultation with the professor. Instructor: Gibson. 3 units. C-L: Visual Arts 740S

741S. The Symbolist Movement in the Arts and European Thought. Investigates the relationship linking Symbolist aesthetics and practice with currents in European philosophy in the late nineteenth and early twentieth centuries. The reaction against Positivism; aesthetic idealism and the Platonic tradition; the influence of Schopenhauer and Nietzsche on artists and writers; Symbolism and mysticism (Theosophy, Rosicrucianism, the occult); Symbolism and the Catholic revival; Art nouveau and theories of psychology; the anarchist impulse. Emphasis on visual arts in France, England and Germany; focus on the relationship between word and image in Symbolist poetics. Instructor: McWilliam. 3 units. C-L: Art History 741S, Literature 741S

743S. Anthropology of Media and Mediation. 3 units. C-L: see Cultural Anthropology 743S; also C-L: Art History 743S

751S. Narrative Projects. Development and production of short narrative film projects. Project-based course taking short film concepts through script development, pre-production, production, and post-production. Prior video production experience recommended. Graduate students will be required to develop an additional production project or submit a supplementary research component for credit in the class. Instructor: Haverkamp. 3 units.

757S. Editing for Film and Video. Theory and practice of film and video editing techniques. Exploration of traditional film cutting as well as digital non-linear editing. Exercises in narrative, documentary and experimental approaches to structuring moving image materials. Graduate-level course paired with AMI 357S. Graduate students will be required to complete more advanced assignments and additional projects related to editing film and video. Instructor: Staff. 3 units. C-L: Documentary Studies 757S, Information Science + Studies 757S

760S. Cinematography. In-depth investigation of cinematographic techniques and principles for motion picture production. Exercises in both film and high definition digital video. Emphasis on advanced lighting techniques, lensing, camera mobility, set operations and close analysis of master works of cinematography. Graduate students will have a supplemental reading list as determined by the instructor and will be responsible for an additional practice assignment and or/ writing assignment linking course content to graduate thesis work. Instructor: Staff. 3 units.

772. The Middle East through Film. Film as access into the region through a series of direct and poetic connections woven across films viewed, filmmakers featured, and lectures, discussions, and texts read. Using integration of course components and students' weekly responses, an understanding of the region is developed by way of inquiry into and rigorous engagement with cultural production. From feature length films to shorts, the breadth of the work we will engage with includes documentaries, dramas, and less traditional forms. Midterm paper, final project required in the form of one of three potential possibilities subject to approval of proposal: a paper, a talk, or a short film. Graduate-level assignments and projects. Instructor: Staff. 3 units.

773S. Russian Language and Culture through Film. 3 units. C-L: see Russian 773S

778S. The Silent Film: An Introduction. In-depth study of the short format movie. Development of short film concept and script, including pre-production, story boarding and look books. Graduate level project and assignments. Instructor: Gibson. 3 units.

788L. Fundamentals of Web-Based Multimedia Communications. 3 units. C-L: see Information Science + Studies 740L

790S. Special Topics in Visual and Media Studies. Topics vary by semester. Subjects, areas, or themes that embrace a range of disciplines in the arts and humanities areas. Instructor: Staff. 3 units.

793. Independent Study in Visual and Media Studies. Directed reading in a field of special interest, under the supervision of a faculty member, resulting in a substantive paper or report. Instructor consent required. Instructor: Staff. 3 units.

794L. Interactive Graphics: Critical Code. 3 units. C-L: see Information Science + Studies 794L; also C-L: Visual Arts 794L

796L. Media, Arts & Cultures Research Practicum I. 3 units. C-L: see Computational Media, Arts & Cultures 796L; also C-L: Historical and Cultural Visualization 796L, Information Science + Studies 796L

797L. Media, Arts & Cultures Research Practicum II. 3 units. C-L: see Computational Media, Arts & Cultures 797L; also C-L: Historical and Cultural Visualization 797L, Information Science + Studies 797L

798L. Media, Arts & Cultures Research Practicum III. 3 units. C-L: see Computational Media, Arts & Cultures 798L; also C-L: Historical and Cultural Visualization 798L, Information Science + Studies 798L

799L. Media, Arts & Cultures Research Practicum IV. 3 units. C-L: see Computational Media, Arts & Cultures 799L; also C-L: Historical and Cultural Visualization 799L, Information Science + Studies 799L

850S. Deleuze: Cinema and Philosophy. 3 units. C-L: see Literature 850S; also C-L: English 860S, Romance Studies 850S, Visual Arts 850S, Computational Media, Arts & Cultures 85, Documentary Studies 850S

859. Roman Catholic Visual Piety in the Modern Era. 3 units. C-L: see Religion 859; also C-L: Art History 859

Asian & Middle Eastern Studies

Professor Rojas, *Director of Graduate Studies*; Professors Liu Kang, Lamarre, and Rojas; Associate Professors Ching, Ginsburg, Hong, and Kwon; Visiting Associate Professor Eileen Cheng-yin Chow; *Secondary Appointments*: Professor Mottahedeh (Literature); Professor of the Practice Kim; Lecturer Yan Liu; *Affiliate Faculty*: Professors Allison (Cultural Anthropology), Rey Chow (Literature), Duara (History), Hardt (Literature), Mignolo (Romance Studies) and Weeks (Gender, Sexuality, and Feminist Studies); Associate Professor McLarney (Asian & Middle Eastern Studies); Assistant Professor Barnes (History); Associate Professors Hadjioannou (Literature), Litzinger (Cultural Anthropology), and Mazumdar (History)

A master's degree is available in this department.

The Department of Asian & Middle Eastern Studies (AMES) offers a master's degree in critical Asian humanities (CAH). This program 1) provides training in the critical analyses of written, visual, and performance cultures of East Asia; 2) integrates approaches and methodologies from literary studies, film studies, and cultural studies; and 3) provides students with the skills needed to pursue either a doctoral or professional degree in a related area or a career in a field relating to East Asian culture and society.

AMES faculty expertise is particularly strong in the early modern, modern, and contemporary periods, and faculty research interests coalesce around the three broad areas of: 1) Global China; 2) Japanese Empire Studies; and 3) Borderlands Korea.

To receive the MA, students must complete ten graduate-level courses, of which at least five must be offered by (or cross-listed with) AMES. All students must have third-year proficiency (or the equivalent) in an East Asian language by the time they graduate. Students who are already proficient or fluent in an East Asian language before they arrive are not required to learn a second language, though they have the option of doing so. All students must also complete an MA thesis and successfully defend it in an oral defense. All students will be offered a first-year faculty advisor before arriving at Duke and will then be assigned a thesis advisor for their second year.

Courses in Asian & Middle Eastern Studies (AMES)

502S. Translation Studies and Workshop. 3 units. C-L: see Theater Studies 530S; also C-L: Romance Studies 520S

503. Asian & Middle Eastern Studies. Graduate credit for undergraduate course in AMES. Consent of the instructor and the director of undergraduate studies required. Instructor: Staff. 3 units.

503S. Asian & Middle Eastern Studies. Graduate credit for undergraduate course in AMES. Consent of the instructor and the AMES DGS required. Instructor: Staff. 3 units.

504S. East Asia's Twentieth Century. 3 units. C-L: see History 504S

505S. Seminar in Asian and Middle Eastern Cultural Studies. Concentration on a theoretical problem or set of issues germane to the study of Asian and Middle Eastern cultures. 3 units. C-L: African & African American Studies 540S, Literature 530S

511. Documentary and East Asian Cultures. Focus on documentary films from various regions in East Asia, including China, Taiwan, Korea and Japan, studying the specific historical and social context of each while attending to their interconnected histories and cultures. Emphasis on the ethical implications of documentary in terms of its deployment of visual-audio apparatus to represent different groups of people and beliefs, values and conflicts, both intra- and inter-regionally in East Asia. Special attention paid to the aesthetics and politics of the documentary form in terms of both its production of meanings and contexts of reception. Instructor: Hong. 3 units. C-L: Documentary Studies 511, International Comparative Studies 513

515S. Interethnic Intimacies: Production and Consumption. Critical examination of cultural dynamics, political economies, and ethical implications of interethnic intimacies or "intercourse" as represented from and about Asia. Examines shifts within and beyond "Asia", asking why cultural representations matter in ways societies construct, produce, and consume objects of desire

and repulsion. Texts from literature and visual culture read along with theories of critical race studies, gender and sexuality, postcolonialism, globalization, visual culture, and other representative technologies of the Self/Other. May be taught simultaneously with AMES 415S with additional requirements. Students who have taken the first-year seminar are not eligible. Instructor: Kwon. 3 units. C-L: Literature 515S, Visual and Media Studies 515S, International Comparative Studies 515S, Gender, Sexuality, and Feminist Studies 505S

518S. Approaches and Practices in Second Language Pedagogy. Introduction to the history and current trends in language teaching with the goal of acquiring the knowledge and skills for informed, effective and reflective language instruction. Focus on psycholinguistic and sociolinguistic dimensions of second language acquisition, key concepts of second language teaching and their applications, and integration of culture and literature in language instruction. Compares features of the target and source languages. Assignments include review of teaching materials, creating lesson plans and modules, and writing an essay stating teaching philosophies. Open only to students who have a background in Asian languages. Instructor: Kim. 3 units. C-L: Linguistics 518S, Education 518S

519S. Andalusia: Muslim, Jewish, Christian Spain. Intersection of cultures, religions, languages, and peoples through history, architecture, poetry, music, philosophy, and everyday life of southern Spain. Cultural flourishing from the contact—and sometimes clash—of European, Spanish, Islamic, Arab, African, Middle Eastern, and Jewish civilizations and of the Arabic, Spanish, and Hebrew languages. Overlaps in mystical conceptions of the divine, in philosophical ideas about rational knowledge, in poetic, musical, and literary forms, in architectural styles, and in shared histories. Ends with how Andalusian culture continues to thrive in modern consciousness (in music, poetry, art, dance, architecture, etc.) at the crossroads of civilizations. Instructor: McLarney/Lieber. 3 units. C-L: Religion 519S, Jewish Studies 519S, Romance Studies 519S

526A. Religion and Civil Society in the Arab World. Examine how the Arab world is embodied in world system of the 21st century. Learn the specific accents that inform its citizens and shape its prospects locally, regionally and internationally. Examine how the major Abrahamic traditions—Judaism, Christianity and Islam—had their historical origins in the eastern Mediterranean world, and how they continue to have adherents that populate the region and challenge the modern notion of citizenship. Explore how the current uprising reflects the challenges of reconciling local aspirations with global forces.Class content is similar to AMES 326A with added reading materials, meeting hours and assignments. STUDY ABROAD: Duke in the Arab World. Instructor: Lo & McLarney. 3 units. C-L: Religion 526A

527S. Cartographies of Gender and Sexuality in Middle East. 3 units. C-L: see Gender, Sexuality, and Feminist Studies 503S; also C-L: International Comparative Studies 503S

528S. Literary Islam. The Quran as scripture; mystical poetry; stories of the early community; literary cultures in the early community; modern reinterpretations of Islamic sources; Islamist literature; modern Islamic poetry, novels, plays, and stories. (Same as Asian and Middle Eastern Studies 328S, but with additional readings, assignments, and meeting times). Instructor: McLarney. 3 units.

529S. Gender Jihad: Muslim Women Writers. Roles and representations of women in Muslim societies of Asia (including Indonesia, South Asia, and the Middle East) and Africa, as well as in Muslim minority societies (including Europe and the United States). Examination of ways writers and filmmakers project images of women in today's Muslim societies. Focus on women as producers of culture and as social critics. Same as AMES 173S but requires extra assignments. Instructor: McLarney. 3 units.

531S. Culture and Environment in Modern Chinese History. 3 units. C-L: see History 514S

532S. Research and Writing About Contemporary Chinese Culture. Addresses how to conduct research and write about contemporary Chinese culture from interdisciplinary and comparative perspectives; introduces critical theory and comparative and interdisciplinary approaches. Engages students in current debates about the rise of China and its implications for social and human values and cultures. Taught in English. Prerequisite: advanced knowledge of Chinese. Original research projects to explore with primary and secondary materials. Instructor: Liu. 3 units.

533. Traffic in Women: Cultural Perspectives on Prostitution in Modern China. Dialectic of prostitution as lived experience, and as socio-cultural metaphor. Focus on literary and cinematic texts, together with relevant theoretical works. The figure of the prostitute will be used to interrogate assumptions about gender identity, commodity value, and national discourse. Transnational traffic in women will provide context for examination of discourses of national identity in China and beyond, together with the fissures at the heart of those same discourses. Same as Asian and Middle Eastern Studies 333 but with additional graduate level work. Instructor: Rojas. 3 units.

535. Chinese Media and Pop Culture. Current issues of contemporary Chinese media and popular culture within the context of globalization. Cultural politics, ideological discourse, and intellectual debates since gaige kaifang (reform and opening up); aspects of Chinese media and popular culture: cinema, television, newspapers and magazines, the Internet, popular music, comics, cell phone text messages, and fashion. Instructor: Liu. 3 units. C-L: Information Science + Studies 535

539S. Queer China. Examines queer discourses, cultures, and social formations in China, Greater China, and the global Chinese diaspora from the late imperial period to the present. Course will focus on cultural representations, particularly literary and cinematic, but will also consider a wide array of historical, anthropological, sociological, and theoretical materials. Not open to students who have taken Asian and Middle Eastern Studies 439. Instructor: Rojas. 3 units. C-L: Cultural Anthropology 539S, Gender, Sexuality, and Feminist Studies 502S, Literature 539S, Visual and Media Studies 539S, Human Rights Program-Franklin Humanities Institute 539S

540S. Reading Heidegger. Closely reading major works by Heidegger Tracing the Turn in Heidegger's thought from the early metaphysical writing to the lecture courses of the 1930s. Underscores the role played by language in Heidegger's thought Probes what aesthetics means within the context of Heidegger's work. Instructor: Ginsburg. 3 units. C-L: Literature 543S, Religion 560S

541S. Jews and the End of Theory. Examines role played by the figure of "the Jew" (or "Jews") in critical theory. Assesses role played by Jewish "giants" in shaping critical theory. Explores role played by images of Jews and Jewishness in linguistic turn of 20th

century theory. Asks how should one understand contemporary theory in relation to "Jews"—literal Jews and figurative Jews, whether demise of these intellectual giants and diminishing interest in "Jews" and "Jewishness" means "the end of theory", and how to conceive the relations between theory and "Jewish Studies" in light of these questions. Instructor: Ginsburg. 3 units. C-L: Jewish Studies 541S, Literature 580S, International Comparative Studies 541S

549S. Techno-Orientalism: Asian/America, (Post)Human and SF. Course examines global Science Fiction genres in literature, film, and social media to understand broad historical and social formations of Otherness, the Alien, Citizenship, (Im) migration. Studies racial assumptions in popular culture, domestic and international law, discourse of the human and human rights, science and technology industries, and other disciplines. Explores intersections of race, gender, sexuality, class, and geopolitical divisions and interactions in Asian/American Studies and Postcolonial Studies from the past to the present. Instructor: Kwon. 3 units. C-L: Visual and Media Studies 549S

551S. Translation: Theory/Praxis. Examines theories and practices of translation from various periods and traditions (Cicero, Zhi Qian, classical and scriptural translators, Dryden, Schopenhauer, Benjamin, Jakobson, Tanizaki, Qian Zhongshu, Derrida, Apter, among others) and considers topics such as incommensurability, cultural exchange, imperialism, "Global Englishes," bilingualism, and techno-language. Prerequisite: open to undergraduates, but all participants must have strong command of one language aside from English, as final project involves original translation and commentary. Instructor consent required. Instructor: Chow. 3 units. C-L: Literature 551S

560S. Reading the Chinese Novel. A close reading of contemporary Chinese-language novels in the original. Texts will include prominent works from China, Taiwan, Hong Kong, and the Chinese diaspora. Recommended prerequisite: high-level reading knowledge of Chinese. Instructor: Rojas, Chow. 3 units.

561. Anime: Origins, Forms, Mutations. Historical origins of Japanese anime, as well as its status as art, narrative, genre. Ways in which anime mutates: formally (literature, manga, live action), culturally (fashion, otaku, fan communities), geographically. No prior knowledge of subject matter or Japanese language required. Not open to students who have taken AMES 361 Anime: Forms and Mutations. Instructor: Chow. 3 units. C-L: Visual and Media Studies 541

563S. Nightmare Japan. Inquiry into social anxieties erupted through encounters with natural or man-made 'disasters.' Examine defining disasters of modern Japan—the encounter with the West, the imperialist war and subsequent defeat, nuclear bomb and the recent Fukushima meltdowns, earthquakes and tsunami, recession and its associated social malady. Reading through literature, films and popular culture as sites where fantasy and desire are materialized and projected in coping with these ineluctable catastrophes. Same as Asian and Middle Eastern Studies 463S but with additional readings, assignments and meeting times. Instructor: Ching. 3 units. C-L: Cultural Anthropology 563S

565S. The World of Japanese Pop Culture. An examination of modern Japanese culture through a variety of media including literary texts, cultural representations, and films. Different material each year; may be repeated for credit. (Same as Asian and Middle Eastern Studies 165S but requires extra assignments.) Instructor: Ching. 3 units. C-L: Cultural Anthropology 565S

566S. Imaging a Nation: Japanese Visual Culture 1868-1945. 3 units. C-L: see Visual and Media Studies 523S

576S. Archiving and Visualizing Asia: Politics of Poetics of Knowledge Production. Engages students in the practices, politics, and theories of conducting original archival research and knowledge productions. Hands-on research in the archives of Duke's Rubenstein Special Collections and elsewhere. Examines histories and theories of movements and encounters between the "West" and "Asia." Teaches research methods through guided excavations in both digital and material resources. Directed readings of histories and theories and special guest lectures guide students on how to think critically on the theories and praxis of knowledge production, collection, circulation, and consumption. Students curate digital humanities projects based on original research. Instructor: Kwon. 3 units.

580S. History of Buddhist and Christian Interactions. 3 units. C-L: see Religion 580S

581S. Pan-Asianism, Religion, and the State in Modern Asia. 3 units. C-L: see Religion 581S

590. Special Topics in Asian and Middle Eastern Studies. Topics vary each semester. Instructor: Staff. 3 units.

593. Research Independent Study. Individual research in a field of special interest under the supervision of a faculty member, the central goal of which is a substantive paper or written report containing significant analysis and interpretation of a previously approved topic. Consent of instructor required. Instructor: Staff. 3 units.

603. The Palestinian-Israeli Conflict in Literature and Film. A cultural study of the collapse of the Israeli-Palestinian peace process and failure of Israeli and Palestinian doves to transform their respective communities and to change conditions on the ground. Focus on self-criticism as manifested in Israeli and Palestinian literature and cinema and on its limits. Instructor: Staff. 3 units. C-L: Jewish Studies 683, Human Rights Program-Franklin Humanities Institute 603

605. East Asian Cultural Studies. East Asia as a historical and geographical category of knowledge emerging within the various processes of global movements (imperialism, colonialism, economic regionalism). Instructor: Ching. 3 units. C-L: Cultural Anthropology 605, Literature 571, International Comparative Studies 605

610S. Trauma and Space in Asia. Space and Trauma across Asia. Introduces theoretical framework of "trauma discourse;" examines how the experience of space in Asia broadly defined has shaped historical traumas, which have marked the transition from colonialism to postcolonialism. Focus on Israel/Palestine, India/Pakistan, China/Taiwan, Japan/Korea; examines how critical terms originating in one historico-geographical context are translated across geographical boundaries. Taught simultaneously with AMES 410, but includes additional readings, assignments, and meeting times. Instructor: Kwon, Ginsburg. 3 units.

611. Melodrama East and West. Melodrama as a genre in literature and as a mode of representation in film and other media. Issues include: gender construction, class formation, racial recognition, and national identity-building. Emphasis on comparative method attending American and Chinese cultures and the politics of cross-cultural representation. (Same as Asian and Middle Eastern Studies 411 but requires extra assignments.) Instructor: Hong. 3 units.

620S. Critical Genealogies of the Middle East: An examination of the canon of Middle East scholarship. This course provides an in-depth investigation into the various theoretical and textual traditions that inform interdisciplinary Middle East studies with a focus on History, Cultural Studies, Religion and Social Sciences. Interdisciplinary in scope, the course will maintain a disciplinary rigor so that students learn how knowledge is produced within the framework of specific disciplines. Foci include social history, literary theory, critical visual studies, and postcolonial theory. Staff: cooke. 3 units.

625. Islamic Awakening: Revival and Reform. Explores religious revival in the Islamic world: revival as reinterpretation of sacred texts, revival as revolution, revival as social movement, revival as spiritual awakening, revival as political mobilization, revival as cultural renaissance. Graduate students will pursue in depth research in their specific area of concentration, read selected sources in the original languages, and design a final project that furthers their course of study. Instructor: McLarney. 3 units.

627S. Comparative Media Studies. 3 units. C-L: see Literature 625S; also C-L: Information Science + Studies 615S, Visual and Media Studies 625S

629. Revolution: The Arab World. Revolution in the Middle East and the Arab world; focus on Tunis, Syria, and Egypt: revolution in theory and practice; histories of revolution in the region; religion and revolution; media, social media, and social change; the poetics of politics; women's political action. Graduate level includes readings and research in Arabic, or any other primary source readings in original language of graduate students' area of specialty; more extensive theoretical readings; a substantive research paper; regular group meetings with instructors to discuss extra readings. Instructor: McLarney. 3 units.

631. Questions of National Cinemas. Films, documentaries, television series, and soap operas produced in mainland China in the post-Mao era. Topics include the history and aesthetics of the cinema, soap operas as the new forum for public debates on popular culture, the emerging film criticism in China, the relationship of politics and form in postrevolutionary aesthetics. (Same as AMES 431 but requires extra assignments.) Research paper required. Instructor: Hong. 3 units. C-L: Literature 632, Visual and Media Studies 632

631S. Seminar on Modern Chinese Cinema. Films, documentaries, television series, and soap operas produced in mainland China in the post-Mao era. Topics include the history and aesthetics of the cinema, soap operas as the new forum for public debates on popular culture, the emerging film criticism in China, the relationship of politics and form in postrevolutionary aesthetics. (Same as AMES 431 but requires extra assignments.) Research paper required. Instructor: Hong. 3 units. C-L: Literature 631S, Visual and Media Studies 631S

650S. Human Rights in Islam. Islamic conceptions of human rights, beginning with early formulations of key concepts like freedom and equality during the Arab "awakening" or Nahda and continuing to Islamic conceptions of rights after WWII and the Universal Declaration of Human Rights. Special attention to how women's rights and women's emancipation became key points of dispute between the West and the Islamic world. How ideas of the human and humanity (and its "rights") are constructed, especially within the humanities. Same as 450S, but with graduate level assignments and discussions. Instructor: McLarney. 3 units. C-L: Religion 661S

661. Japanese Cinema. An introduction to the history of Japanese cinema focusing on issues including the relation between the tradition-modernity or Japan-West in the development of Japanese cinema, the influence of Japanese films on the theory and practice of cinema abroad, and the ways in which cinema has served as a reflection of and an active agent in the transformation of Japanese society. Course includes several film screenings.(Same as Asian and Middle Eastern Studies 261, but requires extra readings, assignments, and meeting times.) Instructor: Chow. 3 units.

669S. Minor Japan. Examine the history and experiences of marginalized peoples in Japan from the Ainu to ethnic Koreans, from queer to the Okinawans, to challenge the myth of racial and ethnic homogeneity and sexual heteronormativity. Enhance understanding about cultural and artistic productions by reading a variety of texts, including fiction, oral histories, philosophical treatises, and films. Same as Asian and Middle Eastern Studies 469S, with extra graduate level assignments, discussion groups, and papers. Instructor: Ching. 3 units.

671. World of Korean Cinema. Introduction to Korean Cinema from postwar to contemporary period. Examination of issues such as national division, gender, pop culture, family, transnational identity and its influence abroad. Same as Asian and Middle Eastern Studies 471, but requires extra assignments. Instructor: Staff. 3 units.

672. Two Koreas: History, Society and Culture. This course introduces the divided histories of North and South Korea and their contemporary legacies in regional and global contexts. The course will be organized around select topics and guest lectures. Some topics explored include colonization, modernization, division, war, migration, gender and sexuality, human rights, popular and political cultures, and globalization in comparative perspectives. This course will have additional readings, meeting times, and a substantially longer research paper requirement for graduate-level credit. The course will teach graduate students the foundational methods of conducting original research and writing a research paper by the end of the semester. Instructor: Kwon. 3 units.

674S. Orhan Pamuk and World Literature. Studies the novels and non-fiction of Nobel Laureate Orhan Pamuk as an introduction into ethics and politics of World Literature. Addresses social consequences of Pamuk's role as an intellectual-author who mediates between the national tradition and an international canon. Political implications of Sufism, cultural revolution, Orientalism, and post-colonialism. Secondary focus on cosmopolitan Islam and the Ottoman Empire. Open to graduate students who must follow a comprehensive reading program and complete graduate-level assignments. No prerequisites; taught in English. Instructor: Göknar. 3 units. C-L: Slavic and Eurasian Studies 674S

683S. The City of Two Continents: Istanbul in Literature and Film. Presents Istanbul, a city located in both Europe and Asia, as a site of political identities in conflict. Overview of contemporary literature and film set in Istanbul. Studies ethical implications of textual and visual representations of various people and groups interacting in urban spaces. Addresses the reasons for Turkey's love-hate relationship with the Ottoman past and Europe. Historical background, modernity, identity, Islam, and cosmopolitanism. Open to graduate students who must follow a comprehensive reading program and complete graduate-level assignments. Knowledge of Turkish not required. Instructor: Göknar. 3 units. C-L: Slavic and Eurasian Studies 683S

687. The Turks: From Ottoman Empire to European Union. Reading and assessment of new scholarship on Ottoman culture,

society, politics, and state. Supplemented by critical texts on historiography, identity, gender, religion, and orientalism. Topics include "gazi thesis," secular and Islamic law, "Kadi justice," everyday life, and role of women. Final research project with interdisciplinary focus. Instructor: Goknar. 3 units. C-L: Slavic and Eurasian Studies 687

690S. Special Topics in Asian and Middle Eastern Studies. Seminar version of Asian and Middle Eastern Studies 590. Topics vary each semester. 3 units.

695. Collaborative Research Projects. Small collaborative research projects of faculty with graduate and undergraduate students. Close mentoring of students. Training in methods of cultural analysis and interpretation. Projects developed in conjunction with ongoing faculty initiatives. Students will present their research in the form of a term paper or some equivalent medium. Funding available to support students' research. Director of Graduate Studies consent required. Instructor: Staff. 3 units.

709. Chinese Im/migration: Chinese Migrant Labor and Immigration to the US. Comparative examination of contemporary China's "floating population" of migrant labor, and of Chinese immigration abroad (particularly to the US). Focus on cultural representation of these phenomena (particularly literary, cinematic, and artistic works), but sociological, anthropological, economic, and political perspectives will also be considered. Topics include cultural alienation, marginalization, and assimilation; education and health care; labor and commodification; gender and ethnicity; narratives of modernization and development; together with the ethical, social, and political implications of migration. Instructor: Rojas. 3 units. C-L: Visual and Media Studies 709

720. Professionalization Workshop in Middle East Studies. This bi-weekly professionalization workshop held alternately at Duke and UNC prepares students for a career in Middle East Studies. It is tailored to the interests of enrolled students who may suggest readings for discussion and present their own work. Instructor: Cooke. 1 unit.

738. Theories of Minority Discourse. Course will introduce a variety of critical theories of minority discourse, or discourses associated with minority groups within a more dominant cultural tradition. Course will also consider examples of these sorts of texts, focusing primarily on works from within a Chinese or Greater Chinese cultural sphere. knowledge of Chinese encouraged, but not required. Instructor: Rojas. 3 units.

740S. Critical Genealogies. 3 units. C-L: see Gender, Sexuality, and Feminist Studies 740S; also C-L: Cultural Anthropology 746S

750. CAH Proseminar: Topics in Critical Asian Studies. Topics in Critical Asian Studies. An in-depth analysis of the work of three leading contemporary scholars working in Asian Cultural Studies. Content and focus of the course will be coordinated with an annual workshop to be offered in late Spring. Focus on theory and methodology. Instructor: Rojas. 3 units.

774S. Ideology and Religion in Muslim Central Eurasia. 3 units. C-L: see Slavic and Eurasian Studies 774S; also C-L: History 774S, Religion 774S

790S. Special Topics in Critical Asian Humanities Methodologies. Course offers in-depth introduction of theories and methodologies that may be used for the study of East Asian Humanities. Approaches may include cultural studies, marxism and psychoanalysis, gender and sexuality studies, nationalism and diaspora studies, empire and postcolonial studies. May be repeated for credit. Instructor: Kwon, Ching, Hong, Rojas. 3 units.

890S. Special Topics in Critical Asian Humanities. Topics vary each semester. Instructor: Staff. 3 units.

Courses in Arabic (ARABIC)

501S. Translation as a Research Tool in Arabic and Islamic Studies. Introduces advanced students of Arabic to the science of translation as a major tool to pursue research in Arabic and Islamic studies. Learn techniques of translating Arabic text, editing, accessing biographical translation. Teach students how to translate literary text, religious text etc. (Qur'an, Hadith, poetry, etc.) Instructor: Jaward. 3 units.

610S. Quranic Arabic: Tafsir and Tajwid. This is a study of the features and structure of classical Arabic with an emphasis on the sciences of Tajwid/Tajweed and Tafsir. Students will learn the various styles, periods and schools in Tafsir and Tajwid. They will read excerpts from the classical schools of Tafsir, and the main characteristics of each. Memorizing and rehearsing selected verses for Tajwid are required in this course. Prerequisite: a minimum of two semesters of Arabic beyond the advanced level. Instructor: Lo. 3 units.

690. Special Readings. Variable credit.

789. Classical Arabic Language & Literature. Explore the development of Arabic language and Literature from the pre-Islamic era to the current epoch. Review major Arabic works in each of the Islamic eras. Explore the role of the Qur'an in the construction of Arabic sciences. Examine a variety of classical texts within the context of each era. Review the content and forms of essential texts of the science of Islamic Studies, including tafsir (Qur'anic exegesis), sirah (biography of the Prophet Muhammad), Hadith, travel literature, biographical literature. The graduate and undergraduate sections will be taught together with extra expectations and additional assignments for the graduate students. Instructor: Lo. 3 units.

791. Independent Study. Individual study of language for conducting research involving sources written or spoken in the language. Students have to submit a proposal describing the purported research, types of sources to be analyzed, and kinds of language knowledge or skills they need to be equipped with. Consent of instructor and director of undergraduate studies required. Instructor: Staff. 3 units.

Course in Chinese (CHINESE)

791. Independent Study. Individual study of language for conducting research involving sources written or spoken in the language. Students have to submit a proposal describing the purported research, types of sources to be analyzed, and kinds of language knowledge or skills they need to be equipped with. Consent of instructor and director of undergraduate studies required. Instructor: Staff. 3 units.

Course in Hebrew (HEBREW)

791. Independent Study. Individual study of language for conducting research involving sources written or spoken in the language. Students have to submit a proposal describing the purported research, types of sources to be analyzed, and kinds of language knowledge or skills they need to be equipped with. Consent of instructor and director of undergraduate studies required. Instructor: Staff. 3 units.

Course in Hindi (HINDI)

791. Independent Study. Individual study of language for conducting research involving sources written or spoken in the language. Students have to submit a proposal describing the purported research, types of sources to be analyzed, and kinds of language knowledge or skills they need to be equipped with. Consent of instructor and director of undergraduate studies required. Instructor: Staff. 3 units.

Courses in Japanese (JPN)

650. Research Methods in Japanese (B). Introduction to various research approaches to literary, sociological, and historical studies of Japan. Emphasis on bibliographical sources that best serve needs in chosen area of specialization. Consent of instructor required. Instructor: Staff. 3 units. C-L: History 503, Sociology 664

772S. Classical Japanese (Kanbun). Introduction to Sino-Japanese (kanbun). Readings in early modern Japanese Confucian and Buddhist texts as well as Chinese Confucian, Daoist, Mohist, Legalist, and Buddhist texts. Emphasis on understanding reading order (yomikudashi), classical Japanese grammar (bungo), and translation of texts. Japanese 772S is same as Japanese 472S with extra assignments for the graduate students. Prerequisite: JPN 471S, 771S or permission of instructor. Instructor: Tucker. 3 units.

791. Independent Study. Individual study of language for conducting research involving sources written or spoken in the language. Students have to submit a proposal describing the purported research, types of sources to be analyzed, and kinds of language knowledge or skills they need to be equipped with. Consent of instructor and director of undergraduate studies required. Instructor: Staff. 3 units.

Course in Korean (KOREAN)

791. Independent Study. Individual study of language for conducting research involving sources written or spoken in the language. Students have to submit a proposal describing the purported research, types of sources to be analyzed, and kinds of language knowledge or skills they need to be equipped with. Consent of instructor and director of undergraduate studies required. Instructor: Staff. 3 units.

Courses in Sanskrit (SANSKRIT)

701. Introductory Sanskrit Language and Literature I. Introduces classical, literary Sanskrit, the ancient and trans-continental language of India's intellectual heritage, history, and sacred scriptures. Teaches students Devanagari script, to learn and analyze grammatical forms and structures, vocabulary, and to interpret meaning. Provides an overview to the literature and civilizational importance of Sanskrit, from the ancient past to the present. Course will give graduate students the grammatical and analytic tools they will need to begin to read and interpret original texts. Instructor: Freeman. 3 units. C-L: Religion 707

702. Introductory Sanskrit Language and Literature II. Continuation of SANSKRIT 701/RELIGION 707 as prerequisite. Further learning of grammatical forms and structures of the higher language. Introduction of elementary readings from literature and scriptures. Introduces graduate students to the various genres of the language and a variety of styles they are likely to encounter in their research. Instructor: Freeman. 3 units. C-L: Religion 708

803. Intermediate Sanskrit. Selected readings in literature and scriptures, with introduction to the conventions of traditional literary forms, grammar, and interpretation. In addition, it provides departure point for graduate students to become familiar with literary, philosophical, and commentarial forms that they will need to comprehend for undertaking primary research in the language. Can lead to continuation in specialized reading courses or Independent Studies. Prerequisite: SANSKRIT 702/RELIGION 708. Instructor: Freeman. 3 units. C-L: Religion 809

Courses in Tibetan (TIBETAN)

701. Elementary Tibetan I. Introductory Tibetan language course for students who have little to no knowledge of Tibetan. Development of speaking, listening, reading, writing skills through Tibetan concepts, grammar and syntax of spoken and written Tibetan. Topics include situations of everyday life (e.g. greetings, introductions, family, habits/hobbies, making appointments, food, visiting friends, weather, shopping, etc.) as well as aspects of Tibetan people and culture (e.g. songs, short stories, etc.). Course taught at University of Virginia; Duke students participate through video conference and/or telepresence classroom. Instructor: Staff. 4 units.

702. Elementary Tibetan II. Continuation of Tibetan 701. Prerequisite: Tibetan 701 or equivalent. Development of speaking, listening, reading, writing skills through Tibetan concepts, grammar and syntax of spoken and written Tibetan. Topics include situations of everyday life (e.g. greetings, introductions, family, habits/hobbies, making appointments, food, visiting friends, weather, shopping, etc.) as well as aspects of Tibetan people and culture (e.g. songs, short stories, etc.). Course taught at University of Virginia; Duke students participate through video conference and/or telepresence classroom. Instructor: Staff. 4 units.

703. Intermediate Tibetan I. Intermediate skill-building in the grammar and syntax of spoken and written Tibetan, along with development of skills in listening, speaking, reading and writing through the integrated use of spoken and literary forms. Students will also enhance their knowledge of Tibetan culture in order to improve their communication skills. Course taught at University of Virginia; Duke students participate through video conference and/or telepresence classroom. Prerequisite: TIBETAN 102 Elementary Tibetan II

or equivalent. Instructor: Staff. 4 units.

704. Intermediate Tibetan II. Intermediate skill-building in the grammar and syntax of spoken and written Tibetan, along with development of skills in listening, speaking, reading and writing through the integrated use of spoken and literary forms. Students will also enhance their knowledge of Tibetan culture in order to improve their communication skills. Course taught at University of Virginia; Duke students participate through video conference and/or telepresence classroom. Prerequisite: TIBETAN 703 or equivalent. Instructor: Staff. 4 units.

Courses in Turkish (TURKISH)

718. The Turks: From Ottoman Empire to European Union. Readings in cultural history and literature to examine transformations in Turkish identity from the Ottoman era to EU accession. Discussion of the "gazi thesis", the "sultanate of women", religious tolerance (millets), conversion, modernity and nationalism. Secondary topics include Sufism, Islam, gender, and historiography. Interdisciplinary focus. Taught in English. Instructor: Goknar. 3 units.

Biochemistry

Professor Brennan, *Chair*; Associate Professor Kuehn, *Director of Graduate Studies*; Professors Al-Hashimi, Beese, Bennett, Beratan, Brennan, Casey, Donald, Erickson, Fitzgerald, Greenleaf, Hellinga, Hershfield, Lefkowitz, Modrich, McCafferty, Newgard, Nicchitta, Oas, D. Richardson, J. Richardson, Schumacher, Spicer, Thiele, and Zhou; Associate Professors Kuehn and Lee; Assistant Professors Hargrove, Meyer, Rajagopal, Yang, and Yokoyama; Professors Emeriti Been, Fridovich, Hammes, Kreuzer, Rajagopalan, and Webster; Adjunct Professors Blackshear, Borgnia, and Masters

A PhD is available in this department.

The Department of Biochemistry offers graduate work leading to the PhD in biochemistry. Preparation for such graduate study may take diverse forms. Undergraduate majors in chemistry, biology, mathematics, or physics are welcome, but adequate preparation in chemistry is essential. Graduate specialization areas include protein structure and function, crystallography and NMR of macromolecules, nucleic acid structure, dynamics, and function, lipid biochemistry, membrane structure and function, molecular genetics, and enzyme mechanisms. Recommended courses consist of Biochemistry 658/659 and 667/668, seminar courses Biochemistry 745/746 and 790S, and 681 (or equivalent training), and additional courses in the area of specialization. The biochemistry department, in cooperation with the university programs in genetics, cell and molecular biology, structural biology and biophysics, offers biochemistry students the opportunity to pursue advanced research and study to fulfill the requirements for the PhD related to these fields.

Courses in Biochemistry (BIOCHEM)

536. Bioorganic Chemistry. 4 units. C-L: see Chemistry 536

593. Research Independent Study. Individual research in a field of special interest, under the supervision of a faculty member, the major product of which is a substantive paper or written report containing significant analysis and interpretation of a previously approved topic. Designed for students interested in either a laboratory or a library project in biochemistry. One course for undergraduate students. One to twelve units for graduate students. Instructor: Staff. Variable credit.

600. General Biochemistry. An introductory survey of fundamental aspects of biochemistry with emphasis on the structure of macromolecules, mechanism of enzyme action, metabolic pathways, biochemical genetics, and the structure and functions of special tissues. Designed for medical students; graduate students only with consent of instructor. Instructors: Brennan, Briggs, Carbrey, Cohn, and McIntosh. 4 units.

622. Structure of Biological Macromolecules. Computer graphics intensive study of some of the biological macromolecules whose three-dimensional structures have been determined at high resolution. Emphasis on the patterns and determinants of protein structure. Two-hour discussion session each week along with computer-based lessons and projects. Instructors: D. Richardson and J. Richardson. 3 units. C-L: Structural Biology and Biophysics 622, Computational Biology and Bioinformatics 622

631. Contemporary Topics in Membrane Biology. This course will highlight modern topics regarding biological membranes and membrane proteins that are important for human physiology and disease. Topics include structure and dynamics of biological membranes, structure and function of membrane proteins that play critical roles in cell signaling, diseases related to dysfunction of membrane and membrane proteins, and current efforts on drug discovery. Major techniques used in membrane research will also be covered. The format will be a combination of lectures and discussion of primary literature. Students will be evaluated based on their class participation and performance at the final presentations. Reserved for graduate students; open to undergraduate students by instructor permission. Instructor: Lee, Bennett, Kuehn, Rajagopal, and Yang. 2 units. C-L: Cell and Molecular Biology 631, Neurobiology 631, Pharmacology and Cancer Biology 631

658. Structural Biochemistry I. Principles of modern structural biology. Protein-nucleic acid recognition, enzymatic reactions, viruses, immunoglobulins, signal transduction, and structure-based drug design described in terms of the atomic properties of biological macromolecules. Discussion of methods of structure determination with particular emphasis on macromolecular X-ray crystallography NMR methods, homology modeling, and bioinformatics. Students use molecular graphics tutorials and Internet databases to view and analyze structures. Prerequisites: organic chemistry and introductory biochemistry. Instructors: Beese and staff. 2 units. C-L: Cell and Molecular Biology 658, Cell Biology 658, University Program in Genetics 658, Structural Biology and Biophysics 658, Computational Biology and Bioinformatics 658

659. Structural Biochemistry II. Continuation of Biochemistry 658. Structure/function analysis of proteins as enzymes, multiple ligand binding, protein folding and stability, allostery, protein-protein interactions. Prerequisites: Biochemistry 658, organic chemistry, physical chemistry, and introductory biochemistry. Instructors: Zhou and staff. 2 units. C-L: Cell Biology 659, Computational Biology

and Bioinformatics 659, Structural Biology and Biophysics 659, University Program in Genetics 659

667. Molecular Aspects of DNA Biology. Addresses molecular aspects of DNA replication, repair, recombination, and chromosome segregation. Disease states linked to aberrations in these processes will also be considered. The course format includes background lectures by participating faculty coupled with student-led presentation and discussion of faculty-selected papers from the primary literature. Student evaluation is based on in-class presentation and participation in the related discussion. Prerequisites: undergraduate courses in biochemistry and molecular biology (or genetics). Mini-course, 1st half-semester. Instructor: Modrich, MacAlpine, Schumacher. 2 units.

668. RNA Biology: Co-Transcriptional and Post-Transcriptional Control of Gene Expression. Explores various aspects of RNA biology and function. Topics will include splicing, translation, RNA: Protein interactions, non-coding RNAs, RNA modifications, viral RNA regulation, RNA structure-function relationships, and RNA-targeted drug discovery. Students will also learn about the major techniques used in RNA research, including in vitro and in vivo methods for understanding global RNA regulation. The format will be a combination of weekly lectures which will also include discussion of primary literature. Students will be evaluated based on their participation and performance during in-class presentations. Students will also write a short mock research grant on a topic of their choosing. Instructor: Meyer. 3 units. C-L: Cell Biology 668, University Program in Genetics 668

681. Biophysical Methods. This course provides an overview of nine prominent methods used in biochemistry, cell biology and structural biology. They are: optical spectroscopy, fluorescence, light microscopy, ligand binding, kinetics, mass spectrometry, magnetic resonance, electrophysiology and cryoelectron microscopy. The goal is to provide students with sufficient background knowledge to allow them to read and understand papers in the primary literature that employ one or more of these methods. Each method is taught by an instructor who employs the method in their own research. Grade is based on problem sets, quizzes and a final presentation to the class of a paper that uses a method of the student's choice. Instructors: Oas, Hellinga, Fitzgerald, Al-Hashimi, Yang, Bartesaghi, Borgnia. 3 units.

690. Advanced Topics in Biochemistry. Topics and instructors announced each semester. Instructor: Staff. 3 units.

695. Understanding NMR Spectroscopy. Course aimed at graduate students who have some familiarity with high-resolution NMR who wish to deepen their understanding of how NMR experiments actually 'work'. Introduces quantum mechanical tools needed to understand pulse sequences, with emphasis on obtaining good understanding of how experiments actually work. Course also covers advanced biomolecular NMR experiments that enable structural and dynamic characterization of biomolecules. For roughly half of course, students will be expected to follow online lectures that accompany course textbook, with class meetings emphasizing concepts, group discussion, and problem solving. Prerequisites: undergraduate physical chemistry, undergraduate biochemistry, and one year of calculus. Instructor: Al-Hashimi. 4 units.

696. Macromolecular Structure Determination by X-Ray Crystallography: Principles and Practice. Theoretical and practical principles of macromolecular X-ray crystallography. Topics covered include crystal symmetry, space group theory and determination, diffraction theory, a practical understanding of crystallization, X-ray intensity data collection and data processing, phase determination, refinement and model validation. Prerequisites: Undergraduate physical chemistry; undergraduate biochemistry; at least one year of calculus. Instructor consent required. Instructor: Schumacher. 4 units.

700. Graduate Training Internship. Designed to allow graduate students in biochemistry to engage in internship lab work and doctoral study with external agencies and institutions for credit. Laboratory work and analysis can be conducted at external agency or institution with consent of the student's advisor and the director of graduate studies. May be repeated with consent of student's advisor and the director of graduate studies. Instructor: Staff. 1 unit.

745S. Biochemistry Seminar. Required of all first, second & third year biochemistry graduate students. Student-presented papers/research. The primary goal of this course is for students to learn how to present the background, data, conclusions and future prospects of their research clearly and concisely. Each second and third year student is required to present a seminar annually (in the fall or spring term), with students providing peer evaluations of each presenter. Instructor: Brennan. 1 unit.

746S. Biochemistry Seminar. Required of all first-, second- & third-year biochemistry graduate students. Student presented papers/research. The primary goal of this course is for students to learn how to present the background, data, conclusions and future prospects of their research clearly and concisely. Each second- and third-year student is required to present a seminar annually (in the fall or spring term), with students providing peer evaluations of each presenter. Instructor: Brennan. 1 unit.

761. Cellular Signaling Module I: GPCR Signaling and Disease. 1 unit. C-L: see Cell Biology 761; also C-L: Molecular Cancer Biology 761, Pharmacology and Cancer Biology 761

762. Cellular Signaling Module II: Intracellular Signaling and Disease. 1 unit. C-L: see Cell Biology 762; also C-L: Molecular Cancer Biology 762, Pharmacology and Cancer Biology 762

763. Cellular Signaling Module III: Growth Factor Pathway in Development and Disease. 1 unit. C-L: see Cell Biology 763; also C-L: Molecular Cancer Biology 763, Pharmacology and Cancer Biology 763

790S. Seminar (Topics). Topics and instructors announced each semester. 2 units or variable. Instructor: Kuehn. Variable credit.

Bioethics and Science Policy

Senior Lecturing Fellow Waitzkin, *Director of Graduate Studies*; Professor Farahany; Assistant Professor Lemmon; Assistant Professor of the Practice Angrist; Senior Lecturing Fellows Waitzkin and Weintraub; Lecturing Fellow Williams (core faculty)

A master's degree is available in this program.

Science & Society, founded in 2013, is a campus-wide initiative at Duke dedicated to interdisciplinary education scholarship, and policy engagement relating to the integral role of science in law, policy, social institutions, and culture. Science & Society offers a master of arts in bioethics and science policy, a program that teaches students how to identify, analyze, and propose solutions to address

cutting edge and historical developments in science, medicine, technology, and policy. The program provides a foundation in the history, philosophy, legal, social, and theoretical approaches to bioethical analysis, as well as an introduction to science and health policy. A distinguishing feature of the program is the option for students to select a topical area in which to concentrate their advanced studies. These concentrations represent existing or emerging areas of knowledge that pose complex questions about the relationship between science, ethics, and society. The three pre-designed concentrations are *Genomics*, *Neuroscience*, and *Public Impact and Engagement*. Students may also design an independent concentration with program faculty.

Degree Requirements

The MA in bioethics and science policy requires a minimum of 36 credits, and can be earned in one year on a full-time basis (3 full semesters) or up to 3 years (6 semesters) on a part-time basis.

Requirements include:

- 4 required core classes (12 credits)
- 5 elective classes (15 credits): Students may select electives from an extensive list of options from across the University or may choose to concentrate by choosing electives from one of several "tracks."
- 1 Capstone Project (9 credits): Each student will complete a capstone project under the guidance of a faculty mentor, either an in-depth research paper, or a field placement ("practicum"), with a written report analyzing the experience and integrating concepts learned in the program. The capstone project is designed to demonstrate that a student has acquired extensive knowledge of current thinking in bioethics; has collected, synthesized, and reflected on these issues; and has developed competence in scholarly writing.

Situated within the Science & Society initiative at Duke, the master of arts in bioethics and science policy and the broader initiative offer a host of workshops and programs to deepen student understanding of the field, help students consider career options, and connect students with leaders in bioethics and science policy and with other departments on campus.

Science & Society also offers a JD/MA degree in cooperation with the Duke Law School and an MD/MA with Duke School of Medicine. During their first semester at the Law School JD students may apply to participate in the joint degree. Duke Medical students may apply to obtain the joint degree during their third year in the Medical School.

Courses in Bioethics and Science Policy (BIOETHIC)

502S. Communicating Science & Bioethics. 3 units. C-L: see Science & Society 502S

510S. Science and the Media: Narrative Writing about Science, Health and Policy. Those who write about science, health and related policy must make complex, nuanced ideas understandable to the nonscientist in ways that are engaging and entertaining, even if the topic is far outside the reader's frame of reference. Course examines different modes of science writing, the demands of each and considers different outlets for publication and their editorial parameters. Students interview practitioners of the craft. Written assignments include annotations of readings and original narratives about science and scientists. Course considers ways in which narrative writing can inform and affect policy. Prerequisites: a 200-level science course and/or permission of the instructor. Instructor: Angrist. 3 units. C-L: Policy Journalism and Media Studies 510S, Public Policy 510S

591. Topics in Science Policy. During this independent research study, students will analyze science policy developments across government, including executive and agency actions, as well as proposed legislation and judicial decisions. Students will regularly produce policy brief summaries that overview the policy, explain the science at issue, present relevant background information, provide context concerning endorsements and opposition, and expound upon related legislation and governmental actions. Instructor consent required. Instructor: Waitzkin. Variable credit.

601S. Foundations of Bioethics. This course is designed to provide the incoming joint degree students in the JD/MA in Bioethics & Science Policy with an introduction to and overview of the central concepts underlying bioethics and the formulation of science policy. In a seminar format, the students will explore the foundations of bioethics, the concept of informed consent, human subject research and the Common Rule, bioethical issues in a clinical setting, risk and the precautionary principle, race and genetics, science and human rights, policy analysis, science communication and the formulation of science policy. Instructor consent required. Instructor: Williams. 3 units.

602S. Law, Research and Bioethics. An examination of the relationship between the law and bioethical issues, particularly in research and medical contexts. The course will explore the ways scientific advances affect law and other social institutions, and, conversely, how law affects the development and use of scientific knowledge. Topics include the history of human subject protections, current regulatory and statutory issues in research, and legal decisions governing informed consent, confidentiality, privacy, the philosophical principles underlying bioethics, and other issues. Consent of instructor is required for undergraduates. Instructor: Williams. 3 units.

603S. Clinical Bioethics and Health Policy. An examination of the leading issues in bioethics, especially those that arise in the context of clinical decision-making and the doctor-patient encounter. The focus will be on the ethical dilemmas faced by medical providers, patients, and their families: how issues are analyzed, what values are considered, and how disputes are resolved. Topics will include end-of-life care; withdrawal or refusal of life-sustaining treatment; pediatric ethics; transplantation; and rationing of scarce drugs or resources. The course will use real case examples to illustrate these dilemmas and challenges. Consent of instructor is required for undergraduates. Instructor: Lemmon. 3 units.

605S. Contemporary Issues in Bioethics and Science Policy. The course will focus on "Professional and Scholarly Writing" (Fall; Instructor: Angrist) and "Communicating Science and Bioethics" (Spring; Instructor: Weintraub). In the fall, we delve into how and where we express ideas about bioethics and science policy in writing. We begin from first principles: Why do we write? What can good writing do for us? How do we know when we're done? During the semester we will write clear, thoughtful, analytic and creative pieces in bioethics and science policy. The spring course provides students with practical training in the communication of scientific research and bioethical issues to the media, policy makers, and the general public. Instructor consent required. Instructor: Angrist. 1.5 units.

606S. Activism and Advocacy Among Patients and Research Participants. In the 1960s, patients appropriated the language and tactics of the civil rights movement to advance clinical and research agendas. In today's post-genomic and digital information era, patient activism is evolving, leading to new solutions, dilemmas, and organizational structures. This course will examine patient and research participant activism and the ways it challenges conventional notions of expertise, amateurism, "human subjects protections," and minimization of risk. Students will bring the tools of investigative journalism, humanities scholarship, and community engagement/citizen science to bear on ethical and policy questions. Instructor consent required for undergraduates. Instructor: Angrist. 3 units.

607. Introduction to Genetics and Genomics. An introduction to the fields of genetics and genomics for students without a formal science background. The course begins with an overview of the structure and function of DNA and the genome, and an introduction to the lab techniques and technologies used in these fields. Students will learn how scientists sequence a genome and how they "map" a disease gene. The course will conclude with an examination of the health and societal applications of genetics and genomics. Throughout the course, examples of ethical controversies will be provided to give perspective to the science. Consent of instructor is required for undergraduates. Instructor: Staff. 3 units.

700. Research Independent Study in Bioethics and Science Policy. Individual research in a bioethics and science policy topic of special interest, under the supervision of a faculty member, the major product of which is a substantive paper or written report containing analysis and interpretation of a previously approved topic. Requires consent of supervising instructor and Director of Graduate Studies. Instructor: Staff. Variable credit.

701. FDA Law and Policy. 3 units. C-L: see Law 341

702. Science Communication for Scientists. 2 units. C-L: see Science & Society 702

703. Frontier AI & Robotics: Law and Ethics. 3 units. C-L: see Law 592

704. Science Law and Policy. How is science regulated? States, federal government and international agencies all set policy. How do disparate regulations impact research and translation? Class is a mix of law, ethics and science students; learning a common language an important element of the course. Classes include analysis of cases studies. No prerequisites. Training in sciences not required. MA, PhD and JD/MA students register in BIOETHIC 704 – consent of professor required. Law students (other than JD/MAs) register in LAW 333. Instructor: Waitzkin. 3 units. C-L: Public Policy 841

705. Capstone: Bioethics & Science Policy. In the Bioethics & Science Policy Capstone, students will complete either (1) a research project on a subject of interest in bioethics, including the history and analysis of relevant current issues, or (2) a practicum, with a written report analyzing the experience and integrating concepts learned in the program. Through their work, students will demonstrate that they have acquired extensive knowledge of current thinking in bioethics; collected, synthesized, reported, and critically reflected on these issues; and developed competence in scholarly writing and procedures. Consent of the director of graduate studies required. Instructor: Staff. Variable credit.

706. Science Regulation Lab. 2 units. C-L: see Law 471

710. Director's Workshop in Bioethics & Science Policy. The purpose of the Director's Workshop is to enhance and refine the skills and capabilities of the master's students in Bioethics & Science Policy in the areas of methodology, risk literacy, communications (both written and oral), policy analysis, research, career preparation, and diversity issues. The Workshop will meet on Mondays from 11:45 a.m. to 1:15 p.m. The course will draw upon faculty from throughout the University, including the Law School, Fuqua School of Business, Sanford School, the School of Medicine, DCRI, SSRI and The Graduate School, as well as Science & Society. This course is intended for master's students in Bioethics & Science Policy. Students in other programs may enroll with instructor's permission if space permits. Instructor: Farahany. 1.5 units.

711. Director's Workshop in Bioethics & Science Policy. The purpose of the Director's Workshop is to enhance and refine the skills and capabilities of the master's students in Bioethics & Science Policy in the areas of methodology, risk literacy, communications (both written and oral), policy analysis, research, career preparation, and diversity issues. The Workshop will meet on Mondays from 11:45 a.m. to 1:15 p.m. The course will draw upon faculty from throughout the University, including Law, Fuqua, Sanford, Medicine, DCRI, SSRI, and The Graduate School, as well as Science & Society. Course intended for master's students in Bioethics & Science Policy. Students in other programs may enroll with instructor's permission if space permits. Instructor: Farahany. 1.5 units.

Biology

Professor Manos, *Chair*; Professor Pryer, *Director of Graduate Studies*; Professors Alberts, Benfey, Bernhardt, Brandon, Clark, Cunningham, Dong, Donohue, Drea, Hartemink, Johnsen, Kiehart, Kornbluth, Lutzoni, Manos, McClay, McShea, Mitchell-Olds, Morris, Nijhout, Noor, Nowicki, Pryer, Rausher, Rittschof, Rosenberg, Roth, Royal, Shaw, D. Sherwood, Smith, Sun, Uyenoyama, Vilgalys, Willis, Wray, and Yoder; Associate Professors Baugh, Bejsovec, Haase, Magwene, Patek, Pei, Schmid, Tung, Volkan, Wernegreen, Wilson, and Wright; Assistant Professors Gibert, Hunt, Johnson, and Silva; Professors Emeriti Klopfer, Nicklas, Searles, Siedow, Strain, Tucker, Wainwright, White, and Wilbur

A PhD is available in this department.

The Department of Biology offers a variety of training opportunities leading to the PhD in biology.

Students in the department may specialize in a wide variety of areas including anatomy; behavior; physiology; cellular and molecular biology; community, ecosystem, physiological, and population ecology; evolution; functional morphology; developmental, ecological, molecular, organelle, and population genetics; genomics; and phylogenetic systematics.

There is a high level of interaction among the various areas of biology and other programs. Faculty members participate in the university programs in developmental biology, ecology, genetics and genomics, cellular and molecular biology, computational biology and bioinformatics, structural biology and biophysics, and neurobiology; tropical research is facilitated through the university's membership

in the Organization for Tropical Studies. There are also strong relationships with the departments of evolutionary anthropology (primatology, phylogenetic systematics, macroevolution), mathematics (theoretical biology), and psychology (behavior); the Pratt School of Engineering (biomechanics); the Medical Center (molecular biology and genomics); and the Nicholas School of the Environment (ecology).

Students entering the program generally have a broad background in biological sciences supplemented with basic courses in chemistry, mathematics, and physics. Biochemistry and physical chemistry are strongly recommended for students interested in molecular areas, and advanced courses in mathematics are recommended for students in population genetics and ecology. While deficiencies may be corrected by taking appropriate courses during the first year of graduate study, it is advised that students search widely in this bulletin for information about the intellectual resources of the university. Courses below the 500 level may not be applied toward the required credits needed for a post-baccalaureate degree. With the approval of their director of graduate studies and the associate dean for academic affairs, graduate students may enroll in lower-level courses, but these courses will not count toward any graduation requirement and will not be included in a student's GPA calculation. Special attention should be given to announcements of the programs and departments listed above, as well as to those of cultural anthropology, history, immunology, molecular genetics and microbiology, pharmacology, philosophy, and sociology, and of the Pratt School of Engineering and the Nicholas School of the Environment.

Courses in Biology (BIOLOGY)

505. Functional Ecology of Plants. 3 units. C-L: see Environment 505

505D. Functional Ecology of Plants. 3 units. C-L: see Environment 505D

515. Principles of Immunology. 3 units. C-L: see Immunology 544

522S. Origins of Cellular Life on Earth and Beyond. This course discusses the origins of cellular life on Earth and beyond. We will ask: How did life originate? What are the limits of conditions that sustain life? Is there life elsewhere in the universe? How would we know life if we found it elsewhere (i.e., how is life defined)? This discussion-based course will delve into the literature reporting the biological and astrobiological research community's response to life's "big questions." Recommended prerequisite: Biology 201L or 203L, Chemistry 201DL, and Biology 212L. Instructor: Schmid. 3 units.

540L. Mycology. Survey of the major groups of fungi with emphasis on life history and systematics. Field and laboratory exercises. Instructor: Vilgalys. 3 units.

546LS. Biology of Mammals. Lab-based version of Biology 546S. Instructor: Roth. 4 units.

546S. Biology of Mammals. The biology of mammals: diversity, evolutionary history, morphology, and aspects of physiology and ecology. Local field trips. Recommended prerequisite: Biology 20, 21, 202L, or 203L, or equivalent. Instructor: Roth. 3 units.

547L. Entomology. The biology of insects: diversity, development, physiology, and ecology. Field trips. Recommended prerequisite: Biology 20, 21, 202L, or 203L, or equivalent. Instructor: H. Nijhout. 4 units.

555S. Problems in the Philosophy of Biology. 3 units. C-L: see Philosophy 634S

556. Systematic Biology. Theory and practice of identification, species discovery, phylogeny reconstruction, classification, and nomenclature. Recommended prerequisite: Biology 202L or 203L or equivalent. Instructor: Lutzoni. 3 units.

556L. Systematic Biology. Laboratory version of Biology 556. Theory and practice of identification, species discovery, phylogeny reconstruction, classification, and nomenclature. Recommended prerequisite: Biology 202L or 203L or equivalent. Instructors: Lutzoni and Swofford. 4 units.

557L. Microbial Ecology and Evolution. Survey of new advances in the field of environmental and evolutionary microbiology, based on current literature, discussion, and laboratory exercises. Topics to include bacterial phylogeny, molecular ecology, emerging infectious diseases, bacterial symbiosis, experimental evolution, evolution of drug resistance, and microbial genomics. Recommended prerequisite: Biology 20, 21, 212L, 201L, 202L, or 203L. Instructor: Vilgalys. 4 units.

559S. Foundations of Behavioral Ecology. Readings on behavioral ecology, both historical papers and papers from the current literature that represent the most vital areas of research in the discipline. Instructors: Alberts. 3 units. C-L: University Program in Ecology 559S

561. Tropical Ecology. 3 units. C-L: see Environment 517

561D. Tropical Ecology. 3 units. C-L: see Environment 517D

563S. Stormwater Science: Pollution, Pavement, and Precipitation. Examines pollution emissions/deposition, impervious surfaces, evapotranspiration, groundwater, stormwater runoff, nutrients, thermal pollution, and freshwater effects. Uses primary literature, as well as a couple of books. Also examines "stormwater control measures" that mitigate problems. Student-driven course: Reading, presenting, and discussing primary literature, asking/answering questions in class, and seeking answers. Course designed for graduate and advanced undergraduate students. Prerequisites: one course in Ecology or Environmental Science or instructor consent. Instructor: Wilson. 3 units. C-L: Environment 565S

564. Biogeochemistry. Processes controlling the circulation of carbon and biochemical elements in natural ecosystems and at the global level, with emphasis on soil and surficial processes. Topics include human impact on and social consequences of greenhouse gases, ozone, and heavy metals in the environment. Prerequisite: Chemistry 101DL or equivalent; Recommended: Chemistry 210DL. Instructor: Bernhardt. 3 units. C-L: Environment 564

564D. Biogeochemistry. Discussion version of Biology 564. Processes controlling the circulation of carbon and biochemical elements in natural ecosystems and at the global level, with emphasis on soil and surficial processes. Topics include human impact on and social consequences of greenhouse gases, ozone, and heavy metals in the environment. Recommended prerequisite: Chemistry 101DL and 210DL. Instructor: Bernhardt. 3 units. C-L: Environment 564D

565L. Biodiversity Science and Application. Processes responsible for natural biodiversity from populations to the globe. Topics include species interactions (e.g., competition, predation, parasitism), natural and human disturbance, climate change, and implications for management and conservation. Lab section involving observation and data from large-scale manipulations, such as experimental hurricanes, fire, and herbivore exclosures. Instructors: Wright. 3 units. C-L: Environment 575L

565S. Biodiversity Science and Application. Non-lab version of Biology 565L. Processes responsible for natural biodiversity from populations to the globe. Topics include species interactions (e.g., competition, predation, parasitism), natural and human disturbance, climate change, and implications for management and conservation. Recommended prerequisite: Biology 209D-2 or equivalent. Instructor: Wright. 3 units. C-L: Environment 575S

566S. Understanding the Ecological Role of Plant Traits in Changing Environments. Ecophysiology studies the adaptation of organism's physiology to its environment and provides a mechanistic framework for understanding how species respond to changing environments and how species interact with each other. As such, it plays a central role in understanding how organisms might respond to global change. This course will explore current topics in plant ecology by reading and discussing recent papers from the scientific literature. Recommended prerequisite: previous coursework in either ecology or physiology. Instructor: Wright. 3 units.

570LA-1. Experimental Tropical Marine Ecology. Distribution and density of marine and semi-terrestrial tropical invertebrate populations; behavioral and mechanical adaptations to physical stress, competition, and predation using rapid empirical approaches and hypothesis testing. Taught in Beaufort at Duke Marine Lab, with preparation for fieldwork before and analysis and presentation of projects after required one-week intensive field experience on the coast of Panama. Consent of instructor required. Instructor: Diaz. 2 units.

570LA-2. Marine Ecology of the Pacific Coast of California. Ecology of the rocky intertidal, kelp forest, and mud flat habitats. Introduction to marine mammals, fish and other large West Coast vertebrates. Taught in Beaufort at Duke Marine Lab, with preparation for fieldwork before and analysis and presentation of projects after required one-week intensive field experience on the coast of Northern California. Prerequisite: introductory course in biology or environmental science and consent of instructor. Instructor: Johnson. 2 units. C-L: Environment 570LA-2

571A. Sojourn in Singapore: Urban Tropical Ecology. 3 units. C-L: see Environment 571A

579LA. Biological Oceanography. Variable credit. C-L: see Environment 579LA; also C-L: Earth and Ocean Sciences 579LA

588S. Macroevolution. Evolutionary patterns and processes at and above the species level; species concepts, speciation, diversification, extinction, ontogeny and phylogeny, rates of evolution, and alternative explanations for adaptation and evolutionary trends. Recommended prerequisite: Biology 202L, 203L, or equivalent. Also recommended: one course in plant or animal diversity and one course in evolution beyond 202L. Instructor: Roth. 3 units. C-L: Evolutionary Anthropology 588S

590. Topics in Biology. Lecture course on selected topic. Offerings vary each semester. Instructor: Staff. 3 units.

590S. Seminar (Topics). Seminar on a selected Topic. Offerings vary each semester. Instructor: Staff. 3 units.

627. Molecular Ecology. 3 units. C-L: see Environment 627; also C-L: Science & Society 627

650. Molecular Population Genetics. Genetic mechanisms of evolutionary change at the DNA sequence level. Models of nucleotide and amino acid substitution; linkage disequilibrium and joint evolution of multiple loci; analysis of evolutionary processes, including neutrality, adaptive selection, and hitchhiking; hypothesis testing in molecular evolution; estimation of evolutionary parameters; case histories of molecular evolution. For graduate students and undergraduates with interests in genetics, evolution, or mathematics. Instructor: Uyenoyama. 3 units.

652S. The Life and Work of Darwin. Readings by and about Darwin and his contemporaries, especially Wallace. Darwin's "Autobiography" and Janet Browne's biography as context for readings of some of his major works and works of his contemporaries. Consent of instructor required. Instructors: Alberts and McShea. 3 units. C-L: Evolutionary Anthropology 652S

660. Evolution from a Coalescence Perspective. Survey of theoretical and empirical aspects of modern population genetics in the post-coalescence era. Coincident with the development of coalescence theory, evolutionary biology began a profound and pervasive transformation. This course presents the basics of coalescence theory. It builds upon this perspective to address an array of summary statistics and inference methods developed for the analysis of genomic data. Instructor: Uyenoyama. 3 units. C-L: University Program in Genetics 660

665. Bayesian Inference for Environmental Models. Formulation of environmental models and applications to data using R. Distribution theory, algorithms, and implementation. Topics include physiology, population growth, species interactions, disturbance, and ecosystem dynamics. Discussions focus on classical and current primary literature. Instructor: J. Clark. 3 units. C-L: Environment 665

668. Population Ecology. Key questions in population ecology from a theoretical perspective. Topics include demography and dynamics of structured populations, population regulation, stochastic and spatial population dynamics, life history characteristics, species interactions, and conservation of threatened populations. Computer labs will emphasize fitting models to data. Prerequisites: One course in Ecology. Instructor: Morris. 3 units.

678. Population Ecology for a Changing Planet. 3 units. C-L: see Environment 678

01-G-B

701. Succeeding in Graduate School in the Biological Sciences. Weekly lecture presentation on choosing a thesis advisor, the grant proposal and scientific manuscript peer review processes, and other topics related to succeeding in graduate school. Instructor: Noor. 0.5 units. C-L: University Program in Genetics 711

702. Succeeding Beyond Grad School: Career Options with a PhD in the Biological Sciences. Weekly lecture presentation

on preparing academic job applications, alternative careers in the biological sciences and other topics related to succeeding beyond graduate school. Instructor: Noor. 0.5 units. C-L: University Program in Genetics 712

703. Professional Development for Careers in Biology. Presentations and activities for Biology PhDs to assist in matching students' skills, interests, and values to their future careers, in or outside the academy. First half of the course focuses on identifying students' career goals, recognizing existing skills, discussing interpersonal dynamics, and learning how to obtain new skills necessary to achieve students' goals. Second half explores contemporary issues like work/life balance and women in science, and will offer students the opportunity to create and peer-edit job application materials. Instructor: Noor and Staff. 1 unit.

704LA. Biological Oceanography. Patterns of abundance, diversity and activity of organisms in major ocean ecosystems. Identifies major physical, chemical and ecological processes that affect these patterns, and analyzes the impact of biology on ecosystems. Uses "flipped" classroom emphasizing hands-on data collection and quantitative analyses, field trips aboard DUML research vessels, and participatory activities to demonstrate core concepts in biological oceanography. Taught in Beaufort at Duke Marine Lab. Spring enrollment requires travel. Graduate section includes experimental design component and research paper on final project. Instructor: Johnson. 4 units. C-L: Environment 704LA, Earth and Ocean Sciences 704LA

705S. Seminar in Teaching Biology. Syllabus design, best practices, and instructional methods in biology for graduate students in Duke University's Preparing Future Faculty Program in Biology. Seminar discussions and projects guided by Duke faculty in conjunction with faculty from Elon, Guilford, and Meredith Colleges. Topics may include "Biological Literacy"; "Using Information Technology"; and "Different Learning Styles, Different Contexts." Instructor: J. A. Reynolds and/or Manos. 1 unit.

706. Grant Writing. Hands-on instruction for preparing grant proposals; preparation and revision of an NSF-format proposal; evaluation and critique of proposals prepared by fellow class members. Instructor: Shaw. 3 units.

710S. Cenozoic Climate, Environment, and Mammalian Evolution in the New World. 3 units. C-L: see Earth and Ocean Sciences 711S; also C-L: Evolutionary Anthropology 711S

711S. Ecology Seminar. Discussion of current research and literature. Instructor: Staff. 1 unit. C-L: Evolutionary Anthropology 743, Environment 702

712S. Plant Systematics Seminar. Weekly presentation of current research in plant systematics by students, faculty, and invited speakers. Instructor: Staff. 1 unit.

715S. Population Genetics Seminar. Discussion of recent developments in population genetics. Topics include population dynamics, forces affecting gene frequency change, molecular evolution, philosophy of evolutionary biology. Student presentations are integral to the course. Instructor: Staff. 1 unit.

717S. Plant Biology Forum. Modern contemporary research on the plant model species Arabidopsis thaliana. Prerequisites: Coursework in molecular and cell biology. Instructor: Staff. 1 unit.

718S. Developmental, Cellular, and Molecular Biology Seminar. Weekly presentations in developmental, cellular, and molecular biology topics by students, faculty, and invited speakers. Consent of instructor required. Instructor: Staff. 1 unit.

723. Statistical Computing for Biologists. Statistical computing for the biological sciences with an emphasis on common multivariate statistical methods and techniques for exploratory data analysis. Goal of the course is to help graduate students in the biological sciences develop practical insights into methods they are likely to encounter in their research. Provides introductions to "R" statistical computing environment and Python programming language. Instructor: Magwene. 3 units.

725. Microscopy and Image Analysis. Concepts and theory involved in a wide variety of microscopy and image analysis. The course is intended for people who will do a significant amount of biological imaging in their graduate research and is best taken after starting to do some imaging. Areas covered: Transmitted light, fluorescence, widefield imaging, scanning confocal, TIRF, live-cell imaging, multiphoton excitation, spinning disk, super-resolution microscopy, imaging techniques, image processing, visualization and analysis. FIJI/ImageJ is used with interactive exercises to complement theory involved in image processing and analysis. Consent of the instructor is required (numbers are limited). Instructor: Staff. 2 units.

726. Dynamic Modeling of Biological Systems. Covers a range of approaches used in the dynamic modeling of biological systems, with applications to ecology, evolution, cellular and molecular biology. Modeling approaches discussed include: difference equations, differential equations, and individual-based models. Analysis of models will include analytical approaches as well as approaches based on simulation. Simulation of models will use the software program Matlab. Instructor: Staff. 3 units. C-L: Computational Biology and Bioinformatics 726

727. Image Processing for Bioscientists. Broad introduction to the principles behind image-based data. Aimed at graduate students actively working in research labs but assumes no prior experience with programming or any computational background beyond that of a typical PC/Mac user. Covers images generally but examples will be based on the types of images commonly used in biological research. Topics: Image fundamentals, Basic image processing, Image compression, Image storage and informatics, 3D and 4D data, Making accurate and optimal figures, Image integrity, Video, Quantification, Limits and confounds in analysis, automation of image processing and analysis. Lecture and computational exercises. 3 units. Instructor: Staff. 3 units.

730. Evolutionary Mechanisms. Population ecology and population genetics of plants and animals. Fitness concepts, life history evolution, mating systems, genetic divergence, and causes and maintenance of genetic diversity. Instructor: Rausher. 3 units.

750S. Introduction to Inclusion, Diversity, Equity, and Anti-Racism in Biology. This half-credit course is designed for graduate students in biology with an interest in inclusion, diversity, equity, and anti-racist (IDEA) efforts in science. We will explore the history of racism and oppression in biology and interrogate the epistemic values and assumptions embedded in the field and its subfields. We will discuss current events related to IDEA topics in biology along with ongoing efforts in universities towards inclusion, equity, diversity, and antiracism. Finally, we will consider how biologists can promote diversity, equity, and inclusion in ways that complement their research. Instructor: Wray. 1.5 units.

773A. Marine Ecology. Ecology from a policy and management perspective. Recitations and discussions target a policy- and management-oriented graduate audience. Lecture topics include factors that influence the distribution, abundance and diversity of marine organisms, characteristics of marine habitats, adaptation to environment, species interactions, biogeography, larval recruitment, and communities found in rocky shore, tidal flats, beached, mangrove, coral reefs and subtidal areas. Recitations and discussions cover ecological principles form a policy and management perspective. Not open to students who have taken Biology 273LA and not open to undergraduates. Taught in Beaufort at Duke Marine Lab. Recommended prerequisite: introductory biology. Instructor: Silliman or staff. 4 units. C-L: Environment 773A

773L. Marine Ecology. Factors that influence the distribution, abundance, and diversity of marine organisms. Course structure integrates lectures, field excursions, lab exercises and an independent project. Lecture topics include physical characteristics of marine systems, adaptation to environment, species interactions, biogeography, larval recruitment, and biodiversity and conservation of communities found in rocky shores, tidal flats, beaches, marshes, mangrove, coral reefs, and subtidal areas. Taught fall, spring, and summer. (Spring enrollment requires travel to Caribbean.) Graduate students submit literature review. Recommended prerequisite: introductory biology. Instructor: Silliman or staff. 4 units. C-L: Environment 773L

773LA. Marine Ecology. Factors that influence the distribution, abundance, and diversity of marine organisms. Course structure integrates lectures, field excursions, lab exercises and an independent project. Lecture topics include physical characteristics of marine systems, adaptation to environment, species interactions, biogeography, larval recruitment, and biodiversity and conservation of communities found in rocky shores, tidal flats, beaches, marshes, mangrove, coral reefs, and subtidal areas. Not open to students who have taken Biology 273LA. Taught in Beaufort at Duke Marine Lab. Taught fall, spring, and summer. (Spring enrollment requires travel to Caribbean.) Grad students submit literature review. Prerequisite: introductory biology. Instructor: Silliman or staff. 4 units. C-L: Environment 773LA

777LA. Biodiversity of Marine Invertebrates. 4 units. C-L: see Environment 788LA

778L. Comparative Physiology of Marine Animals. Physiology of marine animals with emphasis on comparisons between marine vertebrates and humans. Focus on physiological processes including gas exchange, circulation, osmoregulation, metabolism, thermoregulation, endocrine, neural control and sensory systems. Lectures and laboratories illustrate the methodology, analysis techniques, and written reporting of physiological research. Open to undergraduates as Biology or Environment 278L. Instructor: Wise or staff. 4 units. C-L: Environment 778L

778LA. Comparative Physiology of Marine Animals. Physiology of marine animals with emphasis on comparisons between marine vertebrates and humans. Focus on physiological processes including gas exchange, circulation, osmoregulation, metabolism, thermoregulation, endocrine, neural control and sensory systems. Lectures and laboratories illustrate the methodology, analysis techniques, and written reporting of physiological research. Open to undergraduates only under Biology or Environment 278LA. Four units (fall, spring); six units (summer). Taught in Beaufort at Duke Marine Lab. Instructor: Wise or staff. 4 units. C-L: Environment 778LA

782. Mechanisms of Development/Developmental Genetics. 2 units. C-L: see Cell Biology 810

783. Developmental Genetics. 2 units. C-L: see Cell Biology 820

784LA. Sound in the Sea: Introduction to Marine Bioacoustics. 4 units. C-L: see Environment 784LA; also C-L: Electrical and Computer Engineering 784LA

790. Topics in Biology. Lecture course on selected topic. Offerings vary each semester. Instructor: Staff. Variable credit.

790S. Special Topics Seminar. Seminar on a selected topic. Offerings vary each semester. Instructor: Staff. Variable credit.

791T. Tutorial. Carried out under the direction of the appropriate staff members. Consent of instructor required. Hours and credit to be arranged. Taught in Beaufort at Duke Marine Lab. Instructor: Staff. Variable credit.

791TA. Tutorial. Carried out under the direction of the appropriate staff members. Consent of instructor required. Hours and credit to be arranged. Taught in Beaufort at Duke Marine Lab. Instructor: Staff. Variable credit.

792. Research. To be carried on under the direction of the appropriate staff members. Consent of instructor required. Hours and credit to be arranged. Instructor: Staff. Variable credit.

792A. Research. To be carried out under the direction of the appropriate faculty members. Consent of instructor required. Hours and credit to be arranged. Taught in Beaufort at Duke Marine Lab. Instructor: Staff. Variable credit.

841. Ecological Perspectives: Evolution to Ecosystems. 4 units. C-L: see University Program in Ecology 701; also C-L: Environment 841, Evolutionary Anthropology 741

842. Ecological Perspectives: Individuals to Communities. 4 units. C-L: see University Program in Ecology 702; also C-L: Environment 842, Evolutionary Anthropology 742

Biomolecular and Tissue Engineering

Associate Professor Gersbach, *Program Director*

A certificate is available in this program.

The University Program in Biomolecular and Tissue Engineering is a multidisciplinary certificate program that integrates activities in engineering, the life sciences, and medicine. Faculty are from the departments of biochemistry, biomedical engineering, cell biology, chemistry, mechanical engineering and materials science, medicine, neurobiology, ophthalmology, radiation oncology, and surgery.

The program emphasizes research, education (both undergraduate and graduate) and interactions with industry. The research focus of the program is upon the action of proteins, cells, and tissues—and the materials (both natural and synthetic) with which they

interact—in natural biological processes, and in medical diagnosis and therapy. It applies the principles and experimental methods of engineering to improve the understanding of these phenomena, and uses this knowledge to develop solutions to practical as well as fundamental problems. Students apply for graduate study to participating departments and are subject to the degree requirements of the university and these home departments.

The University Program in Biomolecular and Tissue Engineering offers a certificate of graduate study. The requirements for the certificate include completion of two core courses: an approved lab-based course in modern biotechnology and seminars in biomolecular and tissue engineering; approved BTE engineering electives; and, two approved basic science classes. A NIGMS biotechnology training grant offers stipends, tuition, and fees to a number of BTE predoctoral fellows.

Requirements (Engineering Student)

- one lab-based class in modern biotechnology
- two semesters credit of biological engineering seminar series (four semesters required for Training Grant fellows)
- four BTE electives
- two nonengineering biomedical science classes.
- participation in BTE activities, such as the annual poster session and chalk talks

Requirements (Non-Engineering Student)

- one lab-based class in modern biotechnology
- two semesters of credit of biological engineering seminar series (four semesters required for Training Grant fellows)
- two BTE electives
- two nonengineering biomedical science classes
- participation in BTE activities, such as the annual poster session and chalk talks

For more information contact The University Program for Biomolecular and Tissue Engineering, Duke University, Box 90281, Durham, NC 27708-0281 or visit the website at https://cbte.pratt.duke.edu/.

Biostatistics and Bioinformatics

Professor Barnhart, *Director of Graduate Studies (PhD)*; Professors Samsa and Xie, *Interim Directors and Co-Directors of Graduate Studies (Master's)*

A PhD is available in this department through The Graduate School.

The Department of Biostatistics and Bioinformatics offers both doctoral and master's degrees in biostatistics. The doctoral program is offered through the Duke University Graduate School, and the master's degree program is offered through the Duke University School of Medicine (see the relevant year's Bulletin of the Duke University School of Medicine).

As biomedical research becomes increasingly quantitative and complex, a need exists for individuals who possess exceptional analytic skills, a strong foundation in human biology, and the ability to effectively communicate statistical principles to multi-disciplinary research teams. Demand is particularly high for individuals formally trained in biostatistics.

Duke University Medical Center is a world-class medical research institution that provides an ideal setting for training biostatisticians to gain exposure to state-of-the-art biostatistical methodology in the context of cutting-edge science research. Duke's PhD in Biostatistics Program is unique in its balanced focus on three core competencies: statistical methodology, biology, and communication. All faculty members in the Department of Biostatistics and Bioinformatics at Duke are actively engaged in research, with projects collectively spanning a broad array of biomedical research areas. Faculty members actively practice what they teach and are dedicated to ensuring that students develop the skills and knowledge necessary to succeed as biostatisticians.

For more information about the doctoral and/or master's program in Biostatistics, please visit the program website: https://biostat.duke.edu/. If students should have any additional questions, they should contact Kendall Mincey at kendall.mincey@duke.edu.

Courses in Biostatistics (BIOSTAT)

701. Introduction to Statistical Theory and Methods I. This course provides a formal introduction to the basic theory and methods of probability and statistics. It covers topics in probability theory with an emphasis on those needed in statistics, including probability and sample spaces, independence, conditional probability, random variables, parametric families of distributions, sampling distributions. Core concepts are mastered through mathematical exploration, simulations, and linkage with the applied concepts studied in BIOSTAT 704. Prerequisite: 2 semesters of calculus or its equivalent (multivariate calculus preferred). Familiarity with matrix algebra is helpful. Corequisites: BIOSTAT 702, BIOSTAT 703 Credit: 3. 3 units.

701K. Introduction to Statistical Theory and Methods I. This course provides a formal introduction to the basic theory and methods of probability and statistics. It covers topics in probability theory with an emphasis on those needed in statistics, including probability and sample spaces, independence, conditional probability, random variables, parametric families of distributions, sampling distributions. Core concepts are mastered through mathematical exploration, simulations, and linkage with the applied concepts studied in BIOSTAT 704. Prerequisite: 2 semesters of calculus or its equivalent (multivariate calculus preferred). Familiarity with matrix algebra is helpful. Corequisites: BIOSTAT 702, BIOSTAT 703 Credit: 3. 3 units.

701L. Advanced Statistical Theory and Method I Lab. Students who enroll in BIOS 701 may opt to enroll in this advanced lab designed to extend the material presented in BIOS 701. This course will be run as a mixture of lecture and recitation. Each session will start with a short presentation by the instructor of advanced examples that extend the material presented during that week's BIOS 701 lecture. Each session will conclude with students presenting their solutions to advanced problems assigned the prior week. At the end of the semester, students will take a cumulative exam covering the advanced topics covered during the lab session. Corequisite: BIOSTAT 701. 2 units.

702. Applied Biostatistical Methods I. This course provides an introduction to study design, descriptive statistics, and analysis of statistical models with one or two predictor variables. Topics include principles of study design, basic study designs, descriptive

statistics, sampling, contingency tables, one- and two-way analysis of variance, simple linear regression, and analysis of covariance. Both parametric and non-parametric techniques are explored. Core concepts are mastered through team-based case studies and analysis of authentic research problems encountered by program faculty and demonstrated in practicum experiences in concert with BIOSTAT 703. Computational exercises will use the R and SAS packages. Prerequisite: 2 semesters of calculus or its equivalent (multivariate calculus preferred). Familiarity with linear algebras is helpful. Corequisites: BIOSTAT 701, BIOSTAT 703, BIOSTAT 721 Credit: 3. 3 units.

702K. Applied Biostatistical Methods I. This course provides an introduction to study design, descriptive statistics, and analysis of statistical models with one or two predictor variables. Topics include principles of study design, basic study designs, descriptive statistics, sampling, contingency tables, one- and two-way analysis of variance, simple linear regression, and analysis of covariance. Both parametric and non-parametric techniques are explored. Core concepts are mastered through team-based case studies and analysis of authentic research problems encountered by program faculty and demonstrated in practicum experiences in concert with BIOSTAT 703. Computational exercises will use the R and SAS packages. Prerequisite: 2 semesters of calculus or its equivalent (multivariate calculus preferred). Familiarity with linear algebras is helpful. Corequisites: BIOSTAT 701, BIOSTAT 703, BIOSTAT 721 Credit: 3. 3 units.

703. Introduction to the Practice of Biostatistics I. This course provides an introduction to biology at a level suitable for practicing biostatisticians and directed practice in techniques of statistical collaboration and communication. With an emphasis on the connection between biomedical content and statistical approach, this course helps unify the statistical concepts and applications learned in BIOSTAT 701 and BIOSTAT 702. In addition to didactic sessions on biomedical issues, students are introduced to different areas of biostatistical practice at Duke University Medical Center. Biomedical topics are organized around the fundamental mechanisms of disease from both evolutionary and mechanistic perspectives, illustrated using examples from infectious disease, cancer and chronic/degenerative disease. In addition, students learn how to read and interpret research and clinical trial papers. Core concepts and skills are mastered through individual reading and class discussion of selected biomedical papers, team-based case studies and practical sessions introducing the art of collaborative statistics. Corequisites: BIOSTAT 701, BIOSTAT 702 Credit: 3. 3 units.

703L. Introduction to the Practice of Biostatics I Lab. The lab will be an extension of the course. The lab will be run like a journal club. The lab will instruct how to dissect a research article from a statistical and scientific perspective. The lab will also give students the opportunity to present on material covered in the co-requisite and to practice the communication skills that are a core tenant of the program. Corequisite: BIOSTAT 703 or permission of the Director of Graduate Studies. 0 units.

704. Introduction to Statistical Theory and Methods II. This course provides formal introduction to the basic theory and methods of probability and statistics. It covers topics in statistical inference, including classical and Bayesian methods, and statistical models for discrete, continuous and categorical outcomes. Core concepts are mastered through mathematical exploration, simulations, and linkage with the applied concepts studied in BIOSTAT 705. Prerequisite: BIOSTAT 701 or its equivalent. Corequisites: BIOSTAT 705, BIOSTAT 706 Credit: 3. 3 units.

704L. Advanced Statistical Theory and Method II Lab. Students who enroll in BIOS 704 may opt to enroll in this advanced lab designed to extend the material presented in BIOS 704. This course will be run as a mixture of lecture and recitation. Each session will start with a short presentation by the instructor of advanced examples that extend the material presented during that week's BIOS 704 lecture. Each session will conclude with students presenting their solutions to advanced problems assigned the prior week. At the end of the semester, students will take a cumulative exam covering the advanced topics covered during the lab session. 2 units.

705. Applied Biostatistical Methods II. This course provides an introduction to general linear models and the concept of experimental designs. Topics include linear regression models, analysis of variance, mixed-effects models, generalized linear models (GLM) including binary, multinomial responses and log-linear models, basic models for survival analysis and regression models for censored survival data, and model assessment, validation and prediction. Core concepts are mastered through statistical methods application and analysis of practical research problems encountered by program faculty and demonstrated in practicum experiences in concert with BIOSTAT 706. Computational examples and exercises will use the SAS and R packages. Prerequisite(s): BIOSTAT 702 or its equivalent; linear and matrix algebra Corequisite(s): BIOSTAT 704, BIOSTAT 706, BIOSTAT 722 Credits: 3. 3 units.

706. Introduction to the Practice of Biostatistics II. This course revisits the topics covered in BIOSTAT 703 in the context of high-throughput, high-dimensional studies such as genomics and transcriptomics. The course will be based on reading of both the textbook and research papers. Students will learn the biology and technology underlying the generation of "big data", and the computational and statistical challenges associated with the analysis of such data sets. As with BIOSTAT 703, there will be strong emphasis on the development of communication skills via written and oral presentations. Prerequisite: BIOSTAT 703 Corequisites: BIOSTAT 704, BIOSTAT 705 Credit: 3. 3 units.

707. Statistical Methods for Learning and Discovery. This course surveys a number of techniques for high dimensional data analysis useful for data mining, machine learning and genomic applications, among others. Topics include principal and independent component analysis, multidimensional scaling, tree-based classifiers, clustering techniques, support vector machines and networks, and techniques for model validation. Core concepts are mastered through the analysis and interpretation of several actual high dimensional genomics datasets. Prerequisites: BIOSTAT 701, 702, 704, 705, and 721 or 722 or permission of The Director of Graduate Studies. Credit: 3. 3 units.

708. Clinical Trial Design and Analysis. Topics include early phase through late phase clinical trials, including two-stage, Simon's optimal design, parallel group, crossover, cluster randomized, and adaptive designs. Objectives such as endpoint selection, dose range, maximum tolerated dose, non-inferiority, surrogate outcomes, and safety will be considered. Methods for group sequential testing, will include fixed group sequential, O'Brien-Fleming, Pocock, one-sided, Tsiatis, Whitehead triangular and other tests. Wang method, repeated confidence intervals, and a range of related topics in monitoring trials. Prerequisites: BIOSTAT 701, 702, 704, 705 and 721 or 722 or permission of the Director of Graduate Studies. Credits: 3. 3 units.

709. Observational Studies. Methods for causal inference, including confounding and selection bias in observational or quasi-

experimental research designs, propensity score methodology, instrumental variables and methods for non-compliance in randomized clinical trials. Prerequisites: BIOSTAT 701, BIOSTAT 702, or permission of the Director of Graduate Studies Credits: 3. 3 units.

710. Statistical Genetics and Genetics Epidemiology. Topics from current and classical methods for assessing familiality and heritability, linkage analysis of Mendelian and complex traits, family-based and population-based association studies, genetic heterogeneity, epistasis, and gene-environmental interactions. Computational methods and applications in current research areas. The course will include a simple overview of genetic data, terminology, and essential population genetic results. Topics will include sampling designs in human genetics, gene frequency estimation, segregation analysis, linkage analysis, tests of association, and detection of errors in genetic data. Prerequisites: BIOSTAT 701, BIOSTAT 704, or permission of the Director of Graduate Studies. Credits: 3. 3 units.

712. Clustered Data Designs and Applications. Data collected within clusters are not generally independent and analysis strategies are needed to accommodate this construct. Focus will be on identifying clustered design structures, such as: patients within clinics and measurements over time on the same patient. The course will include design, sample size, and power implications for clustered studies and mechanisms for the analysis and estimation of the factors of interest, including the ICC components. Prerequisites: BIOSTAT 201, BIOSTAT 202, BIOSTAT 204, BIOSTAT 205, or permission of the Director of Graduate Studies Credits: 2. 2 units.

713. Survival Analysis. Introduction to concepts and techniques used in the analysis of time to event data, including censoring, hazard rates, estimation of survival curves, regression techniques, applications to clinical trials. Interval censoring, informative censoring, competing risks, multiple events and multiple endpoints, time dependent covariates; nonparametric and semi-parametric methods. Prerequisites: BIOSTAT 701, 702, 704, 705, and 721 or 722 or permission of the Director of Graduate Studies Credits: 3. 3 units.

714. Categorical Data Analysis. Topics in categorical modeling and data analysis/contingency tables; measures of association and testing; logistic regression; log-linear models; computational methods including iterative proportional fitting; models for sparse data; Poisson regression; models for ordinal categorical data and longitudinal analysis. Prerequisites: BIOSTAT 701, BIOSTAT 702, BIOSTAT 704, BIOSTAT 705, or permission of the Director of Graduate Studies Credits: 3. 3 units.

715. Methods in Non-Parametric Statistics. An introduction to the theory and application of classical non-parametric methods with emphasis on applications to design and analysis of clinical and molecular studies: Classical rank tests; permutation resampling based inference; estimation of statistical functionals; functional Central Limit Theorem; influence functions; empirical distribution function; the jackknife and bootstrap; bias-variance tradeoff; curse of dimensionality; kernel smoothing and spline methods for density and regression estimation; isotonic regression; classical inequalities. Prerequisites: BIOSTAT 201, BIOSTAT 204, or permission of the Director of Graduate Studies Credits: 2. 2 units.

716. Integration of Biomarkers from Molecular and Cell Assays in Clinical Biostatistics. Statistical and computational issues associated with identification and clinical characterization of biomarkers, and integration of molecular and cell assays, including RNA and protein probe expressions, SNPs, copy-number variants, flow-cytometry data and other forms of emerging molecular markers in prognostic and diagnostic models: pre-processing of molecular assays including methods for background correction and normalization within and across experiments; methods for accounting for left and interval truncation in the probe intensities and cell counts; methods for identifying and addressing batch effects; methods for assessing agreement and consistency among assays; methods for assessing sensitivity and specificity of assays; data management and compression methods for high-dimensional data. Prerequisites: BIOSTAT 201, BIOSTAT 204, or permission of the Director of Graduate Studies Credits: 2. 2 units.

717. Stochastic Processes. An introduction to classical stochastic processes with an emphasis on applications in population genetics, molecular and cell biology and evolutionary biology: Random walks; Conditional probability and expectation; discrete Markov chains, branching trees; phylogenetic tree, counting process, Poisson process; renewal process; discrete martingales; Brownian motion; Simulation methods. Prerequisites: BIOSTAT 201, BIOSTAT 204, or permission of the Director of Graduate Studies Credits: 2. 2 units.

718. Analysis of Correlated and Longitudinal Data. Topics include linear and nonlinear mixed models; generalized estimating equations; subject specific versus population average interpretation; and hierarchical models. Prerequisite: Biostatistics 701, 702, 704 and 705 or permission of the Director of Graduate Studies. Credits:3. 3 units.

719. Generalized Linear Models. This class introduces the concept of exponential family of distributions and link function, and their use in generalizing the standard linear regression to accommodate various outcome types. Theoretical framework will be presented but detailed practical analyses will be performed as well, including logistic regression with Poisson regression and extensions. Majority of the course will deal with the independent observations framework. However, there will be substantial discussion of longitudinal/clustered data where correlations within clusters are expected. To deal with such data the Generalized Estimating Equations and Generalized Linear Mixed models will be introduced. An introduction to the Bayesian analysis approach will be presented, time permitting. Prerequisites: Biostatistics 701, 702, 704, 705 and 721 or 722 or Permission of Director of Graduate Studies. Credits:3. 3 units.

720. Master's Project. Completed during a student's final year of study, the master's project is performed under the direction of a faculty mentor and is intended to demonstrate general mastery of biostatistical practice. Prerequisite: Biostatistics 701, 702, 703,704, 705 and 706. Corequisite: Biostatistics 707. 3 units.

721. Introduction to Statistical Programming I (R). This class is an introduction to programming in R, targeted at statistics majors with minimal programming knowledge, which will give them the skills to grasp how statistical software works, tweak it to suit their needs, recombine existing pieces of code, and when needed create their own programs. Students will learn the core of ideas of programming (functions, objects, data structures, input and output, debugging, and logical design) through writing code to assist in numerical and graphical statistical analyses. Students will learn how to write maintainable code, and to test code for correctness. They will then learn how to set up stochastic simulations and how to work with and filter large data sets. Since code is also an important form of communication among scientists, students will learn how to comment and organize code to achieve reproducibility. Programming

techniques and their application will be closely connected with the methods and examples presented in the corequisite course. The primary programming package used in this course will be R. Prerequisite(s): None; familiarity with linear algebras is helpful. Corequisite: BIOSTAT 702. Credits: 3. Instructor: Staff. 3 units.

722. Introduction to Statistical Programming II (SAS). This class is an introduction to programming in SAS, targeted at statistics majors with minimal programming knowledge, which will give them the skills to grasp how statistical software works, tweak it to suit their needs, recombine existing pieces of code, and when needed create their own programs. Students will learn the core of ideas of programming (data step, procedures, ODS, input and output, debugging, and logical design) through writing code to assist in numerical and graphical statistical analyses. Students will learn how to write maintainable code, and to test code for correctness. They will then learn how to set up stochastic simulations and how to work with and filter large data sets. Since code is also an important form of communication among scientists, students will learn how to comment and organize code to achieve reproducibility. Programming techniques and their application will be closely connected with the methods and examples presented in the co-requisite course. The primary programming package focus used in this course will be SAS. Prerequisite(s): None; familiarity with linear algebra is helpful. Co-requisite: BIOSTAT 705. Credit: 3. 3 units.

732. Independent Study. Independent Study is a semester long course focused on mentored research in the practice of biostatistics. Students work with an assigned mentor. This course is only open to students by permission of the Director of Graduate Studies. Instructor: Staff. Variable credit.

740. Continuation. Continuation is a semester-based, noncredit-bearing enrollment status used when a student is continuing scholarly activities with the same mentor. This course is only open to students by permission of the Director of Graduate Studies. Credits: 0. 1 unit.

801. Biostatistics Career Preparation and Development I. The purpose of this course is to give the student a holistic view of career choices and development and the tools they will need to succeed as professionals in the world of work. The fall semester will focus on resume development, creating a professional presence, networking techniques, what American employers expect in the workplace, creating and maintaining a professional digital presence and learning how to conduct and succeed at informational interviews. Practicums in this semester include an informational interviewing and networking practicum with invited guests. Students participate in a professional "etiquette dinner" and a "dress for success" module as well an employer panel. Corequisite(s): BIOSTAT 701 through BIOSTAT 703. Credit: 1. 1 unit.

802. Biostatistics and Career Preparation and Development II. The purpose of this course is to further develop the student's job seeking ability and the practical aspects of job/internship search or interviewing for a PHD program. The goal is to learn these skills once and use them for a lifetime. Modules that will be covered include: Communication skills both written and oral, interviewing with videotaped practice and review, negotiating techniques, potential career choices in the Biostatistics marketplace, and working on a team. This semester includes writing and interviewing practicum, and a panel of relevant industry speakers. Students will leave this course with the knowledge to manage their careers now and in the future. Prerequisite: BIOSTAT 801. Credit: 1. 1 unit.

821. Software Tools for Data Science. A data scientist needs to master several different tools to obtain, process, analyze, visualize and interpret large biomedical data sets such as electronic health records, medical images, and genomic sequences. It is also critical that the data scientist masters the best practices associated with using these tools, so that the results are robust and reproducible. The course covers foundational tools that will allow students to assemble a data science toolkit, including the Unix shell, text editors, regular expressions, relational and NoSQL databases, and the Python programming language for data munging, visualization and machine learning. Best practices that students will learn include the Findable, Accessible, Interoperable and Reusable (FAIR) practices for data stewardship, as well as reproducible analysis with literate programming, version control and containerization. Prerequisite: BIOSTAT 721 and permission of the Director of Graduate Studies. Credits: 3. 3 units.

822. Data Science With R. This course will build on the foundation laid in software tools for data science. The course will explore the flow of a typical data science project from importing, cleaning, transforming and visualizing datasets to modeling and communicating results, within the context of R programming. While the course will include best practices, syntax and idioms specific to R, the focus will be on the process of conducting analysis in a reproducible fashion, writing readable, well-documented code and creating a coherent presentation of results. Prerequisite: BIOSTAT 722 or BIOSTAT 821 or permission of the Director of Graduate Studies. Credits: 3. 3 units.

823. Statistical Program for Big Data. This course describes the challenges faced by analysts with the increasing importance of large data sets, and the strategies that have been developed in response to these challenges. The core topics are how to manage data and how to make computation scalable. The data management module covers guidelines for working with open data, and the concepts and practical skills for working with in-memory, relational and NoSQL databases. The scalable computing module focuses on asynchronous, concurrent, parallel and distributed computing, as well as the construction of effective workflows following DevOps practices. Applications to the analysis of structured, semi-structured and unstructured data, especially from biomedical contexts, will be interleaved into the course. The course examples are primarily in Python and fluency in Python is assumed. Prerequisite(s): BIOSTAT 821 or permission of the Director of Graduate Studies. Credits: 3. 3 units.

824. Case Studies in Biomedical Data Science. This course will highlight how biomedical data science blends the field of biostatistics with the field of computer science through the introduction of 3 to 5 case studies. Students will be introduced to analytic programs typically encountered in biomedical data science and will implement the data science and statistical skills introduced in their previous course work. Prerequisite(s): BIOSTAT 707, 821, 822, and 823 or permission of the Director of Graduate Studies. Credits: 3. 3 units.

900. Current Problems in Biostatistics. Advanced seminar on topics at the research frontiers in biostatistics. Readings of current biostatistical research and presentations by faculty and advanced students of current research in their area of specialization. Instructor: Barnhart. 1 unit.

902. Missing Data Analysis: Theory and Application. Theory and application of missing data methodology, ad hoc methods, missing data mechanism, selection models, pattern mixture models, likelihood-based methods, multiple imputation, inverse probability weighting, sensitivity analysis. Prerequisites: Statistical Science 711, 721, and 732, or consent of instructor. Instructor: Allen. 3 units.

903. Advanced Survival Analysis. Designed for PhD students in Biostatistics or DSS departments who may be interested in conducting methodological research in the area of Survival Data Analysis. Applications of counting process and martingale theory to right censored survival data. Applications of empirical process theory to more general and possibly more complex statistical models using nonparametric analysis of interval-censored data as illustrating examples. After completion, students are anticipated to understand the statistical method papers on survival analysis appearing in top tier statistical journals. Prerequisites: BIOSTAT 701, 704, and 713, or equivalent, or consent of instructor. Instructor: Wu. 3 units.

905. Linear Models and Inference. Introduction to linear models and linear inference from the coordinate-free viewpoint. Topics: identifiability and estimability, key properties of and results for finite-dimensional vector spaces, linear transformations, self-adjoint transformations, spectral theorem, properties and geometry of orthogonal projectors, Cochran's theorem, estimation and inference for normal models, distributional properties of quadratic forms, minimum variance linear unbiased estimation, Gauss-Markov theorem and estimation, calculus of differentials, analysis of variance and covariance. Prerequisite: Biostatistics 906. Instructor: Owzar. 3 units.

906. Statistical Inference. Introduce decision theory and optimality criteria, sufficiency, methods for point estimation, confidence interval and hypothesis testing methods and theory. Prerequisite: Biostatistics 704 or equivalent. Instructor consent required. Instructor: Xie. 3 units.

907. Phase II Clinical Trials. Introduction to diverse statistical design and analytical methods for randomized phase II clinical trials. Topics: Minimax, optimal, and admissible clinical trials Inference methods for phase II clinical trials; clinical trials with a survival endpoint; clinical trials with heterogeneous patient populations; and randomized phase II clinical trials. Instructor consent required. Instructor: Jung. 3 units.

908. Independent Study (Rotations). Faculty directed statistical methodology research. Instructor consent required. Instructor: Barnhart. 1 unit.

909. Internship Course. Student gains practical experience by taking an internship in industry/government and writes a report about this experience. Requires prior consent from the student's advisor and from the Director of Graduate Studies. May be repeated with consent of the advisor and the Director of Graduate Studies. Credit/no credit grading only. Instructor: Barnhart. 1 unit.

910. Career Development and Prep. Student gains a holistic view of career choices and individual development plans including tools they will need to succeed as professionals in the world of work. The curriculum focuses on the unique challenges of PhD candidates and tools needed for successful careers in academia or in industry. May be repeated with consent of the advisor and the Director of Graduate Studies. Instructor: Baker. 1 unit.

911. Advanced Inferential Techniques and Theory. The theory for M- and Z- estimators and applications. Semiparametric models, geometry of efficient score functions and efficient influence functions, construction of semiparametric efficient estimators. Introduction to the bootstrap: consistency, inconsistency and remedy, correction for bias, and double bootstrap. U statistics and rank and permutation tests. Prerequisite: Statistical Science 711 and Biostatistics 906. Instructor: Li. 3 units.

914. Graphical Models for Biological Data. Introduction to probabilistic graphical models and structured prediction, with applications in genetics and genomics. Hidden Markov Models, conditional random fields, stochastic grammars, Bayesian hierarchical models, neural networks, and approaches to integrative modeling. Algorithms for exact and approximate inference. Applications in DNA/RNA analysis, phylogenetics, sequence alignment, gene expression, allelic phasing and imputation, genome/epigenome annotation, and gene regulation. Department consent required. Instructor: Majoros. 3 units. C-L: Computational Biology and Bioinformatics 914

990. Biostatistics Special Topics. Advanced course on topics at the research frontiers in biostatistics. Readings of current biostatistical research and presentations by faculty and advanced students of current research in their area of specialization. Department consent required. Instructor: Staff. 3 units.

Business Administration

Professor Boulding, *Dean*; Professor Bansal, *Director of Graduate Studies*; Professors Amaldoss, Anton, Ariely, Arora, R. Ashton, Bansal, Belloni, Bernstein, Bettman, Brandt, Brav, Breeden, Chartrand, Chatterji, Chen, W. Cohen, Coleman, Cummings, Desai, Fischer, G. J. Fitzsimons, G. M. Fitzsimons, Francis, Gervais, Graham, Harvey, Hsieh, Huber, Kay, Larrick, Lewis, Lopomo, Luce, Marx, Mayew, McAdams, Mela, Moorman, Pekec, Puri, Purohit, Rampini, Robinson, Schipper, Shang, Sitkin, Soll, Song, Staelin, Sun, Ubel, Venkatachalam, Viswanathan, Wade-Benzoni, and Winkler; Associate Professors Adelino, Arlotto, Belenzon, Bennett, Bollinger, Brown, Cieslak, Cutright, Dyreng, Edell, Etkin, Hasan, Linville, McDevitt, Rosette, Schmid, Shang, Swinney, Varas, Vashishtha, and Yang; Assistant Professors Black, Ferracuti, Grennan, Guo, Heater, Indarte, Jiang, Kakkar, Keskin, Makdoumi, Nallareddy, Wei, Xiao, Xu, Xue, and Zhang; Professors Emeriti A. Ashton, Bradley, Burton, Clemen, Keller, Laughhunn, Lewin, Lind, McCann, Moore, Payne, Sheppard, and Zipkin; Research Professor Emeritus Keeney

A PhD is available in this program.

The PhD in business administration prepares candidates for research and teaching careers at leading educational institutions and for careers in business and governmental organizations where advanced research and analytical capabilities are required. The PhD program places major emphasis on independent inquiry, on the development of competence in research methodology, and on the communication of research results. The school offers programs of research and training in the areas of accounting, decision sciences, finance, management and organizations, marketing, operations management, and strategy. The student and the faculty in his/her area determine the specific program of study. Each student completes a comprehensive examination or a major area paper requirement by the

end of their third year. The final requirement is the presentation of a dissertation. The PhD program usually requires five years of work. Refer to the Bulletin of Duke University: The Fuqua School of Business for a complete list of courses and course descriptions. Additional information may be obtained by visiting https://www.fuqua.duke.edu/.

Courses in Business Administration (BA)

901. Game Theory. Basic topics in noncooperative game theory: representations of games in normal and extensive form and solution concepts, including Nash equilibrium, subgame perfect Nash equilibrium, perfect Bayesian equilibrium, sequential equilibrium, perfect equilibrium, proper equilibrium, correlated equilibrium, iterated dominance, and rationalizationibility. Discussion of the relation between the normal and extensive form and the relations among the various solution concepts. Application of interest to the students covered as time permits. Instructor: Marx. 3 units.

910. Bayesian Inference and Decision. Methods of Bayesian inference and statistical decision theory, with emphasis on the general approach of modeling inferential and decision-making problems as well as the development of specific procedures for certain classes of problems. Topics include subjective probability, Bayesian inference and prediction, natural-conjugate families of distributions, Bayesian analysis for various processes, Bayesian estimation and hypothesis testing, comparisons with classical methods, decision-making criteria, utility theory, value of information, and sequential decision making. Instructor: Winkler. 3 units. C-L: Statistical Science 502

911. Convex Optimization. Formulation and structure of convex optimization problems with an emphasis on duality. Extensive treatment of linear optimization. Network flows, discrete optimization, and conic (quadratic and semi-definite) optimization. Motivated by examples from economics, engineering, finance, and statistics. Instructor: Brown. 3 units.

912. Dynamic Programming and Optimal Control. Basic models and solution techniques for sequential decision making under uncertainty. Discrete and continuous time models with finite and infinite planning horizon. Applications drawn from economics, finance, operations management and engineering. Instructor: Sun. 3 units.

913. Choice Theory. This seminar deals with the foundations and applications of the theory of rational choice, including Bayesian decision theory (subjective expected utility) as well as nonexpected utility theory, noncooperative game theory, and arbitrage theory. It will survey the classic literature in the field and discuss the interconnections among its branches; dissect a variety of paradoxes, puzzles, and pathologies; and discuss recent advances and controversies. The goal of this seminar is to equip students with an understanding of both the power and the limits of rational choice theory, so that they can construct as well as critically analyze rational choice applications in a wide variety of social science contexts. It will also suggest some new directions for choice-theoretic research that involve a synthesis of ideas from competing paradigms. Instructor: Nau. 3 units. C-L: Statistical Science 503

915. Stochastic Models. This course is an introduction to the theory of stochastic processes. The course begins with a review of probability theory and then covers Poisson processes, discrete-time Markov chains, martingales, continuous-time Markov chains, and renewal processes. The course also focuses on applications in operations research, finance, and engineering. No prior knowledge of measure theory is required. However, the focus of the course is on the mathematics and proofs are emphasized. Prerequisites: at least a one-semester calculus-based course in probability (MATH340/STAT230 or equivalent). A background in real analysis is helpful. Instructor consent is required. Instructor: Arlotto. 3 units. C-L: Mathematics 742, Statistical Science 715

921. Organization Seminar: A Micro Focus. Individual and small-group behavior in organizations. Theories of motivation, decision making, interpersonal behavior, group processes, and leadership. A variety of research approaches and methods includes presentation of behavioral research by members of The Fuqua School of Business and other researchers. Instructor: Staff. 3 units.

922. Organization Seminar: A Macro Focus. The organization and the subunits which make up the organization. Topics include: contingency theory, institutional theory, and population ecology. Theories of organization, structure, decentralization, divisionalization, functional area integration, task design, incentives and rewards, information systems, and decision rules are developed with an orientation toward their choice and design for high performance. Includes presentation of research by members of The Fuqua School of Business and other researchers. Instructor: Staff. 3 units.

925. Behavioral Decision Theory. Examines the development of research in individual and group decision behavior. Major emphasis is given to theoretical developments and empirical research, with a range of articles assigned for each topic. The basic topic areas include: (1) decision problem structuring, (2) thinking about uncertainties, (3) risk taking, (4) dealing with conflicting values, and (5) combining individual judgments into a group decision. Instructor: Larrick. 3 units. C-L: Psychology 716

931. Accounting Seminar: Empirical. This course focuses on empirical-archival research in accounting, emphasizing the framing of research questions, research design choices and research methods. Examples of topics covered include: the valuation relevance and stewardship roles of accounting information; valuation models; voluntary disclosure and accounting choice; earnings management; tax considerations; effects of accounting standards. Prerequisites: PhD. level courses in microeconomics and finance recommended; basic mathematics background in calculus, statistics and algebra; knowledge of financial accounting (US GAAP or IFRS). Instructor: Schipper. 3 units.

932. Accounting Seminar: Analytical. This course focuses on the economic models underlying information economics-based theories of the usefulness of accounting information. It will discuss a variety of models addressing the role of information in financial markets, in contracting settings, as well as their applications for accounting issues. Prerequisites: PhD level courses in microeconomics, econometrics and finance, MBA level financial accounting course, and BA 931 is required; or approval by instructor on a case-by-case basis. Strong mathematics background in calculus, statistics and algebra. Instructor: Chen. 3 units.

933. Advanced Topics in Accounting. Introduces Accounting PhD students to topics at the forefront of the academic accounting literature. Topics include current advances and trends in both subject matter and methodological issues. The course is designed to prepare students to contribute to the academic accounting profession. Prerequisites: PhD level course in microeconomics and econometrics recommended; basic mathematics background in calculus, statistics and algebra. Instructor: Nallareddy, Dyreng, and Vashishtha. 3 units.

951. Introduction to Financial Economics - Finance I. This course provides an introduction to major concepts and methods in financial economics. Topics covered include choice under uncertainty, consumption and portfolio choice and equilibrium in static and dynamic models, consumption and production based asset pricing models, and asset pricing with asymmetric information and heterogeneity. While its focus is on theoretical foundations, the course equally emphasizes motivational empirical evidence, as well as methodological tools for solving dynamic models and assessing their empirical implications. Instructor: Staff. 3 units.

952. Empirical Corporate Finance - Finance II. This course is intended to introduce students to research topics in empirical corporate finance. The course is roughly divided into two parts. In the first part, we spend considerable amount of time on canonical early papers in corporate finance, most of which deal with the role of various capital market imperfections, such as taxes, moral hazard, or asymmetric information, in the determination of optimal capital structure. We also examine the empirical literature these early papers have spawned. In the second half of the course, we examine a range of current topics in empirical corporate finance and explore the tools used to address these questions. Instructor consent required. Instructor: Staff. 3 units.

953. Corporate Finance Theory - Finance III. This course looks at the foundations of the theory in corporate finance. Topics covered include adverse selection, contracting and agency problems, capital structure, initial public offerings, collateral and corporate finance, bubbles and corporate financing decisions, banking and bank runs, and coordination failures. Applications in corporate finance include optimal capital structure, voting, debt regeneration, investment decisions and market valuation, executive compensation, bank runs, initial public offerings, and secondary public offerings, collateralization and securitization. Instructor: Staff. 3 units.

954. Asset Pricing - Finance IV. This course covers central issues in the field of Asset Pricing. Topics covered in the course include (i) state price representation of dynamic asset pricing models (ii) present value and its implications for financial markets (iii) estimation issues in asset pricing (iv) dynamic consumption based models (v) dynamic household portfolio choice (vi) term structure models (vii) option markets (viii) production and asset prices, and (ix) recent developments in asset pricing. The course covers many of the recent ideas/articles in asset pricing. Prerequisite: None. Instructor: Staff. 3 units.

961. Seminar in Quantitative Research in Marketing. Research in marketing endeavors to explain consumer and firm behaviors and use these to abet managerial decision making. This course surveys quantitative research in marketing, with a focus on statistical and game-theoretic models. The goal of the course is to a) raise students' awareness of this literature and b) stimulate new research interests. By the end of the course, students should be familiar with the key issues and approaches in quantitative marketing, the strengths of these research streams, and the opportunities to extend them. Instructor: Staff. 3 units.

962. Seminar in Consumer Behavior. Examines the development of research in consumer behavior. Major emphasis is given to theoretical developments and empirical research, with a range of articles assigned for each topic. Topics include motivation and personality, perceptual processes, information search, choice processes, attitudes and persuasion, learning, and influence in consumer choice. Instructor: Staff. 3 units. C-L: Psychology 715

964. Experimental Design and Analysis Seminar. Examines issues in the design and analysis of experiments. Emphasis on analysis of variance (ANOVA), starting with the basic ANOVA model and examining multiple factor designs, blocking designs, nested models, within subject designs, repeated measure designs, and analysis of covariance. Instructor: Edell. 3 units.

967. Behavioral Research Methods. This course is designed as a practical introduction to conducting behavioral research, with a special emphasis on experiments. In the class, we introduce the PhD students to (i) the research designs and approaches behavioral researchers utilize most frequently in their careers, (ii) explore how to collect data, (iii) work through the analyses that most modern experimental researchers will need to be fluent with, and (iv) examine best practices in reviewing and writing papers. The intent of the course is to get behavioral researchers up and running as quickly as possible in their graduate careers. Instructor: Chartrand and Fitzsimons. 3 units. C-L: Psychology 719

970. Strategy Seminar on Organizational Design. We study the organization of the firm. The portfolio of theories covered include: transaction cost economics, evolutionary economics, the resource (knowledge) based view of the firm, contingency theory, and institutional theory. We discuss research problems related to: the boundaries of the firm (e.g. 'make' vs 'buy'); the internal division of labor (e.g. coordination across divisions); hierarchy and decision rights (e.g. centralization vs decentralization); incentive and rewards systems (e.g. process vs outcome driven performance metrics); and the interplay between the formal and informal structure of the firm. Instructor: Lecuona Torras. 3 units.

971. Economics of Technical Change and Innovation. This course focuses on technological change, its determinants and consequences. Our objective is to understand the economic determinants and consequences of technical change. However, technical change needs to be understood in a historical context, and consequently, the readings cover both historical description and economic analysis. Though an economics course, it is designed to accommodate students from a range of disciplinary backgrounds. We will highlight the implications of the economics of technological change for the study of corporate strategy, entrepreneurship and public policy. Instructor: Belenzon. 3 units.

972. Topics in Strategy. This course provides an introduction to research on core areas of strategy. The goal of the course is twofold: First, students will get a broad overview of the literature on core theories and topics in strategy. Second, students will learn how to critically review research papers. The course covers the following topics: upper echelon theory, agency problems, transaction cost economics, resource based view, social networks, location choice, agglomeration, international strategy, innovation, and entrepreneurship. Instructor: Arora. 3 units.

981. Revenue Management and Pricing. This course focuses on the application of stochastic modeling and optimization to two fundamental and closely related problems: dynamic pricing, and dynamic allocation of limited resources. We will cover fundamental methods and models in dynamic pricing and revenue management, and explore related literature in operations research, statistics, and economics. The course consists of three modules: (a) dynamic capacity control, (b) dynamic pricing, and (c) demand estimation and the tradeoff between learning and earning. Open only to PhD students; MBA students require instructor consent. A background in stochastic processes, microeconomics, optimization, and dynamic programming is helpful. Instructor consent required. Instructor: Keskin. 3 units.

982. Inventory Theory. This course introduces mathematical models designed to support the management of production, distribution, and inventory, the basic physics of a supply chain. A primary concern is the control of logistics systems: Given a scenario describing supply, demand, and cost factors, what is an effective policy for controlling the system over time? Through careful formulation and analysis of a model of the system, we shall learn how to evaluate the key performance metrics of the system under a given policy, and then to compute an optimal policy. Recommended prerequisite: some familiarity with stochastic processes, optimization, and dynamic programming is essential. Instructor consent required. Instructor: Song. 3 units.

983. Effective Academic Communication. A course designed to help students develop skills that will prepare them for success in their academic career. This is a theory-based, skill-building course. Lectures, readings, and in-class exercises will introduce students to the concepts of effective communication in a variety of settings including the academic job market. Because professional skills develop over time, students will build proficiency through multiple assignments including collaborative and individual presentations. Students will also receive individualized coaching and have opportunities to refine conference presentations or job talks as part of this course. Instructor consent required. Instructor: Lovelace. 1.5 units.

990. Selected Topics in Business. Allows the doctoral student the opportunity to study special topics in management on an occasional basis depending on the availability and interests of students and faculty. Instructor consent required. Instructor: Staff. Variable credit.

996. Curricular Practical Training. This course offers international students an experiential learning opportunity in a U.S. work environment. A paper will follow the practical training. Instructor: Staff. 1 unit.

997. Dissertation Research. For students actively pursuing research on their dissertation. Credit to be arranged. Prerequisite: student must have passed the preliminary examination and have the consent of the director of the doctoral program and instructor. Instructor: Staff. Variable credit.

998. Independent Study. Allows the doctoral student the opportunity to engage in study or tutorial on special topics on an individual basis under the supervision of a faculty member. Credit to be arranged. Prerequisite: doctoral program standing and consent of the director of the doctoral program and instructor. Instructor: Staff. Variable credit.

999. Directed Research. Allows the doctoral student to engage in individual research projects under the supervision of a faculty member. Credit to be arranged. Prerequisite: doctoral program standing and consent of the director of the doctoral program and instructor. Instructor: Staff. Variable credit.

Cell and Molecular Biology

Professor Jinks-Robertson, *Director* (Molecular Genetics and Microbiology); Associate Professor Eroglu, *Director of Graduate Studies* (Cell Biology); 150 participating faculty

This is an admitting program.

A certificate is also available in this program.

The Cell and Molecular Biology (CMB) Program is an admitting umbrella program that provides flexible, multidisciplinary training in a research-intensive and highly collegial environment. The program allows broad exposure to a diversity of research areas before a specific focus is chosen. Prospective students apply for admission to CMB through The Graduate School. In the first year, CMB students take a unique, modular course that provides in-depth exploration of six self-chosen topics in intensive, two-week segments with faculty experts. First-year students also are required to select and successfully complete three lab rotations before choosing a faculty research mentor. The student then affiliates with a degree-granting department/program for completion of the PhD. There are currently 150 training faculty from across the University who are affiliated with the CMB Program and 100 pre-doctoral students. In the first two years of training, students are supported by the CMB Training Grant (NIH T32 GM007184) or by The Graduate School.

Certificate Requirements

CMB students will receive their PhD from the department with which they affiliate and they will receive a certificate in cell and molecular biology for completing the CMB curriculum. The two-year course curriculum includes the following as well as courses recommended or required by the PhD-granting department:

- Cell and Molecular Biology 710A-F for two semesters (12 units)
- Cell and Molecular Biology 764 for four semesters

For additional information, please visit https://cmb.duke.edu.

Courses in Cell and Molecular Biology (CMB)

631. Contemporary Topics in Membrane Biology. 2 units. C-L: see Biochemistry 631; also C-L: Neurobiology 631, Pharmacology and Cancer Biology 631

640. Quantitative Approaches to Biological Problems: From Cartoon Models to System Behavior. This class is aimed at biologists who want to gain an appreciation of how mathematical approaches can supplement experimental approaches. We will teach you how to convert cartoon diagrams to differential equations, and re-familiarize you with some basic concepts from math and physics that help us develop a better intuition of how the world works. Then we will discuss how quantitative approaches can yield insights into how control systems behave. The class will use calculus at an elementary level and an occasional computer simulation, but we will focus more on concepts and applications. Instructor: Lew. 3 units. C-L: University Program in Genetics 640

658. Structural Biochemistry I. 2 units. C-L: see Biochemistry 658; also C-L: Cell Biology 658, University Program in Genetics 658, Structural Biology and Biophysics 658, Computational Biology and Bioinformatics 658

710A. Cell & Molecular Biology Module I. One of six mini-courses offered sequentially during the Fall semester and together cover 24 topics. These are the core offerings of the Cell & Molecular Biology Program and allow maximum flexibility for a student-

designed curriculum. Four different topics are available during each mini-course and students choose one. Topics reflect the expertise of the corresponding faculty and emphasize either in-depth critical discussion of the primary literature or quantitative/mathematical approaches to addressing biological questions. Each mini-course lasts for two weeks, with three meetings per week. Instructor: Fox, Di Talia. 1 unit.

710B. Cell & Molecular Biology Module II. One of six mini-courses offered sequentially during the Fall semester and together cover 24 topics. These are the core offerings of the Cell & Molecular Biology Program and allow maximum flexibility for a student-designed curriculum. Four different topics are available during each mini-course and students choose one. Topics reflect the expertise of the corresponding faculty and emphasize either in-depth critical discussion of the primary literature or quantitative/mathematical approaches to addressing biological questions. Each mini-course lasts for two weeks, with three meetings per week. Instructor: Fox, Di Talia. 1 unit.

710C. Cell & Molecular Biology Module III. One of six mini-courses offered sequentially during the Fall semester and together cover 24 topics. These are the core offerings of the Cell & Molecular Biology Program and allow maximum flexibility for a student-designed curriculum. Four different topics are available during each mini-course and students choose one. Topics reflect the expertise of the corresponding faculty and emphasize either in-depth critical discussion of the primary literature or quantitative/mathematical approaches to addressing biological questions. Each mini-course lasts for two weeks, with three meetings per week. Instructor: Fox, Di Talia. 1 unit.

710D. Cell & Molecular Biology Module IV. One of six mini-courses offered sequentially during the Fall semester and together cover 24 topics. These are the core offerings of the Cell & Molecular Biology Program and allow maximum flexibility for a student-designed curriculum. Four different topics are available during each mini-course and students choose one. Topics reflect the expertise of the corresponding faculty and emphasize either in-depth critical discussion of the primary literature or quantitative/mathematical approaches to addressing biological questions. Each mini-course lasts for two weeks, with three meetings per week. Instructor: Fox, Di Talia. 1 unit.

710E. Cell & Molecular Biology Module V. One of six mini-courses offered sequentially during the Fall semester and together cover 24 topics. These are the core offerings of the Cell & Molecular Biology Program and allow maximum flexibility for a student-designed curriculum. Four different topics are available during each mini-course and students choose one. Topics reflect the expertise of the corresponding faculty and emphasize either in-depth critical discussion of the primary literature or quantitative/mathematical approaches to addressing biological questions. Each mini-course lasts for two weeks, with three meetings per week. Instructor: Fox, Di Talia. 1 unit.

710F. Cell & Molecular Biology Module VI. One of six mini-courses offered sequentially during the Fall semester and together cover 24 topics. These are the core offerings of the Cell & Molecular Biology Program and allow maximum flexibility for a student-designed curriculum. Four different topics are available during each mini-course and students choose one. Topics reflect the expertise of the corresponding faculty and emphasize either in-depth critical discussion of the primary literature or quantitative/mathematical approaches to addressing biological questions. Each mini-course lasts for two weeks, with three meetings per week. Instructor: Fox, Di Talia. 1 unit.

733. Experimental Design and Biostatistics for Basic Biomedical Scientists. 2 units. C-L: see Pharmacology and Cancer Biology 733; also C-L: Neurobiology 733, Biomedical Engineering 733, Molecular Cancer Biology 733

764. Cell and Molecular Biology Colloquium. Required of all CMB students. Presentations by upper-year students: one student talks about ongoing dissertation research and another introduces a research paper relevant to that week's seminar. Students attend the Thursday seminar (Cell Structure and Function) and can have lunch with the speaker. Credit is based on attendance. Instructor: Eroglu. 2 units.

797. Modern Techniques in Molecular Biology. This course introduces the fundamental laboratory techniques used in basic research. The course covers proteins, antibodies, reverse-phase protein arrays technique, protein interactions, proteomics, flow cytometry, x-ray crystallography, microscopy, DNA and RNA techniques, the novel CRISPR technology, animals in research, IACUC regulations, xenograft applications, and zebrafish models. This course is built around a team-based learning model. Course reading material and lecture materials will be provided to students to review before class, and class time is spent learning and reinforcing the material through interactive lectures and group discussion. Instructor: Kwatra. 3 units.

Cell Biology

Professor Soderling, *Chair*; Associate Professor Bagnat, *Director of Graduate Studies*; Professors Capel, Caron, Endow, Erickson, Hogan, McIntosh, Nicchitta, Poss, Reedy, and Soderling; Associate Professors Bagnat, Eroglu, Klingensmith, Kuo, and Vigna: Assistant Professors Di Talia, Yildirim, and Tata; Associate Research Professors Barak, Jakoi, and Le Furgey; Assistant Research Professors Carbrey and Perez-Edwards

A PhD is available in this department.

The Department of Cell Biology offers graduate training in cell and molecular biology, developmental biology, and physiology. Molecular cell biology research interests include molecular mechanisms of signal transduction, the cytoskeleton, motor proteins, cell motility, cell polarity, mechanisms of muscle contraction, membrane biophysics, tissue morphogenesis, tissue regeneration, mRNA localization, synapse formation, neural circuitry, stem cell biology, and the genetic/cellular basis of disease. A number of cell biology faculty address cell biology in the context of developing organisms such as mouse, zebrafish, and fly. Developmental interests include germ and stem cells and stem cells, neuronal specification and pathfinding, sex determination, development of the gonad, gut, lung, heart, head and neural tube, and appendage and heart regeneration. Specific interests in cellular, organ, and systemic physiology include neuromuscular junctions, the cellular basis of addiction and innate immunity, as well as heart, lung, gut, muscle, and reproductive organ function. The department has excellent facilities, including a state-of-the-art confocal microscopy suite with time-lapse live cell video

imaging, Typhoon Trio phosphorimaging station, four-color fluorescent scanning/multiplexing, zebrafish facility, and mouse genetics.

The Department of Cell Biology participates in several university-wide interdisciplinary training programs, including genetics, cell and molecular biology, developmental biology, neurobiology, pharmacology, cancer biology, biomedical engineering, and toxicology. Admission to graduate training in cell biology is through one of these interdisciplinary training programs. For more information, contact the director of graduate studies.

Courses in Cell Biology (CELLBIO)

658. Structural Biochemistry I. 2 units. C-L: see Biochemistry 658; also C-L: Cell and Molecular Biology 658, University Program in Genetics 658, Structural Biology and Biophysics 658, Computational Biology and Bioinformatics 658

659. Structural Biochemistry II. 2 units. C-L: see Biochemistry 659; also C-L: Computational Biology and Bioinformatics 659, Structural Biology and Biophysics 659, University Program in Genetics 659

668. RNA Biology: Co-Transcriptional and Post-Transcriptional Control of Gene Expression. 3 units. C-L: see Biochemistry 668; also C-L: University Program in Genetics 668

680. Molecular Cardiovascular Biology. 2 units. C-L: Pharmacology and Cancer Biology 680

701. Human Structure and Function. Core course of preclinical curriculum presents scientific principles underlying structure and function of the normal human body. Focuses on gross anatomy, microscopic anatomy, and physiology of nine organ systems providing the foundation for the practice of medicine. Registration of non-Pathologist's Assistant students requires permission of Course Director. Instructor: Jakoi and Staff. 12 units.

710. Papers and Grant Writing Workshop. Introduction to grant and fellowship writing; writing assignment of two proposal topics; evaluation and critique of proposal by fellow students. Instructor: Soderling. 3 units. C-L: Neurobiology 710, Molecular Cancer Biology 710, Pharmacology and Cancer Biology 710

730. Stem Cell Course. The course is designed for first-year graduate students to learn the fundamentals of stem cell biology and to gain familiarity with current research in the field. The course will be presented in a lecture and discussion format based on the primary literature. Topics include: stem cell concepts, methodologies for stem cell research, embryonic stem cells, adult stem cells, cloning and stem cell reprogramming and clinical applications of stem cell research. Prerequisites: undergraduate level cell biology, molecular biology, and genetics. Instructors: Hogan, Kuo, and Poss. 3 units. C-L: Molecular Cancer Biology 730, Pharmacology and Cancer Biology 730

761. Cellular Signaling Module I: GPCR Signaling and Disease. This module will cover the basic mechanism of signal transduction through G protein coupled receptors (GPCR) and how they control a wide array of biological functions from vison to reproduction and are the largest targets of therapeutic interventions. How new concepts in our understanding of their signal transduction mechanisms is leading to the development of new and improve therapies for various disorder. Instructor: Caron and invited lecturers. 1 unit. C-L: Biochemistry 761, Molecular Cancer Biology 761, Pharmacology and Cancer Biology 761

762. Cellular Signaling Module II: Intracellular Signaling and Disease. This module will cover how ion channels and intracellular nuclear receptors control cellular functions mediated through transcription or calcium signaling to regulate physiological processes in health and disease. Instructor: McDonnell and invited lecturers. 1 unit. C-L: Biochemistry 762, Molecular Cancer Biology 762, Pharmacology and Cancer Biology 762

763. Cellular Signaling Module III: Growth Factor Pathway in Development and Disease. The focus of this module is on signaling pathways induced by extracellular factors that regulate growth, survival, and development, and their deregulation in disease including cancer. Among the pathways covered are those regulated by ligand-activated Receptor Tyrosine Kinases, Wnt/beta-catenin signaling, Notch signaling, and Hedgehog signaling. Instructor: Pendergast and invited lecturers. 1 unit. C-L: Biochemistry 763, Molecular Cancer Biology 763, Pharmacology and Cancer Biology 763

791. Research in Cell Biology. Guided independent study and research experience in cell biology. Nature of topic to be decided by individual arrangement with faculty advisor. Prerequisite: consent of faculty advisor. Instructor consent required. Instructor: Staff. Variable credit.

810. Mechanisms of Development/Developmental Genetics. Half-semester minicourse targeted to first-year graduate students in the Biological Sciences. Taught sequentially in the Fall semester with Biology 783. Introduces basic concepts of cell specification, morphogenesis, induction, and other mechanisms that enable cells, tissues and organs to assemble the animal. Emphasis is on model organisms, mainly Drosophila, C. elegans, mouse, and zebrafish, where genomics, mutations, gene modifiers, epistasis analyses, gene knockouts, and transgenesis, plus many other genetic approaches have yielded important insights into the differentiation of cells and the development of complex organisms. Cross-listed with Biology 782. Instructors: Klingensmith and McClay. 2 units. C-L: Biology 782

820. Developmental Genetics. Half-semester mini-course targeted to first year graduate students in the Biological Sciences. Taught sequentially in the Fall semester with Biology 282. Focuses on genetic approaches to solve mechanistic problems of development. Emphasis is on model organisms, mainly Drosophilia, C. elegans, mouse and zebrafish, where genomics, mutations, gene modifiers, epistasis analysis, gene knockouts, and transgenesis, plus many other genetic approaches have yielded important insights into the differentiation of cell and the development of complex organisms. Instructors: Klingensmith and McClay. 2 units. C-L: Biology 783

830. Developmental Biology Colloquium. Instructor: Staff. 3 units.

850. Research. Specific areas of investigation include: membrane structure; extracellular matrix; cell adhesion; cell motility; cytoskeletal elements; chromosome structure and movement; genetics and molecular biology of contractile proteins; muscle ultrastructure; gamete biology; molecular and structural biology of photoreceptors; hormone receptors; cell growth; developmental biology; membrane transport and electrophysiology; metabolism; cardiovascular physiology; microcirculation; hyperbaric physiology; and theoretical studies and computer modeling of physiological processes. Instructor: Staff. Variable credit.

899. Internship. Student gains practical experience related to research project by completing an internship. An internship can be completed if it allows them to gain practical experience in a work environment related to their academic training and enhances their overall academic experience. At the completion of the internship submits a report about this experience to their advisor. Requires prior consent from the student's advisor and from the director of graduate studies. Credit/no credit grading only. Instructor: Staff. 1 unit.

Chemistry

Professor Franz, *Chair*; Associate Professor Charbonneau, *Associate Chair*; Professor Fitzgerald, *Director of Graduate Studies*; Professors Ashby, Baldwin, Becker, Beratan, Craig, Fitzgerald, Franz, Hong, Liu, McCafferty, Rubinstein, Therien, Vo-Dinh, Warren, Widenhoefer, and Yang; Associate Professors Charbonneau, Franklin, MacPhail, Wang, and Wiley; Assistant Professors Derbyshire, Hargrove, Malcolmson, Roizen, and Welsher; Professors Emeriti Arnett, Chesnut, Crumbliss, McPhail, Palmer, Quin, Ramsay-Shaw, and Toone; Associate Professors of the Practice Canelas and Roy; Associate Research Professors Fischer and Yang; Assistant Research Professors Migliore; *Secondary Appointments*: Professors Al-Hashimi, Chilkoti, Curtarolo, Donald, Lefkowitz, Mitzi, Modrich, West, Zauscher, and Zhou; Associate Professors Arya, Blum, Brown, Ferguson, Lu, and Payne; Assistant Professors Lynch and Yokoyama

A PhD is available in this department.

The Department of Chemistry offers graduate work leading to the PhD in chemistry.

While students are normally admitted only to the PhD program, some students do ultimately pursue an MS degree. Entering graduate students should normally have taken an undergraduate degree in chemistry, along with related work in mathematics and physics. Graduate courses are offered in the fields of analytical, biological, inorganic, organic, physical, and theoretical chemistry, and there are active research programs in each of these areas. In addition, chemistry graduate students are also involved in a variety of interdisciplinary research programs, including biological chemistry, toxicology, pharmacology, and molecular biophysics.

Students should complete 22 course credits by the end of the fall semester of the second year of residence. Normally, students will complete a minimum of 12 course credits during their first semester, along with the research orientation seminar (Chemistry 701S). Courses from outside the department may be substituted for chemistry graduate courses, with permission of the director of graduate studies.

Further details concerning the general departmental program, admissions, departmental facilities, the faculty, ongoing research, and financial support may be obtained from the director of graduate studies, email: dgs@chem.duke.edu, or the department's website, https://chem.duke.edu/.

Courses in Chemistry (CHEM)

501. Analytical Chemistry. Fundamental considerations of chemical measurements, optical spectroscopy, mass spectrometry, and separation methods. Instructor: Fitzgerald. 4 units.

506. Biomolecular Mass Spectrometry. Advanced topics in the mass spectral characterization of biopolymers with an emphasis on protein and DNA analysis. Fundamental and practical aspects of the ionization processes and the instrumentation associated with MALDI- and ESI-Mass spectrometry discussed along with applications of these techniques to structural problems in chemistry and biochemistry. Prerequisite: Chemistry 501 or consent of instructor. Instructor: Fitzgerald. 2 units.

511. Chemistry of Biomolecular Interactions. Chemistry of the noncovalent interactions governing biological systems. Topics include: review of biomacromolecules; chemical principles of non-covalent interactions and the use of model systems; experimental methods to determine binding interactions; interactions responsible for molecular recognition in biological systems; and applications in signal regulation. Recommended precursor to Chemistry 518. Instructor: Hargrove. 4 units.

517. Molecules in Life and Disease. Molecules are an essential component of life as they dictate our development, enable adaptation to our environment, and carry our thoughts. This course explores the roles of molecules in normal physiological functions and disease states ranging from genetic disorders to those caused by deadly toxins, such as anthraxin toxin. Case studies on bacterial pathogenesis, drug resistance and modern drug development are among the topics that will be discussed. Prerequisites: Organic Chemistry and Introductory Biology or consent of instructor. Instructor: Derbyshire. 4 units.

518. Chemical Biology. The application of chemical concepts and methods to solving problems in molecular and cell biology, with emphasis on the use of small molecules to elucidate and control information transfer in biological systems. Provides relevant background on both useful chemical tools and new biological targets. Instructors: Hong, McCafferty, and Wang. 4 units.

521. Inorganic Chemistry. Bonding and spectroscopy, reactions, transition metal chemistry, main group chemistry, organometallics/catalysis, and solid state. Instructors: Franz and Therien. 4 units.

524. Bioinorganic Chemistry. Topics covered include metal activated enzymes in hydrolysis, oxygencarriers, nitrogen fixation, iron storage and transport, photosynthesis, protein electron transfer, and DNA mediated electron transfer. Instructors: Franz and Therien. Variable credit.

526. Inorganic Reaction Mechanisms. A discussion of the mechanism of coordination reactions in solution. Examples include redox reactions and linear free energy relationships. Instructor: Staff. 2 units.

531. Organic Chemistry. Bonding and structure, stereochemistry, conformational analysis, substitution, addition, and elimination reactions, carbon reactive intermediates, concerted reactions, photochemistry, carbon alkylation, carbonyl addition nucleophilic substitution, electrophilic additions, reduction, cycloadditions, rearrangements, main group organometallics, oxidation. Instructors: Baldwin, Craig, Hong, and Widenhoefer. 4 units.

532. Organic Reactions. Highlights strategic operations that enable selective synthesis of small molecules, including organic ligands, natural products, and molecular probes. Topics include chemical synthesis and retrosynthetic analysis; arrow-pushing mechanisms of polar, radical, transition metal-mediated and pericyclic reactions; protecting groups, oxidation, reduction, enolate reactivity; stereoselective reactions and conformational analysis; cross-coupling transformations. Instructor: Hong and Roizen. 4 units.

533. Nuclear Magnetic Resonance. Structural elucidation of organic and inorganic compounds by NMR. Fundamentals of data acquisition (pulse sequences, detection), multidimensional techniques, study of dynamic processes and their application to the determination of structure. Instructors: Baldwin and Widenhoefer. Variable credit.

534. Physical Organic Chemistry. Reactive intermediates: carbocations, carbanions, carbenes radicals, photochemistry. Prerequisite: Chemistry 531. Instructor: Craig. 4 units.

535. Organic Synthesis. Application of organic reactions to the synthesis of structurally and biologically interesting compounds. Topics include synthetic design, retrosynthetic analysis, synthetic methods, and total syntheses of natural products. Prerequisite: Chemistry 532 or consent of instructor. Instructor: Baldwin and Hong. 4 units.

536. Bioorganic Chemistry. Basic enzymology, mechanisms of enzymatic reactions, cofactors, oxidoreductases, C1 chemistry, carbon-carbon bond formation, carboxylation/decarboxylation, heme, pyridoxal enzymes, thiamine enzymes. Prerequisite: Chemistry 331 or equivalent. Instructor: McCafferty. 4 units. C-L: Biochemistry 536

538. Organometallic Chemistry and Catalysis. Introduction to the structure and bonding of organometallic and coordination complexes, stressing the origin of metal-ligand interactions from a molecular orbital theory perspective. Elementary reactions of transition metal complexes and their application to organic synthesis, with special emphasis on catalytic reactions. General concepts of catalysis and the advantages and benefits of catalytic systems. Instructor: Malcolmson. 4 units.

541. Quantum Chemistry. Foundations and approximate methods in quantum chemistry, with an emphasis on their applications to molecular structure and modeling. Instructors: Beratan, Liu, MacPhail, Warren, and Yang. 4 units.

542. Quantum Mechanics. Special emphasis on chemical applications. Topics include: linear algebra, the uncertainty relations, angular momentum, perturbation theory, time-dependent phenomena, molecules in electromagnetic fields, group theory, and electron correlation. Prerequisite: Chemistry 541 or consent of instructor. Instructors: Beratan, Warren, and Yang. 4 units.

543. Statistical Thermodynamics. Introduction to statistical thermodynamics, with an emphasis on ideal systems and selected model approaches to more complex systems, for example, lattice models. Instructors: Beratan, Charbonneau, MacPhail, and Yang. 2 units.

544. Statistical Mechanics. Fundamentals of quantum and classical statistical mechanics using the ensemble approach. Introduction of modern techniques and applications including the renormalization group treatment of phase transitions and linear response theory of time-dependent statistical mechanics. Prerequisite: Chemistry 543 or consent of instructor. Instructors: Beratan, Charbonneau, MacPhail, and Yang. 4 units.

548. Solid-State and Materials Chemistry. Introduction to the structure, physical, and electronic properties of solid-state materials. Instructor: Liu, Franklin, and Wiley. 4 units.

590. Special Topics in Chemistry. Special topics in chemistry and chemistry-related areas. Content varies by instructor. Instructor: Staff. Variable credit.

590-1. Special Topics in Chemistry. Special topics in chemistry and chemistry-related areas. Content varies by instructor. Instructor: Staff. 2 units.

601. Biosensors. Theory and applications of biosensors. Basic principles of interactions between analytes and bioreceptors and various transduction techniques: optical, electrochemical, ion-selective electrode-based, voltametric, conductometric, and mass-sensitive techniques as well as novel nanotechnology-based biosensing systems including nanosensors, plasmonic nanoprobes, quantum dots, carbon nanotubes, molecular beacons, and molecular sentinel systems. Applications in chemical, environmental, biological and medical sensing. Paired with Biomedical Engineering 567. Prerequisites: senior or graduate standing or instructor's consent. Instructor: Vo-Dinh. 3 units.

611. Foundations of Nanoscale Science and Technology. 3 units. C-L: see Nanosciences 511; also C-L: Electrical and Computer Engineering 511

630. Advances in Photonics (GE, IM). 3 units. C-L: see Biomedical Engineering 555

701S. Research Orientation Seminar. A survey of departmental research. Required of all entering graduate students in chemistry. Consent of director of graduate studies required. Instructors: All members of the graduate staff. 1 unit.

760S. Seminar. One hour a week discussion. Credit/no credit grading only. Instructors: All members of the graduate staff. 1 unit.

801. Research. Instruction in methods used in the investigation of original problems. Individual work and conferences. 1 to 6 units each. Instructors: All members of the graduate staff. Variable credit.

990-0. Special Topics in Analytical Chemistry. Advanced topics and recent developments in analytical chemistry. Instructor: Staff. Variable credit.

990-1. Special Topics in Biological Chemistry. Advanced topics and recent developments in biological chemistry. Instructor: Staff. Variable credit.

990-2. Special Topics in Inorganic Chemistry. Advanced topics and recent developments in inorganic chemistry. Instructor: Staff. Variable credit.

990-3. Special Topics in Organic Chemistry. Advanced topics and recent developments in organic chemistry. Instructor: Staff. Variable credit.

990-4. Special Topics in Physical Chemistry. Advanced topics and recent developments in physical chemistry. Variable credit. Instructor: Staff. Variable credit.

995. Graduate Training Internship. Designed to allow graduate student in Chemistry to engage in internship lab work and

doctoral study with external agencies and institutions for credit, when determined necessary for degree completion. Laboratory work and analysis can be conducted at external institution with permission of immediate faculty supervisor. Permission of instructor required. Instructor: Staff. 1 unit.

Classical Studies

Professor Johnson, *Chair*; Associate Professor Sosin, *Director of Graduate Studies*; Professors Boatwright, Davis, Forte, Janan, and Johnson; Associate Professors Atkins, González, Sosin, and Woods; Assistant Professor Jiménez; Professors Emeriti Antonaccio, Burian, Newton, Rigsby, and Stanley; Adjunct Professors Dillon (Art, Art History & Visual Studies), Ferejohn (Philosophy), and Lieber (Religious Studies)

A PhD is available in this department.

The Department of Classical Studies offers graduate work leading to the PhD in Classical studies.

Work in the department encompasses all aspects of the Greco-Roman world: students in the program are able, through coursework, directed research, and their own teaching, to prepare for careers of teaching and research as broadly trained classical scholars. For regular admission, students should offer at least three years of college study in one of the classical languages and two in the other. Before developing a specialization within the program, students are expected to acquire facility in both Greek and Latin, a broad knowledge of the literatures and of ancient history and archaeology, and command of research methods. Reading knowledge of French and German is required for the PhD. There are no specific course requirements for the PhD in Classical studies, but students normally complete their coursework by the end of the fifth semester. The resources of the department include important collections of Greek and Latin manuscripts and papyri, and a study collection of Greek and Roman art.

For additional information and further details on graduate courses offered, visit https://classicalstudies.duke.edu.

Courses in Classical Studies (CLST)

524S. Greek History from the Bronze Age to the Fifth Century BCE. Study of Greek history from the Bronze Age to the fifth century BCE via survey, case-studies, or a combination of both. Offerings might include Fifth-century Greece, Archaic Greece, The Athenian Empire, Western Greeks, Ancient Democracy, *vel sim*. Instructor: Johnson or Sosin. 3 units. C-L: History 533S

528S. Greek History: Fifth through First Centuries BC. Studies in later Greek History from the fifth through first centuries BC. Coverage within these chronological boundaries via survey, case-studies, or a combination of both. Offerings might include Fourth-century Greece, The Hellenistic World, Ptolemaic Egypt, *vel sim*. Instructor: Johnson or Sosin. 3 units. C-L: History 528S

532. The Roman Republic. The rise of Rome, to its mastery of the Mediterranean; the political, social, and cultural consequences. Instructor: Staff. 3 units. C-L: History 516

532S. Roman History from Romulus to Augustus. Study of Roman history from its earliest beginnings to the age of Augustus. Coverage via survey, case-studies, or a combination of both. Offerings might include The Roman Republic, Conflict of the Orders, Roman Revolution, *vel sim*. Instructor: Staff. 3 units. C-L: History 534S

536. The Roman Empire. The foundation, consolidation, and transformation of Roman rule from Augustus to Diocletian. Instructor: Staff. 3 units. C-L: History 538

536S. Roman History from Augustus through Late Antiquity. Study of Roman history from Augustus to the early medieval period via survey, case-studies, or a combination of both. Offerings might include The Roman Empire, The Julio-Claudians, The Second Sophistic, The Severans, The Third-Century Crisis, Late Antiquity, *vel sim*. Instructor: Staff. 3 units. C-L: History 539S

540S. Roman Coinage: The Materiality of the Roman Economy. New trends in Roman numismatics (from the late Republic to the early Empire, 3rd c. BCE-2nd c. CE). Archaeology from coins. Barter, money and coinage. The introduction of coinage in Rome and the provinces. Making money (coin production), using money (monetary, non-monetary and ritual uses), losing money (coin circulation, hoards, single finds): contextual interpretations. Monetary systems: coins from Rome and coins from the provinces. Coinage and identity. False coinage. Instructor: Jiménez. 3 units. C-L: Art History 549S

541S. Greek Art and Society: Archaic to Classical. 3 units. C-L: see Art History 501S

542S. Greek Art: Hellenistic to Roman. 3 units. C-L: see Art History 502S

543S. The Archaeology of Death: Ritual and Social Structure in the Ancient World. Contextual study of material culture linked to funerary practices and traditions in the ancient Greek or Roman world. Topics may include funerary rituals, the ritualization of space around cities and in the countryside; ancestor cult and ancestor representation; monumental and not so monumental tombs, grave offerings and grave assemblages; public personas and funerary iconography: gender, age, occupation. Death in Greece/Rome and death in the provinces. Instructor: Jiménez. 3 units. C-L: Art History 545S

544L. Introduction to Digital Archaeology. Course studies the radical changes that new methodologies and technologies have wrought in archaeology. Remote sensing technologies, digital tools, virtual reality systems for data recording, documentation, simulation and communication of archaeological data have profoundly changed archaeological field operations. Course surveys the state of the art in: techniques of digital recording and digital documentation; GIS and remote sensing; international case studies in digital archaeology; virtual reality and virtual simulation; Web and digital publications. Instructor: Forte. 3 units. C-L: Art History 547L, Information Science + Studies 544L

546S. Ancient Spain and Portugal: The Roman Provinces of the Iberian Peninsula. Examines how Roman provinces were created and incorporated into the Roman Empire. Investigates traces in ancient visual and material culture of bonds between provinces and Rome. Approaches complex issues of colonialism, change and continuity connected with Roman conquest of new territories in the Mediterranean. Examines monuments and new archaeological data available from Roman Spain and Portugal, selected samples from

other Roman provinces. Instructor: Jiménez. 3 units. C-L: Art History 503S

547S. Roman Provincial Archaeology: The West. Investigates ancient visual and material culture for information about relations between Rome's western provinces (especially Spain) and Rome, from initial, brutal conquest through incorporation. Within an archaeological context we address complex issues, such as colonialism and indigenous change and continuity, as evidence in Rome's conquest of new territories in the Mediterranean. Examines monuments and new archaeological data available from Roman Spain, as well as selected samples from other Roman provinces of the western Mediterranean (Britain, Gaul, and others). Instructor: Jiménez. 3 units. C-L: Art History 520S

550. Principles of Pre-Roman and Etruscan Archaeology. This course is about the study of one of the most important and fascinating civilizations of ancient Italy and of the pre-Indoeuropean world, which deeply influenced the Classical world and the Mediterranean basin. It will involve archaeological study and comparative analyses of pre-urban and urban settlements, the necropoleis, art, art history, language, iconography and cultural assets and archaeological remains of the Etruscan and pre-Roman Italic worlds. Ultimately, the archaeological interpretation of Etruscans and other ancient societies in the first millennium BCE will raise new research questions in the field of Mediterranean and classical archaeology. Instructor: Forte. 4 units.

551S. Principles of Roman Archaeology. Survey of the material culture of the Roman world, from the creation of the first provinces in the Late Republic to the end of the principate under Diocletian (late 3rd c. BCE–late 3rd c. CE). The course analyzes the archaeology of Rome and the provinces from a thematic perspective. Subjects include imperialism and colonization, rural and city landscapes, housing and households, necropoleis, the ancient economy, social identities (such as gender and age) and social structure (slavery). The course addresses various theoretical models to understand, among other topics, the creation and the decline of the empire and incorporates, when possible, hands-on work with artifacts at the Nasher Museum. Instructor: Jiménez. 3 units. C-L: Art History 553S

552. Greek Archaeology Survey, Part 1. The first of a two-part intensive survey of the material culture of the Ancient Greek world in the early period, focusing on the Iron Age and Archaic periods (ca. 1000-480 BC). The course will examine the archaeological evidence for civic, rural, sacred, funerary and domestic activities and will consider the development of architectural, sculptural, and ceramic forms throughout the period in order to understand how material culture both reflects and shapes cultural identity. Various methodological approaches and theoretical models will be introduced, and the distinction of Greek culture from others in the Eastern Mediterranean will be interrogated. Instructor: Morgan. 3 units.

553. Greek Archaeology Survey, Part 2. The second of a two-part intensive survey of the material culture of the Ancient Greek world, this time focusing in the Classical and Hellenistic periods (ca. 480-31 BC). The course will examine the archaeological evidence for civic, rural, sacred, funerary and domestic activities and will consider the development of architectural, sculptural, and ceramic forms throughout the period in order to understand how material culture both reflects and shapes cultural identity. Special attention will be paid to the definition of "Classical" Greek culture and its re-definition in the Hellenistic period. Various methodological approaches and theoretical models will be introduced. Instructor: Morgan. 3 units.

556SL. Roman Topography: Urban Life and Cityscapes in Ancient Rome. Advanced undergraduate and graduate seminar on ancient Rome's great monuments and humble buildings, public spaces and streets, and infrastructure and natural features used by and influencing its inhabitants and visitors from 1st c. BCE to 4th c. CE. We turn to traditional topographical research and new visual technologies alike. Survey of ancient Rome's topographical data and methodologies, followed by student team projects. Course plus lab. Instructor: Staff. 3 units. C-L: Art History 560SL, Visual and Media Studies 570SL

558S. Live Images: Ancient and Medieval Representations of the Divine. 3 units. C-L: see Visual and Media Studies 533S; also C-L: Religion 552S, Medieval and Renaissance Studies 507S

560. Etruscan Cities. Focuses on concept and definition of city in Etruscan society and its socio-political role in territorial organization. Main topics include pre-urban and urban development of Etruscan society, the first settlements, space and rituals, formation and development of Etruscan City States, cities and landscapes, cultural models between Greeks and Etruscans, colonies and emporia, transformations and changes in Roman times. Primary evidence for all the above will be visualization of material remains from antiquity. Instructor: Forte. 3 units. C-L: Art History 561

564S. Toleration, Freedom of Conscience, and Religious Liberty. Explores the ideas of toleration, freedom of conscience, and religious liberty through a careful study of philosophers and theologians in the Roman world, where arguments for these concepts first emerged. Also considers the important contributions of early modern political philosophers and discussions by contemporary theorists. Readings may include Cicero, Seneca, Epictetus, Tertullian, Cyprian, Lactantius, St. Augustine, Spinoza, Locke, Rousseau, Roger Williams, Jefferson, Nussbaum, and Forst. Instructor: Atkins. 3 units. C-L: Political Science 588S, Religion 564S, History 564S

568. The Legacy of Greece and Rome. The reception of classical antiquity—its literature, art and architecture—in subsequent ages, from the early medieval period to the present day. Instructor: Woods. 3 units. C-L: Medieval and Renaissance Studies 648

571S. Ancient Political Philosophy. 3 units. C-L: see Political Science 575S; also C-L: Philosophy 571

572S. Plato. 3 units. C-L: see Philosophy 511S

573S. Aristotle. 3 units. C-L: see Philosophy 512S

580S. Proseminar: Introduction to Classical Studies. Credit/no credit grading only. Instructor: Staff. 3 units.

590S. Special Topics in Greek Art. 3 units. C-L: see Art History 590S-1

590S-1. Special Topics in Greek Archaeology. Focused studies in Greek archaeology on specific themes, assemblages or problems. Offerings might include Homeric Archaeologies, Greek Sanctuaries, Hero Cult, War and Commemoration, Western Greece, vel sim. Instructor: Forte or Jiménez. 3 units. C-L: Art History 590S-11

590SL. Special Topics in Roman Archaeology. Studies in Roman art and archaeology on focused themes, or on particular

assemblages or problems. Offerings might include Art and Architecture of Pompeii, Roman Portraiture *vel sim*. Includes laboratory component. Instructors: Forte or Jiménez. 3 units. C-L: Art History 590SL

690S. Special Topics in Classical Studies. Topic varies from semester to semester. Instructor: Staff. 1 unit.

691. Directed Reading and Research. Credit to be arranged. Instructor: Staff. Variable credit.

724S. Seminar in Ancient History I (Topics). Selected topics. Instructor: Boatwright, Johnson, or Sosin. 3 units.

725S. Women in Antiquity: An Intensive Methodological Introduction. 3 units. C-L: see Art History 725S

728S. Seminar in Ancient History II (Topics). Selected topics. Instructor: Boatwright, Johnson, or Sosin. 3 units.

733L. Virtual Museums: Theories and Methods of Twenty-First-Century Museums. 3 units. C-L: see Visual Arts 733L; also C-L: Computational Media, Arts & Cultures 733L, Information Science + Studies 733L

744S. Archaeology Seminar I (Topics). Selected topics. Instructor: Forte or Jiménez. 3 units.

748S. Archaeology Seminar II (Topics). Selected topics. Instructor: Forte or Jiménez. 3 units.

754S. Greek Sculpture in Athens, Archaic to Roman. 3 units. C-L: see Art History 727S

790. Special Topics in Classical Studies. Special Topics in Classical Studies. Topics vary by semester. Instructor: Staff. 3 units.

808S. Classical Studies Pedagogy. This weekly workshop examines in practical and theoretical terms both traditional and new methods in teaching ancient languages, ancient culture and history, and archaeology, including topics such as the role of technology in and out of the classroom, syllabus design, aims and methods of evaluation, classroom dynamics, lesson planning, teaching resources. Instructor: Staff. 1 unit.

881. Christian Manuscript Culture. 3 units. C-L: see Religion 885; also C-L: History 881

940. Death and Dying in Late Antiquity. 3 units. C-L: see Religion 930 .

Courses in Greek (GREEK)

504. Historians. Investigation of the Greek concept and practice of writing history from the Atthidographers to Agathias, with attention to key themes, periods, historiographical conventions. Authors and works might include Herodotus, Thucydides, Xenophon, Polybius, Diodorus Siculus, Arrian, Appian, Eusebius, Procopius, Agathias. Instructor: Johnson, Sosin, or Staff. 3 units.

508S. Greek Philosophy. Readings of philosophical works (e.g. fragments of the pre-Socratics, Plato's Dialogues, Aristotle's treatises). Prerequisite: Successful completion of at least one 300-level Greek course, or equivalent, or approval of instructor. Instructor: Johnson, González, or staff. 3 units.

512S. Greek Rhetoric and Oratory. Readings of rhetorical speeches and treatises (e.g. Demosthenes, Isocrates, Dio Chrysostom, Libanius, Plato's *Gorgias,* Aristotle's *Rhetoric, Rhetorica ad Alexandrum*); focus on oratory in action, rhetoric as academic discipline or combination of both. Prerequisite: Successful completion of at least one 300-level Greek course or equivalent, or approval of instructor. Instructor: Sosin or staff. 3 units.

516S. Ancient Greek Literary Criticism. Readings from ancient Greek literary criticism (e.g. Aristophanes' Frogs, Aristotle's Rhetoric, Ps.-Longinus, Demetrius, Dionysius of Halicarnassus, Hermogenes, Menander Rhetor); from ancient grammarians (e.g. Aristarchus of Samothrace); from scholia (e.g. to Homer or to Pindar); and from authors, works, and trends in Greek literature under the Roman Empire. Recommended prerequisite: successful completion of at least one 300-level Greek course or equivalent. Instructor: Gonzalez or staff. 3 units.

520S. Greek Epic. Readings in Greek epic, with attention to genre, language, meter, poetics, characterization, narrative structure, ancient and modern interpretations, traditions beyond Greece and Rome, epic poems as codifiers of socially constructed cultural norms, and examination of Greek cultural identity. Authors and works might include the *Iliad,* the *Odyssey,* Apollonius' *Argonautica,* and/or the fragments of the epic cycle. Preqrequisite: Successful completion of at least one 300-level Greek course or equivalent, or approval of instructor. Instructor: González, Johnson, or staff. 3 units.

524S. Greek Lyric. Readings in Greek Lyric, with attention to genre, language, meter, poetics, persona, ancient and modern interpretations, traditions beyond Greece and Rome, and examination of gender and cultural identity. Authors and works include selections from Sappho, Pindar, Bacchylides, Callimachus, Theocritus, the Greek Anthology, and others. Prerequisite: Successful completion of at least one 300-level Greek course, or equivalent, or approval of instructor. Instructor: González or staff. 3 units.

528. Drama. Readings in the dramatic and mimetic genres, especially Attic Tragedy and Comedy, with attention to language, meter, staging, characteristic themes and conventions, and especially the cultural context of ancient drama and its use as an instrument of public ethical and political debate. Authors may include Aeschylus, Sophocles, Euripides, Aristophanes, Menander, Sophron, Herodas, Lycophron. Instructor: Weiberg. 3 units.

534S. Ancient Greek Scholarship: G(r)eeks on Greek. Team-based translation (and web publication) of ancient encyclopedias, lexica, scholia, commentaries, and other ancient scholarly works; most have not been translated into a modern language, so that the work of this class is an immediate, compelling, and citable contribution to scholarship. Instructor: Sosin. 3 units.

551. Elementary Greek for Graduate Students outside Classical Studies. Structure of the language (grammatical forms, syntax, vocabulary, and pronunciation); introduction to reading. The course will feature additional work commensurate with the difference in expectations between undergraduate and graduate classes. This could involve additional reading, additional or differently scoped exam/quiz opportunities or assignments, additional out-of-class meetings, or the like, as consistent with the goals of the class. Instructor: Staff. 3 units.

552. Elementary Greek for Graduate Students outside Classical Studies. Second half of Greek 551-552. The course will feature additional work commensurate with the difference in expectations between undergraduate and graduate classes. This could involve additional reading, additional or differently scoped exam/quiz opportunities or assignments, additional out-of-class meetings, or the like, as consistent with the goals of the class. Prerequisite: Greek 551. Instructor: Staff. 3 units.

580. Survey of Greek Literature. Instructor: Staff. 3 units.

582S. Greek Epigraphy. Introduction to the field of Greek Epigraphy, its history, methods, and place within the field of Classical Studies. Close attention to reading and translation of the variety of inscribed documentary and literary Greek. Instructor: Sosin. 3 units.

586S. Papyrology. Introduction to the field of Greek Papyrology, its history, methods and place within the field of Classical Studies. Close attention to reading and translation of the variety of documentary and/or literary papyrological Greek. Instructor: Johnson or Sosin. 3 units.

653. Intermediate Greek for Graduate Students outside Classical Studies. Readings in classical Attic prose literature. The course will feature additional work commensurate with the difference in expectations between undergraduate and graduate classes. This could involve additional reading, additional or differently scoped exam/quiz opportunities or assignments, additional out-of-class meetings, or the like, as consistent with the goals of the class. Prerequisite: Greek 552 or equivalent. Instructor: Staff. 3 units.

654S. Advanced Intermediate Greek for Graduate Students outside Classical Studies. Introduction to Athenian Drama. The course will feature additional work commensurate with the difference in expectations between undergraduate and graduate classes. This could involve additional reading, additional or differently scoped exam/quiz opportunities or assignments, additional out-of-class meetings, or the like, as consistent with the goals of the class. Prerequisite: Greek 653. Instructor: Staff. 3 units.

691. Directed Reading and Research. Instructor: Staff. Variable credit.

01-G-B

750S. Foundations of Ancient Greek: History, Morphology, Semantics, Syntax, Stylistics. This course takes students through a graduate-level review of common features of ancient Greek. Emphasis will be on developing firm command of vocabulary, syntax, and certain aspects of the history of the language, while also developing an appreciation for elements of stylistics and fluency in reading at sight. Typical components of the course might include elements of historical linguistics, insofar as they illuminate and help with the command of morphology and semantics; practice in composition or similar exercises that nurture firm command of syntax; close reading of texts with a view to elucidation of stylistics; practice in reading at sight. Instructor: Johnson, Gonzalez. 3 units.

764S. Seminar in Greek Literature I (Selected Topics). Selected authors and topics. Instructor: González, Johnson, or Sosin. 3 units.

768S. Seminar in Greek Literature II. Broader themes in Greek Literature. Offerings might focus on themes such as Ancient Scholarship, Praise and Blame, Early Christian Authors. Instructor: González, Johnson, or Sosin. 3 units

Courses in Latin (LATIN)

504S. Selections from Latin Texts/Authors in the Genres of History, Oratory, and/or Philosophy. Detailed study of selections from one or more genres. Typical iterations might investigate Roman concept and practice of writing history from Cato to Ammianus Marcellinus; study of Roman oratory (readings might include Cicero, Quintilian, Tacitus); and/or philosophical texts (readings might include Lucretius, Seneca, Pliny the Elder, Vitruvius, Augustine, Boethius). Instructor: Atkins or staff. 3 units.

508S. Medieval and Renaissance Latin. Detailed study of selections from one or more authors or genres. Selections either constitute a survey of Latin literature from late antiquity through the Renaissance, or focus on specific locations or periods (e.g. Insular Writers, or the Carolingian "Renaissance", or the Long Twelfth Century). Authors and readings might include Augustine, Isidore of Seville, Bede, Einhard, Carolingian poetry, Hrotsvita, the *Carmina Burana,* Heloise and Abelard, Hildegard of Bingen, Petrarch, Lorenzo Valla, Leonardo Bruni. Topics may vary. Instructor: Woods. 3 units. C-L: Medieval and Renaissance Studies 608S

528S. Selections from Latin Texts/Authors in the Genres of Drama, Satire, and/or the Novel. Detailed study of selections from one or more of the genres Drama, Satire, Novel. Authors and readings might include Plautus, Terence, Seneca, Horace, Persius, Juvenal, Petronius, Apuleius. Instructor: Ginsberg or Janan. 3 units.

551. Elementary Latin for Graduate Students outside Classical Studies. Study of the structure of the language (i.e., forms, vocabulary, syntax, and pronunciation); selected readings in prose and poetry. The course will feature additional work commensurate with the difference in expectations between undergraduate and graduate classes. This could involve additional reading, additional or differently scoped exam/quiz opportunities or assignments, additional out-of-class meetings, or the like, as consistent with the goals of the class. Instructor: Staff. 3 units.

552. Elementary Latin for Graduate Students outside Classical Studies. Second half of Latin 551-552. The course will feature additional work commensurate with the difference in expectations between undergraduate and graduate classes. This could involve additional reading, additional or differently scoped exam/quiz opportunities or assignments, additional out-of-class meetings, or the like, as consistent with the goals of the class. Prerequisite: Latin 551. Instructor: Staff. 3 units.

580. Survey of Latin Literature from its Beginnings to Late Antiquity. Instructor: Staff. 3 units.

581S. Latin Prose Syntax and Style. Latin prose composition combined with analysis of the style and syntax of select Latin prose authors. Instructor: Staff. 3 units.

584S. Latin Palaeography. Introduction to the field of Latin Palaeography, its history and methods; also the role of the book in the intellectual life of the medieval and Renaissance periods. Particular emphasis placed on learning to read Latin scripts from antiquity to the Renaissance. Instructor: Woods. 3 units. C-L: Medieval and Renaissance Studies 647S

585S. Latin Epigraphy. Introduction to the field of Latin epigraphy, its history, methods, and place within the field of Classical Studies. Close attention to reading and translation of the variety of inscribed documentary and literary Latin texts, and to the original physical and social contexts of inscriptions. Instructor: Staff. 3 units.

653. Intermediate Latin for Graduate Students outside Classical Studies. Politics and thought in the late Republic: Caesar and Cicero. The course will feature additional work commensurate with the difference in expectations between undergraduate and graduate classes. This could involve additional reading, additional or differently scoped exam/quiz opportunities or assignments, additional out-of-class meetings, or the like, as consistent with the goals of the class. Prerequisite: Latin 552 or equivalent. Instructor: Staff. 3 units.

654. Advanced Intermediate Latin for Graduate Students outside Classical Studies. The culture of Republican and Augustan Rome: selections from Cicero, Catullus, Vergil, Horace, Ovid or similar. The course will feature additional work commensurate with the difference in expectations between undergraduate and graduate classes. This could involve additional reading, additional or differently scoped exam/quiz opportunities or assignments, additional out-of-class meetings, or the like, as consistent with the goals of the class. Prerequisite: Latin 653 or equivalent. Instructor: Staff. 3 units.

655. Refresher Latin for Graduate Students outside Classical Studies. This course is for graduate students who have had high school Latin and want or need a single refresher or preparatory course to transition to advanced (500-level) Latin. It includes grammar review and readings of real (unsimplified) prose and poetry texts not read in high school. The course will feature additional work commensurate with the difference in expectations between undergraduate and graduate classes. This could involve additional reading, additional or differently scoped exam/quiz opportunities or assignments, additional out-of-class meetings, or the like, as consistent with the goals of the class. Recommended prerequisite: at least 3 years of high school Latin (or the equivalent). Instructor: Staff. 3 units.

691. Directed Reading and Research. Credit to be arranged. Instructor: Staff. Variable credit.

01-G-B

764. Seminar in Latin Literature I. Selected authors and topics. Instructor: Atkins, Boatwright, Davis, Janan, or Woods. 3 units.

768S. Seminar in Latin Literature II. Selected authors and topics. Instructor: Atkins, Boatwright, Davis, Janan, or Woods. 3 units.

Cognitive Neuroscience

Associate Professor Egner, *Director of Graduate Studies*

This is an admitting program.

A certificate is also available in this program.

The Cognitive Neuroscience Admitting Program (CNAP) provides an interdisciplinary education in cognitive neuroscience. Cognitive neuroscience uses the techniques and principles of neuroscience to understand the neural and psychological mechanisms that underlie cognitive processes such as attention, perception, memory, decision making, motor control, conscious awareness, and many others. This program is a graduate admitting program designed for students who are interested in broad training that integrates ideas and techniques across this diverse and rapidly growing field. Research experience will provide expertise in the major methods that drive cognitive brain research. Program faculty are drawn from a wide range of departments and programs including psychology and neuroscience, neurobiology, psychiatry, biomedical engineering, philosophy, evolutionary anthropology, computer science, linguistics, neurology, and radiology.

Students who matriculate to the Cognitive Neuroscience Admitting Program do not initially affiliate with any particular department or advisor. They begin by completing broad coursework and laboratory research rotations within the umbrella of the CNAP program. Typical early coursework includes a two-week neuroscience bootcamp followed by a year-long core course in cognitive neuroscience. During their first year, students complete rotations in three laboratories, often chosen because they investigate different research topics or use diverse research methods. During their second year in the program, students select a primary advisor and declare a department with which they will affiliate and complete their degree. Students typically also select a secondary advisor who provides complementary expertise in a relevant research topic. After the degree-granting department has been selected, students become full members of that department, while also remaining affiliated with the CNAP program and participating in its activities. The doctoral degree that is eventually obtained consists of a PhD in the field of the selected department, with a concentration in cognitive neuroscience.

Certificate in Cognitive Neuroscience

Students who matriculate directly into a PhD-granting departmental program also have the opportunity to acquire training in cognitive neuroscience at Duke by means of a certificate program in the field. This program is designed for students whose interests are more focused on studies present within a particular department, but who want to also include training in cognitive neuroscience in their graduate program. In addition to the curricular requirements of their home department, students in the certificate program complete a year-long core course in cognitive neuroscience, and participate in relevant seminars and journal clubs. To enroll in the Cognitive Neuroscience Certificate Program, students must first be admitted to one of the participating departments (see each department's listing for additional information) and then contact the director of graduate studies.

Certificate Requirements

- Must first be admitted to a participating department, i.e., psychology and neuroscience, neurobiology, philosophy, computer science, evolutionary anthropology, or biomedical engineering. For information regarding application to the above departments see their individual websites.
- must complete a year-long core course in cognitive neuroscience
- participate in relevant seminars and journal clubs
- complete curricular requirements of their home department

For additional information and updated instructions, visit https://dibs.duke.edu/centers/ccn/graduate-cnap.

College Teaching

Assistant Dean for Academic Affairs Crumley, *Program Director*

A certificate is available in this program.

The Certificate in College Teaching (CCT) Program, administered within The Graduate School, is available for enrolled PhD students in any department or program of study. This program makes use of both departmental training and resources as well as The Graduate School programming. The certificate in college teaching is being offered in order to recognize and validate professional development activities undertaken by PhD students and add competitiveness and value to PhDs awarded to Duke graduate students.

The goals of the CCT program are to facilitate and recognize graduate students' completion of

- sustained, systematic pedagogical training that promotes;
- current best practices in teaching and learning;
- appropriate use of instructional technology;
- systematic assessment of student learning outcomes;
- a reflective teaching practice including peer observation; and
- development of materials suitable for use in applying for teaching positions after graduation.

Requirements

Coursework

Participants should successfully complete two courses in college teaching. This can include any combination of The Graduate School and/or discipline specific pedagogy courses offered by a department or program.

- Graduate Studies courses
  - Graduate Studies 745: Oral Communication for International Teaching Assistants (parallel course to Graduate Studies 750)
  - Graduate Studies 750: Fundamentals of College Teaching
  - Graduate Studies 755: College Teaching and Course Design (syllabus & materials design, teaching statement)
  - Graduate Studies 760: College Teaching and Visual Communication (graphic and web design for teaching)
  - Graduate Studies 762: Online College Teaching
  - Graduate Studies 765: College Teaching Practicum (video recorded teaching demos)
  - Graduate Studies 770: Topics and Careers in Higher Education (job application materials)
- Departmental pedagogy courses
  - African and African American Studes 780S: Teaching Race, Teaching Gender (cross-listed in Gender, Sexuality, and Feminist Studies, History, and Literature)
  - Biology 705S: Seminar in Teaching College Biology
  - English 890S: 21st Century Literacies: Digital Knowledge, Digital Humanities (cross-listed in Information Science + Studies)
  - English 996: Teaching College English
  - Environment 737: Environmental Education and Interpretation
  - Environment 865SA: Teaching and Course Design (DUML)
  - German 700S: Foreign Language Pedagogy: Theories and Practices
  - History 703S: Focusing on Teaching and Pedagogy
  - Information Science + Studies 640: History and Future of Higher Education
  - Math 771S: Teaching College Mathematics
  - Nursing 543: Facilitating Student Learning (online)
  - Nursing 545: Integrating Technology into Nursing Education (online)
  - Nursing 546: Innovative Curriculum Development in Nursing (online)
  - Nursing 547: Educational Program Evaluation and Accreditation (online)
  - Nursing 548: Test Construction and Item Analysis (online)
  - Nursing 549: Using Qualitative Assessment and Evaluation Strategies (online)
  - Nursing 550: Role of the Nurse Educator: Issues and Challenges (online)
  - Philosophy 795S: Teaching Philosophy
  - Political Science 790: Teaching Politics
  - Religion 996S: Teaching in Religion
  - Religion 885: The Study of Asian Religions (UNC)
  - Romance Studies 700: Theories and Techniques of Teaching Foreign Languages
  - Russian 714: Methods in Teaching Russian
  - Statistical Science 790.04: Special Topics (Teaching Statistics)
  - Gender, Sexuality, and Feminist Studies 820S: The Pedagogy of Women's Studies

Teaching Experience and Observation

Participants should have formal experience teaching a group of students over the course of a term in a classroom or lab setting. Depending on the discipline and department, this could include serving as a teaching assistant with appropriate teaching responsibilities, leading a recitation section or lab, being a co-instructor of a course or being the primary instructor of record. With the approval of the CCT program director, other types of teaching experience may be used to fulfill this program requirement.

Students in the program should participate in teaching observations, both as a teacher being observed and as an observer of others teaching. In their teaching role, participants should be observed by at least two who provide brief written feedback. Observers can be faculty from the participant's department or a related program, The Graduate School staff, trained peer graduate students or others as approved by the program director. Participants should also conduct at least two observations of other faculty or graduate students teaching.

Online Teaching Portfolio

The online teaching portfolio can be created in any web authoring tool the participant is comfortable using (Word Press, Dreamweaver, Google Sites, etc.) It may include a current CV, a teaching statement and other materials as appropriate to the student's discipline. Note that students will create portfolio materials in the college teaching classes and as part of their teaching experience as described above in requirements one and two.

Application Information

Applications can be made at any time for the program, which should take about a year to complete; this may vary, though, as opportunities for gaining teaching experience vary across departments. Typically, PhD students close to or beyond their prelims (or equivalent) would be well-situated to enroll. However, if students have teaching responsibilities early in their program (as in the first or second year), it would make sense to enroll then. The latest that an application can be made is before Drop/Add of the semester in which a PhD student intends to graduate; a much earlier application (as in at least a year or more before) is recommended.

For more information, visit https://gradschool.duke.edu/professional-development/programs/certificate-college-teaching or contact Dr. Hugh Crumley, CCT program director at crumley@duke.edu.

Computational Biology and Bioinformatics

Associate Professor Magwene, *Director* (Biology); Assistant Professor Reddy, *Director of Graduate Studies* (Biostatistics and Bioinformatics); sixty participating faculty

A certificate and a PhD are available in this department.

The Duke University PhD Program in Computational Biology and Bioinformatics (CBB) is an innovative degree program designed to provide rigorous training at the interface of the quantitative and biological sciences. CBB students receive classroom training and engage in original research under the supervision of program faculty, who represent more than eighteen departments spanning biological and computational disciplines in the medical school and main campus.

The CBB Program is explicitly designed to prepare students for the broad and rapidly evolving field of computational biology research. To this end, the curriculum is flexible and tailored to the needs and interests of each student through regular meetings with the Student Advisory Committee, consisting of faculty experts in the various disciplines that make up computational biology on campus.

The CBB core curriculum emphasizes the integration of biology and computation, as reflected in the syllabus of each core course, which includes lectures on quantitative principles and methods along with biological applications. The core courses taken by all CBB students include Computational Biology and Bioinformatics 520, Computational Biology and Bioinformatics 540, and one of Computational Biology and Bioinformatics 561, 662, or 663. In addition to the core courses, all CBB graduate students are expected to take several elective courses, within CBB and outside the program, in areas of biological and quantitative sciences related to their chosen research. In addition, all first and second-year students must register for Computational Biology and Bioinformatics 510S (Computational Biology Seminar) and Computational Biology and Bioinformatics 511 (Journal Club).

Along with this didactic training, faculty supervised research is an integral component of the training program. This begins in the first year when students join faculty-lead research groups for research rotations which provide an introduction to new research problems and methods in an immersive environment. Trainees conduct three rotations in their first year of study and choose a dissertation advisor at the end of the summer of their first year.

For additional information, visit https://genome.duke.edu/education/CBB or email cbbdgs@duke.edu.

Certificate in Computational Biology and Bioinformatics

The Certificate Program in Computational Biology and Bioinformatics is intended for Duke students enrolled in departmental PhD programs who wish to expand their current studies to apply to or include the fields of computational biology and bioinformatics. A student may qualify for the certificate program after completing the following course of study: two out of the three core courses (Computational Biology and Bioinformatics 520, 540, or 561/662/663); one additional computational biology and bioinformatics course and registration for Computational Biology and Bioinformatics 510S seminar for every semester except the semester of graduation.

Courses in Computational Biology and Bioinformatics (CBB)

510S. Computational Biology Seminar. A weekly series of seminars on topics in computational biology presented by invited speakers, Duke faculty and CBB doctoral and certificate students. This course is required for all first and second year CBB students. In addition, all certificate students must register and receive credit for the seminar for four semesters. 1 unit.

511. Journal Club. A weekly series of discussions led by students that focus on current topics in computational biology. Topics of discussion may come from recent or seminal publications in computational biology or from research interests currently being pursued by students. First and second year CBB doctoral and certificate students are strongly encouraged to attend as well as any student interested in learning more about the new field of computational biology. 1 unit.

520. Genome Tools and Technologies. This course introduces the laboratory and computational methodologies for genetic and protein sequencing, mapping and expression measurement. Instructor: Dietrich. 3 units.

540. Statistical Methods for Computational Biology. Methods of statistical inference and stochastic modeling with application to functional genomics and computational molecular biology. Topics include: statistical theory underlying sequence analysis and database searching; Markov models; elements of Bayesian and likelihood inference; multivariate high-dimensional regression models, applied linear regress analysis; discrete data models; multivariate data decomposition methods (PCA, clustering, multi-dimensional scaling); software tools for statistical computing. Prerequisites: multivariate calculus, linear algebra and Statistical Science 611. Instructor: Mukherjee or Schmidler. 3 units. C-L: Statistical Science 613

541. Statistical Genetics. Mechanisms, probability models and statistical analysis in examples of classical and population genetics, aimed at covering the basic quantitative concepts and tools for biological scientists. This module will serve as a primer in basic statistics for genomics, also involving computing and computation using standard languages. Instructor: Staff. 3 units. C-L: Statistical Science 504

550. Computational Structural Biology. 3 units. C-L: see Computer Science 664; also C-L: Statistical Science 614

561. Computational Sequence Biology. 3 units. C-L: see Computer Science 561

561L. Genome Science and Technology Lab (GE, MC). 3 units. C-L: see Biomedical Engineering 561L

573S. Modeling of Biological Systems. 3 units. C-L: see Mathematics 573S; also C-L: Modeling Biological Systems 573S

574. Modeling and Engineering Gene Circuits (GE, MC). 3 units. C-L: see Biomedical Engineering 574

590. Special Topics in Computational Biology. Instructor: Staff. 3 units.

591. Independent Study. Faculty directed experimental or theoretical research. Instructor: Staff. Variable credit.

612. Ethics and Policy in Genomics. 3 units. C-L: see Science & Society 612; also C-L: Public Policy 634

622. Structure of Biological Macromolecules. 3 units. C-L: see Biochemistry 622; also C-L: Structural Biology and Biophysics 622

634. Geometric Algorithms. 3 units. C-L: see Computer Science 634

658. Structural Biochemistry I. 2 units. C-L: see Biochemistry 658; also C-L: Cell and Molecular Biology 658, Cell Biology 658, University Program in Genetics 658, Structural Biology and Biophysics 658

659. Structural Biochemistry II. 2 units. C-L: see Biochemistry 659; also C-L: Cell Biology 659, Structural Biology and Biophysics 659, University Program in Genetics 659

662. Computational Systems Biology. 3 units. C-L: see Computer Science 662

663. Algorithms in Structural Biology and Biophysics. 3 units. C-L: see Computer Science 663

700. Internship. Student gains practical experience by taking an internship in industry, and writes a report about this experience. Requires prior consent from the student's advisor and from the director of graduate studies. May be repeated with consent of the advisor and the director of graduate studies. Credit/no credit grading only. Instructor: Staff. 1 unit.

720. Applications of High-Throughput Sequencing for Genomic Analysis. High-throughput sequencing has revolutionized our ability to study genomic function. In this class, students will learn how to design, perform, and analyze experiments to measure genome-wide changes in chromatin state, transcription factor occupancy, and gene expression. Topics will include approaches for constructing high-throughput sequencing libraries, data quality control, and statistical techniques to measure gene expression and to identify differential activity. Emphasis will be placed on computational analysis and hands on experience. Upon completion, students will have a strong foundation to design and analyze sequencing-based genomic assays in their own research. Prerequisites: Experience working in the UNIX environment and in a programming language of choice. Instructor: Reddy. 3 units.

724L. Differential Expression Proteomics. This course is designed to train and carry out a quantatative differential expression proteomics experiment. The course materials will provide an overview of the fundamentals of protein chemistry and mass spectrometry, as well as detailed information on LC/MS/MS methods for both open platform ('omic) proteomics experiments for biomarker discovery, and targeted LC/MS/MS methods (Mass Spec "Westerns") for biomarker verification/validation. Emphasis will be placed QC metrics and commercial and open source bioinformatics tools for bioinformatic data interpretation. Instructor: Moseley. 1 unit.

726. Dynamic Modeling of Biological Systems. 3 units. C-L: see Biology 726

914. Graphical Models for Biological Data. 3 units. C-L: see Biostatistics 914

06-G-B

85. Deleuze: Cinema and Philosophy. 3 units. C-L: see Literature 850S; also C-L: Visual and Media Studies 850S, English 860S, Romance Studies 850S, Visual Arts 850S, Documentary Studies 850S

564S. Physical Computing. 3 units. C-L: see Visual Arts 564S; also C-L: Information Science + Studies 555S

575S. Generative Media Authorship - Music, Text & Image. 3 units. C-L: see Visual Arts 575S; also C-L: Information Science + Studies 575S, Music 575S

580S. Historical and Cultural Visualization Proseminar 1. 3 units. C-L: see Art History 580S; also C-L: Information Science + Studies 580S

581S. Historical and Cultural Visualization Proseminar 2. 3 units. C-L: see Art History 581S; also C-L: Information Science + Studies 581S

590S. Special Topics in Computational Media, Arts, and Cultures. Topics vary by semester and include subjects, areas, or themes that embrace a range of disciplines in the arts and humanities areas. Instructor: Staff. 3 units.

591. Individual Independent Study. This course is an independent study which encourages students to pursue original/individual research in their academic field within Computational Media, Arts and Cultures. Students will conduct directed research and writing in areas unrepresented by regular course offerings. Students will meet with instructor on a weekly basis to discuss project progress; other requirements are to be determined based on needs of project proposal. Only students with pre-approved project proposals should register for this course. Instructor consent required. Instructor: Staff. 3 units.

592. Individual Independent Study. This course is an independent study that encourages students to pursue original/individual research in their academic field within Computational Media, Arts and Cultures. Students will conduct directed research and writing in areas unrepresented by regular course offerings. Students will meet with instructor on a weekly basis to discuss project progress; other requirements are to be determined based on needs of project proposal. Only students with pre-approved project proposals should register for this course. Instructor consent required. Instructor: Staff. 3 units.

613S. Computational Media Studio in Advanced Digital Practice. 3 units. C-L: see Historical and Cultural Visualization 613S; also C-L: Information Science + Studies 613S

650S. Computational Media, Arts & Cultures Proseminar. This course is an introduction to scholarship at the nexus of theory and practice. It includes theoretical readings in computational media, design, and critique, and focuses on how these inform and provide critical context for practice-based modes of learning and production. Students will learn about various areas of computational media theory and culture, including media archaeology, data and visualization, computation and culture, database and narrative, and data-mining and big data. Students will explore how theoretical approaches can guide and challenge practical work in media design. Students will be oriented to Media Labs and other computationally-based projects around campus. Instructor: Staff. 3 units. C-L: Information Science + Studies 650S, Literature 621S, Art History 537S, Visual and Media Studies 561S

690S. Special Topics in Computational Media, Arts, and Cultures. Subjects, areas, or themes that embrace a range of disciplines in the arts and humanities areas. Instructor: Staff. 3 units.

691. Individual Independent Study. This course is an independent study that encourages students to pursue original/individual research in their academic field within Computational Media, Arts and Cultures. Students will conduct directed research and writing in areas unrepresented by regular course offerings. Students will meet with instructor on a weekly basis to discuss project progress; other requirements are to be determined based on needs of project proposal. Only students with pre-approved project proposals and a faculty mentor should register for this course. Students will not be allowed to register for individual research without a faculty mentor. Instructor consent required. Instructor: Staff. 3 units.

692. Individual Independent Study. This course is an independent study that encourages students to pursue original/individual research in their academic field within Computational Media, Arts and Cultures. Students will conduct directed research and writing in areas unrepresented by regular course offerings. Students will meet with instructor on a weekly basis to discuss project progress; other requirements are to be determined based on needs of project proposal. Only students with pre-approved project proposals should register for this course. Instructor consent required. Instructor: Staff. 3 units.

706. Digital Imaging. 3 units. C-L: see Visual Arts 706

715. Historical Geographic Information Systems (GIS). 3 units. C-L: see Information Science + Studies 715; also C-L: Art History 714

720. Programming and User Interface Design in Unity 3D. 3 units. C-L: see Information Science + Studies 720

720S. Programming and User Interface Design in Unity 3D. 3 units. C-L: see Information Science + Studies 720S

733L. Virtual Museums: Theories and Methods of Twenty-First-Century Museums. 3 units. C-L: see Visual Arts 733L; also C-L: Information Science + Studies 733L, Classical Studies 733L

751S. Digital Storytelling and Interactive Narrative. 3 units. C-L: see Information Science + Studies 751S; also C-L: Literature 751S

758S. Bass Connections: Digital Durham. 3 units. C-L: see Information Science + Studies 758S; also C-L: Education 758S, History 758S

760S. Critical Digital Humanities: Theory and Practice. 3 units. C-L: see Information Science + Studies 760S

766. Media History: Old and New. Development of media forms in historical and social contexts. Impact of old "new" media on established art, commerce, education, politics, entertainment from 19th c on. Changing ideas about authenticity, authority, agency, reception, identity, and power relating to emerging media forms, production, circulation. Overlaps, disjunctures, convergences, persistences and antiquations. Print publishing, photography, audio recording, film, telegraph, maps, exhibitions, architecture and installations; web, multimedia, database, game, virtual reality, and telepresence. Final rich media research project required. Graduate version also requires theoretically and historically informed seminar paper. Instructor: Szabo. 3 units. C-L: Information Science + Studies 768

770S. Constructing Immersive Virtual Worlds. 3 units. C-L: see Information Science + Studies 770S

780S. Visualizing Cities: Representing Urban Landscapes, Cultures, and Environments. 3 units. C-L: see Information Science + Studies 780S

790S. Special Topics in Computational Media, Arts, and Cultures. Topics vary by semester. Subjects, areas, or themes that embrace a range of disciplines in the arts and humanities areas. Instructor: Staff. 3 units.

791. Individual Research Independent Study. This course is an independent study that encourages students to pursue original/individual research in their academic field within Computational Media, Arts and Cultures. Students will conduct directed research and writing in areas unrepresented by regular course offerings. Students will meet with instructor on a weekly basis to discuss project progress; other requirements are to be determined based on needs of project proposal. Only students with pre-approved project proposals should register for this course. Instructor consent required. Instructor: Staff. 3 units.

792. Individual Research Independent Study. This course is an independent study that encourages students to pursue original/individual research in their academic field within Computational Media, Arts & Cultures. Students will conduct directed research and writing in areas unrepresented by regular course offerings. Students will meet with instructor on a weekly basis to discuss project progress; other requirements are to be determined based on needs of project proposal. Only students with pre-approved project proposals should register for this course. Instructor consent required. Instructor: Staff. 3 units.

796L. Media, Arts & Cultures Research Practicum I. Students will be involved in a research apprenticeship to a faculty member for hands-on experience with research efforts. Experience exploring computational media technology applications to interdisciplinary lab-based research projects in the arts and humanities. Graduate-level apprenticeship focused on a specific digital project, with

measurable outcomes based both on project deliverable and demonstrated computational media competencies as shown through weekly progress reports, blogs, and portfolios. Project management and mentoring of undergraduate research teams under the supervision of the faculty advisor. Instructor consent required. Instructor: Szabo. 3 units. C-L: Visual and Media Studies 796L, Historical and Cultural Visualization 796L, Information Science + Studies 796L

797L. Media, Arts & Cultures Research Practicum II. Students will be involved in a research apprenticeship to a faculty member for hands-on experience with research efforts. Experience exploring computational media technology applications to interdisciplinary lab-based research projects in the arts and humanities. Graduate-level apprenticeship focused on a specific digital project, with measurable outcomes based both on project deliverable and demonstrated computational media competencies as shown through weekly progress reports, blogs, and portfolios. Project management and mentoring of undergraduate research teams under the supervision of the faculty advisor. Instructor consent required. Instructor: Staff. 3 units. C-L: Visual and Media Studies 797L, Historical and Cultural Visualization 797L, Information Science + Studies 797L

798L. Media, Arts & Cultures Research Practicum III. Students will be involved in a research apprenticeship to a faculty member for hands-on experience with research efforts. Experience exploring computational media technology applications to interdisciplinary lab-based research projects in the arts and humanities. Graduate-level apprenticeship focused on a specific digital project, with measurable outcomes based both on project deliverable and demonstrated computational media competencies as shown through weekly progress reports, blogs, and portfolios. Project management and mentoring of undergraduate research teams under the supervision of the faculty advisor. Instructor consent required. Instructor: Staff. 3 units. C-L: Visual and Media Studies 798L, Historical and Cultural Visualization 798L, Information Science + Studies 798L

799L. Media, Arts & Cultures Research Practicum IV. Students will be involved in a research apprenticeship to a faculty member for hands-on experience with research efforts. Experience exploring computational media technology applications to interdisciplinary lab-based research projects in the arts and humanities. Graduate-level apprenticeship focused on a specific digital project, with measurable outcomes based both on project deliverable and demonstrated computational media competencies as shown through weekly progress reports, blogs, and portfolios. Project management and mentoring of undergraduate research teams under the supervision of the faculty advisor. Instructor consent required. Instructor: Staff. 3 units. C-L: Visual and Media Studies 799L, Historical and Cultural Visualization 799L, Information Science + Studies 799L

890S. Special Topics in Computational Media, Arts, and Cultures. Topics vary by semester. Subjects, areas, or themes that embrace a range of disciplines in the arts and humanities areas. Instructor: Staff. 3 units.

Computational Media, Arts & Cultures

Professor Seaman, *Director of Graduate Studies*; Professors Calderbank, DeFrantz, Dillon, Forte, Hansen, Johnsen, Lindroth, Seaman, Stiles, Van Miegroet, Vo-Dinh, and Wharton; Associate Professor Supko; Associate Professor of the Practice Cetinkaya-Rundel; Associate Research Professors Lasch and Szabo; Assistant Professor of the Practice Olson; Assistant Research Professor Kopper

A PhD is available in this program.

The Computational Media, Arts & Cultures Program offers graduate work leading to the PhD in computational media, arts & cultures. The doctoral program is meant to be small, experimental, and interdisciplinary. Its focus is on the intersection of media arts and humanities, sciences, and technology, both in theory and in practice. The program is committed to full and equal funding of its students during their time in residence at Duke, up to five years. Admission to the program is usually limited to one new student per year.

The PhD program is affiliated with the interdisciplinary arts and humanities media labs led by the CMAC program faculty. Lab emphases include digital archaeology, emergent media arts, information science + studies, digital art history & visual culture, art, law and markets, digital humanities, media theory, and physical computing. At the core of the program is the computational revolution, and its implications for how humans live, think, work, create, and communicate within and across various disciplines. Critical engagement with the global, social and cultural impact of computational media is a central feature and value of the program, alongside media affordances and effects within existing and emerging fields.

For further information on the PhD program, prospective applicants may visit the program's website at https://cmac.duke.edu/phd or write to the director of graduate studies.

The program also offers a graduate certificate in Computational Media, Arts & Cultures.

The purpose of the IS+S graduate certificate in Computational Media, Arts & Cultures is to offer an interdisciplinary program at the graduate level that focuses on the study and creation of new information technologies and the analysis of their impact on art, culture, science, medicine, commerce, society, policy, and the environment. The program is designed for master's and doctoral students wishing to complement their primary disciplinary focus with an interdisciplinary certificate in CMAC. The goal of the certificate is to broaden the scope of the typical disciplinary PhD program and to engage the student in related research. The graduate certificate is not intended to provide a disciplinary canon but rather to develop a structured set of transdisciplinary skills and resources for exploring new areas of academic research and teaching. As such, the CMAC graduate certificate does not lead students down an existing path of traditional academic research but rather provides them with the means for expanding the scope of their main disciplinary focus by creating new paths of their own.

For further information on the graduate certificate, prospective applicants may visit the Information Science + Studies website at iss.duke.edu or write to the director of graduate studies.

Computer Science

Professor Agarwal, *Chair*; Professor J. Yang, *Associate Chair*; Professor Chase, *Director of Graduate Studies*; Professors Agarwal, Calderbank, Carin, Chase, Conitzer, Cummings, Donald, Groh, Hartemink, Kim, Lebeck, Maggs, Marinos, Mukherjee, Munagala, Parr, Reif, Rudin, Sapiro, Sorin, Sun, Tarokh, Tomasi, Trivedi, and J. Yang; Associate Professors Bartesaghi, Board, Farsiu, Hilton, Lee, Li, Machanavajjhala, Panigrahi, Schmidler, J. Yang, and X. Yang; Assistant Professors Carson, Ge, Gordân, Gorlatova, Heller, Pajic, Randles, Roy, Steorts, Wills, and Zavlanos; Professors Emeriti Biermann, Ellis, Loveland, and Starmer; Associate Professors of the Practice Emeriti Lucic and Ramm; Professors of the Practice Astrachan and Rodger; Associate Professors of the Practice Daily and Forbes; Assistant Professors of the Practice Stephens-Martinez; Adjunct Associate Professor Pitsianis; Adjunct Assistant Professor Konidaris; Adjunct Professors Baldin, Hsu, Kaltofen, Labean, and Patel; Assistant Research Professor Fain; Executive in Residence Quan; Senior Lecturer Duvall

A master's degree and a PhD are available in this department.

The Department of Computer Science offers programs leading to the MS and PhD in computer science, with areas of concentration including algorithms, artificial intelligence, scientific computing and numerical analysis, and systems and architecture. The MS program consists of an option involving coursework only (30 graded course credits) or an option involving a combination of coursework (24 graded and up to 6 ungraded course credits) and a research thesis or project under the supervision of a faculty advisor. The PhD program consists of coursework and a sequence of research milestones culminating in a doctoral dissertation. The PhD course program includes a breadth requirement, satisfied by earning qualifying credit in four of six core areas of subject knowledge. All entering PhD graduate students participate in a special seminar course (Computer Science 701S) to introduce them to the discipline and profession of computer science. A student entering graduate study in computer science should have a strong undergraduate grounding in the fundamentals of calculus, linear algebra, and discrete mathematics, and basic knowledge of data structures, algorithms, and one or more higher-level computing programming languages; some undergraduate research experience is preferred. Students should consult the official departmental document *Computer Science Graduate Program Degree Requirements* for a full explanation of requirements not listed in this bulletin.

Outstanding programs in algorithms and computational complexity; computational geometry; internet systems, networking and security; computer architectures and distributed systems; computational biology; biological computing and nanotechnologies; databases, mobile, and cloud computing; learning and modeling; and artificial intelligence, computational economics, computer vision, sensor networks, and scientific computing provide exciting and challenging research opportunities to students in computer science. The research interests of the department's faculty overlap with these areas and with research areas in other disciplines such as biology, engineering, nanotechnology, environmental sciences, economics, biochemistry, statistics, and medicine.

Courses in Computer Science (COMPSCI)

510. Operating Systems. Fundamental principles of operating system design applied to state-of-the-art computing environments (multiprocessors and distributed systems) including process management (coscheduling and load balancing), shared memory management (data migration and consistency), and distributed file systems. Instructor: Chase, Cox, or Maggs. 3 units.

512. Distributed Systems. Principles and techniques for sharing information and resources in computer networks, ranging from high-speed clusters and data centers to the global Internet. Topics include advanced distributed storage, distributed programming environments, replication, caching and consistency, transactional concurrency control, reliable update and recovery, and issues of scale and security for Internet services. Recommended prerequisite: Computer Science 310 or 510. Instructor: Chase or Maggs. 3 units.

514. Advanced Computer Networks. Entry-level graduate course. Basic systems support for process-to-process communications across a computer network. The TCP/IP protocol suite and the Berkeley sockets application programs interface. The topics include congestion control, packet scheduling, routing, software defined networking, datacenter networks, network function virtualization, programmable switches, network measurement, remote direct memory access, residential networks, peer-to-peer networks, and content distribution networks. Recommended prerequisite: entry-level computer systems course (Computer Science 310, 356, 510); knowledge of the C or Python. Instructor: Maggs or X. Yang. 3 units. C-L: Electrical and Computer Engineering 558

515. Wireless Networking and Mobile Computing. 3 units. C-L: see Electrical and Computer Engineering 556

516. Database Systems. Principles and techniques for making intelligent use of the massive amounts of data generated in commerce, industry, science, and society. Topics include basic concepts in databases (SQL, relational algebra, relational calculus, normal forms), indexing and hashing, query processing and query optimizations, transactions (concurrency control and recovery), parallel and distributed data processing, NOSQL and column store, and selected advanced topics (e.g. Datalog, cloud computing fault-tolerant / self-tuning data management, Web information retrieval/extraction, data warehouse, OLAP, data mining). Prerequisites: Computer Science 316 or an introductory database course or consent of instructor. Instructor: Machanavajjhala, Roy, or J. Yang. 3 units.

520. Numerical Analysis. Error analysis, interpolation and spline approximation, numerical differentiation and integration, solutions of linear systems, nonlinear equations, and ordinary differential equations. Prerequisites: knowledge of an algorithmic programming language, intermediate calculus including some differential equations, and Mathematics 221. Instructor: Sun. 3 units. C-L: Mathematics 565, Statistical Science 612

524. Nonlinear Dynamics. 3 units. C-L: see Nonlinear and Complex Systems 513

527. Introduction to Computer Vision. Image formation and analysis; feature computation and tracking; image, object, and activity recognition and retrieval; 3D reconstruction from images. Prerequisites: Mathematics 221, 218 or 216; Mathematics 212; Mathematics 230 or Statistical Science 230; Computer Science 101; Computer Science 230. Instructor: Tomasi. 3 units.

528. Introduction to Computational Science. Introduction to scientific computing and its applications to facilitate interdisciplinary collaborative research. Brief intro to contemporary high performance computer architectures, basic linear algebra, numerical analysis, programming languages and widely available software packages. Study high performance algorithms in finite elements, fast transforms, molecular dynamics, high dimensional optimization, computational quantum mechanics and visualization. Parallel lab sessions by experts offer further specialization. Prerequisite: programming experience in Fortran or C, calculus, numerical

linear algebra or equivalent. Instructor: Staff. 3 units.

531D. Introduction to Algorithms. Applications include dynamic data structures,graph algorithms, randomized algorithms. Intractability and NP completeness. Prerequisite: Computer Science 201 and 230, or equivalent. Instructor: Agarwal, Ge, Munagala, Panigrahi or Reif. 3 units.

532. Design and Analysis of Algorithms. Design and analysis of efficient algorithms. Algorithmic paradigms. Applications include sorting, searching, dynamic structures, graph algorithms, randomized algorithms. Computationally hard problems. NP completeness. Prerequisites: Computer Science 201 and 330 or equivalent. Instructor: Agarwal, Ge, Munagala, Panigrahi, or Reif. 3 units.

534. Computational Complexity. Turing machines, undecidability, recursive function theory, complexity measures, reduction and completeness, NP, NP-Completeness, co-NP, beyond NP, relativized complexity, circuit complexity, alternation, polynomial time hierarchy, parallel and randomized computation, algebraic methods in complexity theory, communication complexity. Prerequisite: Computer Science 334 or equivalent. Instructor: Agarwal or Reif. 3 units.

550. Advanced Computer Architecture I. Fundamental aspects of advanced computer architecture design and analysis. Topics include processor design, pipelining, superscalar, out-of-order execution, caches (memory hierarchies), virtual memory, storage systems, simulation techniques, technology trends and future challenges. Prerequisite: Computer Science 250 or Electrical and Computer Engineering 350 or equivalent. Instructors: Lebeck, Lee, or Sorin. 3 units. C-L: Electrical and Computer Engineering 552

553. Compiler Construction. 3 units. C-L: see Electrical and Computer Engineering 553

554. Fault-Tolerant and Testable Computer Systems. 3 units. C-L: see Electrical and Computer Engineering 554

555. Probability for Electrical and Computer Engineers. 3 units. C-L: see Electrical and Computer Engineering 555

561. Computational Sequence Biology. Introduction to algorithmic and computational issues in analysis of biological sequences: DNA, RNA, and protein. Emphasizes probabilistic approaches and machine learning methods, e.g. Hidden Markov models. Explores applications in genome sequence assembly, protein and DNA homology detection, gene and promoter finding, motif identification, models of regulatory regions, comparative genomics and phylogenetics, RNA structure prediction, post-transcriptional regulation. Prerequisites: basic knowledge algorithmic design (Computer Science 532 or equivalent), probability and statistics (Statistical Science 611 or equivalent), molecular biology (Biology 118 or equivalent). Alternatively, consent instructor. Instructor: Gordan or Hartemink. 3 units. C-L: Computational Biology and Bioinformatics 561

570. Artificial Intelligence. Design and analysis of algorithms and representations for artificial intelligence problems. Formal analysis of techniques used for search, planning, decision theory, logic, Bayesian networks, robotics, and machine learning. Prerequisite: Computer Science 201 and Computer Science 330. Instructor: Conitzer or Parr. 3 units.

571D. Probabilistic Machine Learning. 3 units. C-L: see Statistical Science 561D; also C-L: Electrical and Computer Engineering 682D

579. Statistical Data Mining. 3 units. C-L: see Statistical Science 622

590. Advanced Topics in Computer Science. Instructor: Staff. 3 units.

624. Nanoscale and Molecular Scale Computing. 3 units. C-L: see Electrical and Computer Engineering 611

630. Randomized Algorithms. Models of computation, Las Vegas and Monte Carlo algorithms, linearity of expectation, Markov and Chebyshev inequalities and their applications, Chernoff bound and its applications, probabilistic methods, expanders, Markov chains and random walk, electric networks and random walks, rapidly mixing Markov chains, randomized data structures, randomized algorithms for graph problems, randomized geometric algorithms, number theoretic algorithms, RSA cryptosystem, derandomization. Prerequisite: Computer Science 532. Instructor: Agarwal, Ge, Munagala, Panigrahi, or Reif. 3 units.

632. Approximation Algorithms. Cover traditional approximation algorithms with combinatorial and linear programming techniques; extended survey of cut problems and metric embeddings; embeddings, dimensionality reduction, locality sensitive hashing, and game theory. Instructor: Agarwal, Munagala, or Panigrahi. 3 units.

634. Geometric Algorithms. Models of computation and lower-bound techniques; storing and manipulating orthogonal objects; orthogonal and simplex range searching, convex hulls, planar point location, proximity problems, arrangements, linear programming and parametric search technique, probabilistic and incremental algorithms. Prerequisite: Computer Science 532 or equivalent. Instructor: Agarwal. 3 units. C-L: Computational Biology and Bioinformatics 634

636. Computational Topology. Introduction to topology via graphs; facts about curves and surfaces; representing triangulations; discussion of simplicial complexes; emphasis on Delaunay and alpha complexes and on homology groups; computational via matrix reduction; Morse functions; PL functions; Reeb graphs; development of persistent homology; proof of stability; applications and extensions. Prerequisite: Computer Science 532. Instructor: Staff. 3 units. C-L: Mathematics 619

638. Graph Algorithms. This is an advanced course in theoretical computer science covering some of the most influential work in graph algorithms. Given the broad impact that graph algorithms have had on the general algorithmic toolkit, this course also provides exposure to many key techniques that have been developed in algorithmic theory. Specific topics covered include network flows, graph connectivity, spectral graph theory, and network design algorithms. Recommended prerequisite: Computer Science 532 or an equivalent course in algorithms at a graduate level. Instructor: Panigrahi. 3 units.

650. Advanced Computer Architecture II. Parallel computer architecture design and evaluation. Design topics include parallel programming, message passing, shared memory, cache coherence, cache coherence, memory consistency models, symmetric multiprocessors, distributed shared memory, interconnection networks, and synchronization. Evaluation topics include modeling, simulation, and benchmarking. Prerequisite: Computer Science 550 or Electrical and Computer Engineering 552 or consent of instructor. Instructor: Lebeck, Lee, or Sorin. 3 units. C-L: Electrical and Computer Engineering 652

662. Computational Systems Biology. Provides a systematic introduction to algorithmic and computational issues present in the analysis of biological systems. Emphasizes probabilistic approaches and machine learning methods. Explores modeling basic biological processes (e.g., transcription, splicing, localization and transport, translation, replication, cell cycle, protein complexes, evolution) from a systems biology perspective. Lectures and discussions of primary literature. Prerequisites: basic knowledge of algorithm design (Computer Science 532 or equivalent), probability and statistics (Statistical Science 611 or equivalent), molecular biology (Biology 201L or equivalent), and computer programming. Alternatively, consent of instructor. Instructor: Hartemink. 3 units. C-L: Computational Biology and Bioinformatics 662

663. Algorithms in Structural Biology and Biophysics. Introduction to algorithmic and computational issues in structural molecular biology and molecular biophysics. Emphasizes geometric algorithms, provable approximation algorithms, computational biophysics, molecular interactions, computational structural biology, proteomics, rational drug design, and protein design. Explores computational methods for discovering new pharmaceuticals, NMR and X-ray data, and protein-ligand docking. Prerequisites: students should have some familiarity with algorithms, and a basic knowledge of molecular biology. Alternatively, consent of instructor. Instructor: Donald. 3 units. C-L: Computational Biology and Bioinformatics 663

664. Computational Structural Biology. Introduction to theory and computation of macromolecular structure. Principles of biopolymer structure: computer representations and database search; molecular dynamics and Monte Carlo simulation; statistical mechanics of protein folding; RNA and protein structure prediction (secondary structure, threading, homology modeling); computer-aided drug design; proteomics; statistical tools (neural networks, HMMs, SVMs). Prerequisites: basic knowledge algorithmic design (Computational Biology and Bioinfomatics 230 or equivalent), probability and statistics (Statistics 611 and 721 or equivalent), molecular biology (Biology 118 or equivalent), and computer programming. Alternatively, consent of instructor. Instructor: Schmidler. 3 units. C-L: Computational Biology and Bioinformatics 550, Statistical Science 614

671D. Theory and Algorithms for Machine Learning. This is an introductory overview course at an advanced level. Covers standard techniques, such as the perceptron algorithm, decision trees, random forests, boosting, support vector machines and reproducing kernel Hilbert spaces, regression, K-means, Gaussian mixture models and EM, neural networks, and multi-armed bandits. Covers introductory statistical learning theory. Recommended prerequisite: linear algebra, probability, analysis or equivalent. Instructor: Rudin. 3 units. C-L: Statistical Science 671D, Electrical and Computer Engineering 687D

01-G-B

701S. Introduction for Graduate Students in Computer Science. Introduction for graduate students in computer science. Topics for discussion include: computer science as a research discipline, views of what constitutes a research contribution, approaches to research in different subfields, tools and methodologies, publishing and presenting research results, the role of computer science as an "amplifier" in other sciences, ethical and policy issues, the information technology industry, grants and funding, and guidelines for success as a graduate student and as a scientist. Instructor: Staff. 1 unit.

710. Topics in Operating Systems. Not open to students who have taken Computer Science 332. Instructor: Staff. 3 units.

724. Advanced Topics in Nonlinear and Complex Systems. 3 units. C-L: see Physics 813

734. Theory of Computation. Not open to students who have taken Computer Science 325. Instructor: Staff. 3 units.

770S. Seminar in Artificial Intelligence. Topics in artificial intelligence, such as natural language understanding, learning, theorem proving and problem solving, search methodologies. Topics will vary from semester to semester. Includes research literature reading with student presentation. Not open to students who have taken Computer Science 382. Instructor: Staff. Variable credit.

776. Advanced Topics in Artificial Intelligence. Course content will vary from year to year and will include a detailed study of one or more of the following: mechanical theorem proving, natural language processing, automatic program synthesis, machine learning and inference, representations of knowledge, languages for artificial intelligence research, artificial sensorimotor systems, and others. Not open to students who have taken Computer Science 315. Prerequisite: Computer Science 570. Instructor: Staff. 3 units.

791. Internship. Student gains practical computer science experience by taking a job in industry, and writes a report about this experience. Requires prior consent from the student's advisor or from the director of graduate studies. For PhDs, internship may be taken in Fall, Spring, or Summer semesters and may be repeated with consent of the advisor and the director of graduate studies. Master's students may do an internship after completion of first year; academic year internships for master's students may be approved only after consultation with the director of graduate studies. Credit/no credit grading only. Instructor: Staff. 1 unit.

805. Topics in Numerical Mathematics. Advanced topics in numerical mathematics to be selected from areas of current research. Not open to students who have taken Computer Science 321. Prerequisite: Computer Science 520 and 252. Instructor: Greenside or Sun. 3 units.

891. Special Readings in Computer Science. Special individual readings in a specified area of study in computer science. Approval of Director of Graduate Studies required. Instructor: Staff. Variable credit.

Cultural Anthropology

Professor Baker, *Chair*; Professor Nelson, *Director of Graduate Studies*; Professors Allison, Baker, Ho, Matory, Nelson, O'Barr, Piot, Silverblatt, Starn, and Thompson; Associate Professors Litzinger, Makhulu, Meintjes, Solomon, and Stein; Assistant Professors Folch and McIntosh; Professor Emeritus Quinn; *Secondary Appointments*: Professors Andrews (Slavic and Eurasian Studies), Mignolo (Romance Studies), and Reddy (History); Associate Professor Wilson (Gender, Sexuality, and Feminist Studies)

A PhD is available in this department.

The department offers graduate work leading to the PhD in cultural anthropology. On the way to the PhD students may also acquire a master's. Students are expected to take an active role in development of their own research goals and plan of study, compiling a

portfolio of papers and other writing over the first three years. Requirements include courses in anthropological theory, cross disciplinary coursework, and spoken and/or written competence in at least one foreign language, at the level appropriate to the planned research program. The core courses include two year-long sequences: Cultural Anthropology 801S and 802S (Theories in Cultural Anthropology), required of first-year graduate students, and research/grant writing seminar Cultural Anthropology 803S (Research Methods) and 804 (Grant Writing), required in the fourth and fifth semesters. Preliminary field research is required in the summer following the first and second years of classes. The *Guidelines for Graduate Students in the Doctoral Program in Cultural Anthropology* fully describes these and additional requirements and the detailed steps in the student's graduate career.

Applications for admission to both the PhD and JD/MA programs are accepted every year. Please review the departmental website at https://culturalanthropology.duke.edu.

Courses in Cultural Anthropology (CULANTH)

501S. Anthropology and History. Recent scholarship that combines anthropology and history, including culture history, ethnohistory, the study of mentalité, structural history, and cultural biography. The value of the concept of culture to history and the concepts of duration and event for anthropology. Prerequisite: major in history, one of the social sciences, or comparative area studies; or graduate standing. Instructor: Staff. 3 units. C-L: History 572S, Romance Studies 521S

502S. Race, Class, and Gender in the University. The American university generates some of the most influential ideas and policies on the planet. It is the product of culture-specific ideas and aspirations, as well as a long history of selective social exclusion, inclusion, and transformation. Yet most of us take for granted the culture-specific forms of reasoning, discourses, political loyalties, administrative practices, social relationships, and financial flows that constitute it. Through theoretical, historical, ethnographic, statistical, policy-oriented, novelistic, and journalistic accounts, we will de-naturalize and historicize the power/knowledge that not only forms us but also, in many ways, rules the world. Instructor: Matory. 3 units. C-L: History 513S, Sociology 502S

503S. The Black Radical Tradition: COVID-19, #JusticeForGeorgeFloyd, and the Movement for Black Lives. 3 units. C-L: see African & African American Studies 503S; also C-L: Religion 503S, Political Science 589S, International Comparative Studies 504S

511S. The Fetish: The Role of Things in Spiritual, Economic, and Sexual Life. 3 units. C-L: see African & African American Studies 512S; also C-L: Religion 511S

520. Eco-Media: Studies in Planetary Futures. This course explores film, photography, online media, museum and artistic productions about the contemporary planetary ecological crisis. Visual materials will focus on climate change, environmental activism, plastic and nuclear waste, digital rubbish, "cancer alleys" and "cancer villages," pollution and toxic environments, among other topics. Course readings will introduce students to debates about the Anthropocene, post-human natues, species extinction, multi-species care, geo-engineering, and planetary futures. Instructor: Litzinger. 3 units. C-L: Literature 522, Visual and Media Studies 520

520S. Eco-Media: Studies in Planetary Futures. This seminar explores film, photography, online media, museum and artistic productions about the contemporary planetary ecological crisis. Visual materials will focus on climate change, environmental activism, plastic and nuclear waste, digital rubbish, "cancer alleys" and "cancer villages," pollution and toxic environments, among other topics. Course readings will introduce students to debates about the Anthropocene, post-human natures, species extinction, multi-species care, geo-engineering, and planetary futures. Instructor: Litzinger. 3 units. C-L: Literature 522S, Visual and Media Studies 520S

525S. Culture, Power, History. Debates in cultural theory and anthropology: identity and nationalism, memory and tradition, globalization, and poststructuralist, feminist and postcolonial theory. Some previous coursework in anthropology and or cultural theory recommended. Instructor: Starn and Stein. 3 units. C-L: International Comparative Studies 525S

530S. Millennial Capitalisms: Global Perspectives. Critical examination of the problematic of capital from the late nineteenth century until the present moment. Anthropological frameworks and related disciplinary approaches to the multiple cultural productions and lived experiences under divergent forms of capitalism in the new millennium. Theories of capitalism, globalization and anti-globalization movements, "imaginaries" and fantasies, nature and the virtual, consumption, and disciplinary practices of the body. Instructor: Staff. 3 units.

533. Culture and Explosion: How Russian Culture Changed the World. 3 units. C-L: see Russian 533; also C-L: Public Policy 508

535S. Race, Racism, and Democracy. The paradox of racial inequality in societies that articulate principles of equality, democratic freedom, and justice for all. Instructor: Baker. 3 units. C-L: African & African American Studies 545S

539S. Queer China. 3 units. C-L: see Asian & Middle Eastern Studies 539S; also C-L: Gender, Sexuality, and Feminist Studies 502S, Literature 539S, Visual and Media Studies 539S, Human Rights Program-Franklin Humanities Institute 539S

540S. Masculinities. How masculinities are constructed, performed and inhabited. Theorization of the masculine subject in sociocultural, political and psychodynamic terms within colonial and modernizing contexts. Issues of gendered citizenship. Role of scholarship and the media in constituting hegemonic, subaltern, ethnic, female, and stigmatized masculinities. Instructor: Staff. 3 units. C-L: Gender, Sexuality, and Feminist Studies 581S

545S. Transnationalism and Public Culture. Critical examination of issues in transnational studies in anthropology and beyond. Tracking the theories of contemporary scholars of the global, and examining new multisited strategies of method, we explore the emerging ethnographic landscape of the global and the role transnational studies is playing in a revitalized anthropology of the twenty-first century. Instructor: Piot. 3 units.

555S. Development, Modernity, and Social Movements. Modernization and ideologies of progress and nationalism; social movements, revolution, and political protest in the United States and around the world. Some prior background in cultural anthropology or social theory preferred. Consent of instructor required for undergraduate students. Instructor: Starn. 3 units.

560S. African Modernities. 3 units. C-L: see African & African American Studies 645S

561S. Global Africa. Africa's participation in globalization has not simply been a matter of "joining the world economy." Rather, Africa's inclusion has been selective, uneven, and partial. This is quite a different proposition than arguing, as many social theorists, economists, and journalists have suggested that the Continent is somehow structurally irrelevant to the process of globalization. This course responds to this debate by retracing the history of globalization, beginning with the Atlantic trade in human beings and concluding with an account of Africa's place in the global circulation of people things, ideas, and currencies in early twenty-first century. Instructor: Makhulu. 3 units. C-L: African & African American Studies 510S, History 561S, Political Science 527S, International Comparative Studies 510S

562S. African Cities. 3 units. C-L: see African & African American Studies 640S

563S. Nightmare Japan. 3 units. C-L: see Asian & Middle Eastern Studies 563S

565S. The World of Japanese Pop Culture. 3 units. C-L: see Asian & Middle Eastern Studies 565S

570S. Ethnohistory of Latin America. Analysis of what can be known about nonwestern cultures described in texts written by European colonizers. Focus on native peoples whose lives were transformed by Spanish colonialism, with particular attention to post-Inca Andean Societies. Instructor: Silverblatt. 3 units. C-L: History 540S, Literature 573S

590. Selected Topics. Special topics in methodology, theory, or area. Instructor: Staff. 3 units.

590S. Seminar in Selected Topics. Same as Cultural Anthropology 590 except instruction provided in seminar format. Instructor: Staff. 3 units.

594S. Cultural (Con)Fusions of Asians and Africans. 3 units. C-L: see African & African American Studies 594S; also C-L: Latin American Studies 594S, Sociology 594S

605. East Asian Cultural Studies. 3 units. C-L: see Asian & Middle Eastern Studies 605; also C-L: Literature 571, International Comparative Studies 605

610S. Africa, Cuba, Brazil: Great Powers of the Black Atlantic. 3 units. C-L: see African & African American Studies 610S; also C-L: History 610S, Romance Studies 522S

611. Global Mental Health. 3 units. C-L: see Global Health 660; also C-L: Psychology 611, Human Rights Program-Franklin Humanities Institute 660

641S. Citizen and Subject in a Neoliberal Age. 3 units. C-L: see African & African American Studies 641S; also C-L: Sociology 645S

660. Health in the African Diaspora. 3 units. C-L: see African & African American Studies 660; also C-L: Global Health 672

01-G-B

705S. Popular Culture, Theories and Practices. Theories and writings about popular culture questioning what it is, its relation to mass and dominant culture(s), what politics and pleasures it carries, and how it varies over time and across space. Project-based with emphasis on conducting studies of popular culture. Focus on methodology analyzing specific forms of popular culture. Issues include transnationalism, capitalism, postmodernism, production, consumption, ethnography, fantasy, and identity. Instructor: Allison. 3 units.

706S. Popular Culture: Theory and Ethnography. This courses studies influential theories of popular and commodity culture from the last century, including the work of Marx and Gramsci, scholars of the Frankfurt school (Benjamin, Adorno), Birmingham School (Hall, Gilroy, Williams), and two decades of ethnographic scholarship (Gingsburg, Larkin, Varzi). We will place considerable emphasis on themes of media and mediation, visuality and the image, the human and the machine, and the digital. Instructor: Stein. 3 units.

709S. Science, Medicine, and the Body. Introduces students to scholarship about the body's complex relations to science, technology and medicine. Examines how embodied knowledges and experiences of pain, disease, injury, and ability relate to forms of gender, sexuality, race, state power, coloniality, and capital. Explores these connections across debates in medical anthropology, science and technology studies, cultural theory, and the medical humanities, while paying close attention to different genres of writing. Instructor: Solomon. 3 units. C-L: Gender, Sexuality, and Feminist Studies 709S, Science & Society 709S, Global Health 709S, Literature 709S

710S. Foucault and Anthropology. A close examination of the work of Foucault and the impact of his work on cultural anthropology. Traces shifts in Foucault's thinking over the course of his career, examines his work in the context of other major French thinkers, and considers selected works in anthropology that have been particularly influenced by his theories. Instructor: Staff. 3 units.

715S. Nationalism. Focuses on anthropological approaches to the nation-state, nationalist movements, and state formation. Examines the dynamic relationships between nations and states, colonial and post-colonial policies, and anti-colonial strategies within a changing global context. Addresses the ways belonging and participation are defined within particular states, as well as how these definitions are socialized through a variety of institutional contexts. Finally, explores the relationships between popular culture and state formation, examining these as dialectical struggles for hegemony. Instructor: Staff. 3 units.

716S. Capitalism. This course introduces students to some of the debates relating to the current financial crisis—both within and beyond the field of finance itself. Combining media accounts with scholarly critiques of the current structures for money making, this course is primarily committed to theorizing the culture of capitalism in the early 21st Century. The larger inter-disciplinary framework for the course encompasses inter-related fields of inquiry including anthropology, cultural geography, and political economy. Instructor: Makhulu. 3 units. C-L: Sociology 716S, Political Science 720S

720S. Postcolonialism and Its Cultures. An introduction to colonial and postcolonial cultures, forms of knowledge, and theoretical traditions. Explore the foundational scholarship on colonialism within the Indian, European, and U.S. academies; investigate the central debates and arguments in the field of postcolonial theory; and consider postcolonial theory's relationship to the theoretical traditions

of poststructuralism and psychoanalysis. Examine historical and the tropological relationship between colonialism and globalization. Develop a set of critical theoretical tools with which to approach the study of colonial and postcolonial cultures, institutions, discourses, and communities. This course pays particular attention to questions of subjectivity and subject formation, notions of resistance and struggle, and the ways in which colonial power has articulated with race, gender, and sexuality at particular historical moments. Readings in the works of Asad, Fanon, Derrida, Said, Spivak, Stoller and others. Instructor: Stein. 3 units.

721S. Violence: Anthropological Approaches. Anthropologists have long been concerned with questions of violence in many forms: structural violence, everyday violence, state violence, gendered violence, violence and the body, violence and visuality, violence and the built environment, etc. Over the course of the semester, we will study both foundational works on violence from the last century as well as the ways that violence, in its varied forms, has been theorized and narrativized in recent ethnographic texts. Readings from Agamben, Arendt, Bourgois, Butler, Das, Fanon, Farmer, Foucault, Jain, Hoffman, Masco, Said, Scarry, Scheper-Hughes, Tickin, Taussig, Wohl and others. Instructor: Stein. 3 units.

725S. Anthropology and the Religious Imagination. An examination of religious movements through the political, racial, gendered, and globalized contours of the contemporary moment. Among other cases to be explored: Jerry Falwell and the religious right, neo-Pentecostalism in the global south, African derived religions in the Americas, Black Hebrew Israelites, transnational Islamic movements, the occult economies of the neoliberal moment, and popular imaginaries of conspiracy. Instructor: Piot. 3 units.

726S. Governmentality. Governmentality - a concept articulated by the French historian and philosopher Michel Foucault (1926-1984) - has become a key analytic of much recent critical writing in cultural anthropology. Taking governmentality as a point of departure, this graduate seminar will investigate governmentality as an analytical framework oriented towards interpreting our world. We will consider works by anthropologists, and scholars in related fields, who have drawn on Foucault's methods and concepts in relationship to a wide range of socio-political, philosophical and historical thought, and critically engage their attempts to deploy his approach in ethnographic analysis. Instructor: McIntosh. 3 units.

727S. Dissertation Writers' Workshop. Weekly seminar for Cultural Anthropology students who have returned from fieldwork and are in the process of writing up their dissertations. Each seminar will focus on a particular aspect of anthropological writing: the introduction and conclusion to a thesis, for example, or when/where/how to lay out methodology, literature review, and positionality. As integrating ethnography and theory is particular to our discipline, emphasis will be placed on examining different strategies, techniques, styles, and tropes for doing this. Instructor: Staff. 3 units.

728S. Development: History, Theory, Politics. Examines development as history, as theory, and as politics with a focus on the postcolonial world. Considers development as knowledge and political economy, as a technology of subject formation and a locus of collective mobilization, and as a project of rule and rights. Instructor: Subramanian. 3 units.

729S. Space and Power. Through readings of ethnographic and historical monographs, and theoretical essays from the discipline of geography, we will examine the spatial production of social worlds and how this process has unfolded in varied cultural and historical settings. Instructor: Subramanian. 3 units.

731S. Critical Ethnographies. Ethnography has long defined anthropology as a discipline. But what precisely does ethnography mean today at a moment of transnational migration, mobile lifestyles, consumer citizenship, and deterritorialized subjectivities? And how does ethnography work as a (social, political) critique and how to think critically about ethnography if we are to challenge, rather than merely accept, the tenets of "being there"? In this class, we 1) engage a close reading of a number of ethnographies—both old and new, canonical and experimental—and 2) consider the meta-issue of Ethnography by looking at debates of the 1980s and more recent attempts to theorize a practice and ethics of ethnography. Instructor: Allison. 3 units.

735S. Anthropology and History. 3 units. C-L: see History 850S

740S. Space, Place, and Power. Graduate seminar studies foundation and contemporary scholarship on space and place. Trace and compare the ways space is conceptualized and articulated differently in varied disciplinary locations, and aim to establish a conversation between disciplinary literatures and methodologies that are infrequently considered in tandem. Course themes include: the production of space; Marxist and feminist geographies; urban anthropology; home and intimacy; the public sphere; landscape and the production of nature; the politics of cartography; and global cities. Instructor: Stein. 3 units. C-L: Literature 735S

741S. Globalization. "Globalization" is variously described in terms of the integration of markets, the increasing velocity of transactions, the opening up of new geographies for capital accumulation, de-regulation, and so on. This course looks to the Atlantic world as a starting point in understanding the rise of modern capitalism by way of the slave trade, the rise of finance capital, and the circulation of objects, ideas and people. This course goes on to questions relations of debt and dispossession; novel forms of governance and governmentality; flexibility and superfluity; and growing inequalities and constraints of late capitalism. Instructor: Makhulu. 3 units. C-L: African & African American Studies 741S

742S. Nature/Culture. What are the frontiers of the nature/culture debates? What is their lineage in cultural and critical theory? And how do these debates unfold in the practice of ethnography and in ethnographic writing? These three questions guide this graduate seminar, whose topic for 2013 will be "Objects and Environments." Foundational readings may include works by Strathern, Serres, Canguilhem, Tsing, Bateson, Latour, Haraway, and Barad, and will be put into conversation with a series of recent ethnographies. Seminar participants will be responsible for writing weekly reading notes, guiding course discussions, and writing a final research paper. Instructor: Solomon. 3 units.

743S. Anthropology of Media and Mediation. This graduate seminar introduces students to anthropological scholarship on the politics of media. We begin with classic theoretical works on mass media the early twentieth century and progress to contemporary anthropological scholarship on the interplay between media, culture, and politics. Our seminar will pay particular attention to issues of photography and visuality; media and/of war; technologies of witnessing; the cultural politics of music and sound; media and globalization; social media and grassroots politics. This graduate seminar will focus on professionalizing strategies, culminating in a proto-publishable research paper that draws on class material. Instructor: Stein. 3 units. C-L: Visual and Media Studies 743S, Art History 743S

744S. Mobility. This seminar explores theories (e.g. Locke on portable property), vehicles (boats), travellers (pirates, pilgrims, migrants), media (books, money, gravestones, genealogies) to recognize the phenomenon of mobility and its consequences. The historical expansion of western state and trade forms will be a major theme, contrasted with non-western mobilities. The course emphasises external rather than internal social relations. Instructor: Ho. 3 units.

745S. The Anthropology of the Facts of Life. Course will explore in detail our understandings of "facts" and "life." Using classic anthropology as well as work in critical science and technology, political philosophy, feminism, and radiology, course will examine relation between nature and culture, how individuals reproduce a society, kinship, and human development. Instructor: Nelson. 3 units.

746S. Critical Genealogies. 3 units. C-L: see Gender, Sexuality, and Feminist Studies 740S; also C-L: Asian & Middle Eastern Studies 740S

747S. Theorizing Environment. Readings in environment, political ecology, and the socio-cultural/political economic construction of space. Rather than the neutral backdrop to human life, space, place, and environment are crucial components to our material and symbolic worlds. This course overviews geographical thought and theory and then explores its use in anthropology and other social scientific disciplines. Authors include: Lefebvre, Harvey, Massey, etc. Instructor: Folch. 3 units.

748S. Infrastructure and/as Ethics. Readings in infrastructure, disaster studies, the political ecology of ruin, and the anthropology of information systems and processes. Although infrastructures are often invisible outside of disasters or crises, we center the built environment, structures, and processes as constitutive of our material and symbolic worlds. And we engage the ethical and values that undergird those very processes and structures which undergird society. Instructor: Folch. 3 units.

750S. Citizenship. In this course, we approach modern citizenship as a form of political belonging that is lived collectively and culturally. Second, we will understand citizenship, not through the legal/constitutional ideal of formal equality but as one modality for the elaboration of social inequality. Finally, we will seek to "provincialize" the framework of national citizenship by looking to the elaboration of political belonging and rights in transnational circuits of cultural and political exchange. Instructor: Staff. 3 units.

751S. Theorizing the Anthropocene. Critical engagement with emergent theories of the "Anthropocene." This concept is now deployed in eco-apocalyptic scenarios of a dying atmosphere, storms, tsunamis, and earthquakes, melting arctic glaciers, the flooding of coastlines and cities, and the slow, or sudden, death of the biosphere. The term also points to a contentious interdisciplinary and public space, where scholars, activists, and artists reflect upon, document, experiment with, and produce meaning about the end times of carbon-dependent industrialism, urbanization, slow violence and inequality, displacement and environmental refugees, fossil fuel livelihoods and post-carbon futures, and the very meaning of the planet. Instructor: Litzinger. 3 units.

755S. Africa in a Global Age. James Ferguson tells us that "Africa's participation in globalization has certainly not been a matter simply of 'joining the world economy.'" Rather, Africa's inclusion has been selective, uneven, and partial. This is quite different than arguing, as many social theorists, economists, and journalists have suggested that the Continent is somehow structurally irrelevant to the process of globalization. This course responds to this debate by first retracing the history of "globalization," and concludes by thinking about Africa's place in relation to a new global order. Instructor: Makhulu. 3 units.

760. Indigenous Medicine and Global Health. 3 units. C-L: see Global Health 721

790S. Special Topics in Linguistics. Same as Linguistics 890 except instruction is provided in a seminar format. Instructor: Staff. 3 units.

791. Special Readings. Supervision and guidance of selected readings at an advanced level. Instructor: Staff. 3 units.

793. Individual Research in Cultural Anthropology. Supervision and guidance of A.M. thesis preparation, Ph.D. dissertation preparation, or other intensive research on a selected problem. Instructor: Staff. 3 units.

801S. Theories in Cultural Anthropology. A two-semester seminar in which the historical development of the field and its modern currents and debates are examined and discussed. Particular topics to be chosen by the instructors. Instructor: Staff. 3 units.

802S. Theories in Cultural Anthropology. A two-semester seminar in which the historical development of the field and its modern currents and debates are examined and discussed. Particular topics to be chosen by the instructors. Instructor: Staff. 3 units.

803S. Research Methods/ Porfolio Seminar. In addition to exploring a range of research methods, students work on their field reading lists and other elements of their portfolios and begin to develop the dissertation proposal. Required course for CA graduate students in the second year. Instructor: Staff. 3 units.

804S. Grant Writing. This course focuses on the development of the dissertation research proposal and the preparation of grant proposals. Required for CA graduate students in the third year. Instructor: Staff. 3 units.

890S. Advanced Selected Topics. Special topics in methodology, theory, or area. Consent of instructor required. Instructor: Staff. 3 units.

Developmental and Stem Cell Biology

Professor Sherwood (Biology), *Program Director*; Associate Professor Silver (Molecular Genetics and Microbiology), *Director of Graduate Studies*

This is an admitting program.

A certificate is also available in this program.

The Developmental and Stem Cell Biology (DSCB) Training Program provides a broad interdepartmental consortium of students and faculty doing developmental research at the molecular, cellular, genetic, evolutionary, and system levels. Each of the commonly used animal modes is investigated, as well as plant models. The curriculum is designed to provide a strong core of knowledge in developmental biology, while allowing students the flexibility to explore individual interests in particular fields, such as developmental genetics,

mechanisms of development, stem cells and regeneration, or evolution and development. In the fall of the first year, DSCB students to take CMB 710A-F (the Cell and Molecular Biology modules) and UPGEN 778A-F (Genetic and Genomic Solutions to Biological Problems). The program encourages students to take at least 6 modules with a developmental focus. DSCB students are also required to take a full-semester graduate-level course in either cell biology or genetics along with the weekly student-organized informal research seminar series, in which program students present short talks on their research projects. In the spring of the first and second years, students will be required to take CELLBIO 830 (the developmental and stem cell biology colloquium). Finally, a key component provided by the program is a teaching experience.

Students entering The Graduate School through the DSCB training program usually declare by the end of the first year a department in which to earn their PhD. The student must then fulfill all of the normal graduation requirements of the chosen department to complete their PhD studies. This includes additional coursework and the successful passing of a qualifying or preliminary exam. The student then focuses on thesis research leading to a doctoral degree from that department, with a certificate in developmental and stem cell biology.

For more information, visit https://sites.duke.edu/dscb/.

Course in Developmental and Stem Cell Biology (DSCB)

700. Classic Papers in Development, Stem Cell Biology and Regeneration. The goal of this seminar course is to deepen understanding of the classic findings and advances in the field of development, stem cell, and regenerative biology and to provide a historical view of how these findings affect our approaches in the field today. The course will meet in the fall semester and will consist of both first and second year DSCB students and 20 faculty members who will select papers and facilitate group discussions. Instructor: Silver. 1 unit.

730. Hands on Development. This class will expose students to basic principles and techniques in development and stem cell biology. Students will spend the afternoon in six different Duke labs learning diverse approaches within different model systems. This is a hands-on lab based course and is designed so that students will interact closely with Duke faculty and students in the different labs. The class is open and required only for first-year DSCB students. Instructor consent required. Instructor: Silver. 1 unit. Developmental Psychology

Professor Asher, *Director of Certificate Program*

A certificate is available in this program.

The facilities in developmental psychology at Duke University and The University of North Carolina at Chapel Hill offer a collaborative approach to graduate training in developmental psychology: the UNC-Duke Collaborative Graduate Certificate Program in Developmental Psychology. Graduate students in the doctoral programs in psychology and neuroscience at Duke and students in UNC's Department of Psychology can apply to this program that offers training opportunities in addition to those of their home department. Students in the certificate program attend developmental talks at both universities and have opportunities to take developmental seminars or engage in supplemental research training with the faculty of their nonhome university. Among the research emphases of the participating faculty are cognitive development, social development, applied development and developmental psychobiology. Students apply to the program by the beginning of their third year of graduate study.

Requirements

- Must attend at least three program-affiliated developmental events per semester at the nonhome institution, for at least six semesters:
  - Center for Developmental Science talks;
  - Center for Child and Family Policy talks;
  - Colloquium series at both universities;
  - Developmental research and current topics groups, which meet regularly at both universities; or
  - Other program-affiliated events in the future.

Fulfill two of the following:

- Complete a minimum of two developmentally relevant psychology for-credit courses, taken at the student's nonhome institution (a relevant home institution course cotaught by nonhome institution faculty would count).
- At least one of the student's major committees (e.g., advisory, comprehensive exam or dissertation committee) must have at least one member who is on the developmental faculty of the nonhome institution.
- Participation in a research activity with a developmental faculty member from the nonhome university. May be fulfilled as deemed appropriate by the faculty member providing the experience (e.g., by enrolling in a formal research practicum course, by collaborating on a research project for no course credit, or by employment as a research assistant).

For more information, visit https://psychandneuro.duke.edu/graduate/developmental or contact Director, UNC-Duke Collaborative Program in Developmental Psychology, Duke University, Box 90086, Durham, NC 27708-0085; (919) 660-5715.

Digital Art History/Computational Media

Associate Research Professor Szabo, *Director of Graduate Studies*

Faculty in Digital Art History: Professors Jaskot, Dillon, and Van Miegroet; Associate Professor Galletti; Assistant Professor of the Practice Olson; Lecturing Fellow Huffman; Associate Research Professor Szabo; Instructor Triplett

Faculty in Computational Media; Professors Forte, Hansen, Seaman, and Van Miegroet; Assistant Professors of the Practice Olson, Salvatella de Prada, and Wendell; Associate Research Professor Szabo; Instructor Triplett

A master's degree is available in this program.

Two specialties are offered: a track in digital art history and a track in computational media. Both are eighteen-month programs.

The digital art history track integrates historical disciplines and the study of cultural artifacts with digital visualization techniques for the analysis and presentation of research. The computational media track focuses instead on new approaches to computational processes, and forms of interpreting quantitative and qualitative data. Both programs build on courses and well-developed strengths at Duke University and require ten (10) courses over three semesters in addition to summer research. Students affiliate with an existing faculty research initiative, from which they develop their own independent research project for the MA thesis.

The digital art history track prepares students for future work in fields such as graduate study in Art History and Archaeology, public history, city planning and architectural design, cultural heritage, museum exhibition design, and visualization-based journalism, and provides a springboard for more advanced study in art history, archaeology, architectural history, and visual or media studies. The ideal candidate seeks engagement with the digital humanities, digital art and architectural history, or digital archaeology; this student can conceptualize digital visualization as a part of the research process and for the publication or presentation of scholarship. Common themes that unite the various projects are the visualization of process, the representation of change over time, the recontextualization of displaced objects, and the biographies of objects.

The digital art history track encourages applicants from across the Humanities and Social Sciences, whether from established disciplines, such as history, archaeology, and art history, or emerging fields of study, such as spatial history, media arts & sciences, and cultural geography.

The core required courses are:

- Digital Art History/Computational Media Proseminar 1 (ARTHIST 580S)
- Digital Art History/Computational Media Proseminar 2 (ARTHIST 581S)
- Grant Writing and Prospectus (ARTHIST 723S)
- Thesis Research (ARTHIST 791) (third and fourth semesters)

In addition to these core courses, students are expected to take subject-area graduate electives relevant to their final project work. For more information, visit https://aahvs.duke.edu/graduate/MA-historical-cultural-visualization.

The computational media track explores research and presentation strategies enabled by the information sciences, new approaches to computational processes, and new forms of interpreting quantitative and qualitative data. The goals of the program are for students to understand the critical affordances and potential of digital media, to develop competencies in data-driven and computational approaches to knowledge production, and to develop a hybrid theory-practice MA thesis that demonstrates their expertise in action around a particular subject. Students in this track affiliate with an interdisciplinary Lab focused on digital archeology, generative media arts, art history, law, and markets, digital humanities, physical computing, or information science and studies as a way to learn new technologies and situate their work within a specific research domain. The program's skills-centered instruction, combined with the requirement for lab affiliation and collaborative research and the emphasis on theoretical analysis, will produce graduates who not only have hands-on know-how and technical skills but who have developed a sophisticated understanding of informational globalization and a rapidly changing world.

The core required courses for the computational media track are:

- Digital Art History/Computational Media Proseminar 1 (VMS 580S)
- Digital Art History/Computational Media Proseminar 2 (VMS 581S)
- Computational Media Research
- Practicum (VMS 756; 2 semesters)
- Thesis Research (VMS 791) (third and fourth semesters)

In addition to these core courses, students are expected to take subject-area graduate electives relevant to their final project work.

For more information, visit https://www.dukemas.org/cmac/.

Earth and Ocean Sciences

Professor Klein, *Chair*; Professor Murray, *Director of Graduate Studies*; Professors Baker, Boudreau, Klein, Murray, Pratson, Shindell, and Vengosh; Associate Professors Cassar and Li; Associate Professor of the Practice Johnson; *Adjunct Faculty*: Darrah, Erickson, Gunnell, Hegerl, Isaksen, Malin, Marani, and Stanislaw; Professors Emeriti Barber, Chameides, Corliss, Haff, Heron, Lozier, Perkins, Pilkey, and Schlesinger

A PhD is available in this department.

The Division of Earth and Ocean Sciences offers research opportunities in three broad areas of geoscience: earth-surface processes, oceans and climate, and earth resources. Earth-surface processes in EOS focus on the interactions between life, water, and landscapes, including coastal ecomorphodynamics and remote sensing, watershed ecohydrology, and landscape evolution, including that of coupled human-landscape systems. Oceans and climate research in EOS includes ocean circulation, atmospheric dynamics, paleoclimatic/paleoenvironment reconstruction, marine biogeochemistry, and ocean/atmosphere interactions, particularly as they relate to global climate change. In addition, research in earth resources addresses the geologic formation and human use of mineral, energy, water, and land resources, including mineral formation, life-cycle analysis, energy consumption/emissions, water quality as it relates human health, and the role of technology in the Anthropocene.

Laboratory facilities available in the department are described in this bulletin under the chapter "Resources for Study" on page 379.

Degree Requirements

Students entering the graduate program normally have an undergraduate degree in one of the natural sciences. It is expected that the incoming student will have taken one year of college chemistry, one year of college physics, and mathematics through calculus. Both MS and PhD graduate students take 30 course credits of courses and research. Typically, the total time for a PhD is five years beyond the BS or three years beyond the MS. Because the division encourages participation in fieldwork and other research opportunities outside the university, there are no firm time limits for degrees, except as required by the university.

MS on the Way to PhD Option

A student in the PhD program may elect to get an MS degree while working toward the PhD. If this option is elected, the requirements are the same as for the MS program in terms of coursework, time limits, and thesis requirements.

The student must indicate their intention to receive the MS degree before the deadline in the semester during which they wish to receive the degree. If agreeable to both the student and their committee, the MS defense can be part of the PhD preliminary exam. If this is the case, both a MS Defense and a Preliminary Exam Report must be submitted to The Graduate School. The MS thesis can be on the same topic as the PhD dissertation or different. If the former, the MS thesis must be a fully independent piece of work, which can be referenced but not duplicated in the PhD dissertation.

Up-to-date information about the division and the faculty can be found at https://nicholas.duke.edu/academics/doctoral-programs/earth-ocean-sciences-eos. For further information on the graduate program, email danielle.wiggins@duke.edu.

Courses in Earth and Ocean Sciences (EOS)

507DS. The Amazon: Evolution of Its Climate, Landscape, Ecology, and Human Civilizations. Introduction to the natural and human evolution of the Amazon region of South America, from the Andes Mountains, to the rain forests, to the Amazon River delta. Exploration of the interactions among changes in landscapes, ecology, biota, climate, and human civilizations through time. Topics include human impacts on biodiversity, landscape processes, and resources from pre-history to modern societies, and their future outlook. Instructor: Baker. 3 units. C-L: Environment 507DS

507S. The Amazon: Evolution of Its Climate, Landscape, Ecology, and Human Civilizations. Introduction to the natural and human evolution of the Amazon region of South America, from the Andes Mountains, to the rain forests, to the Amazon River delta. Exploration of the interactions among changes in landscapes, ecology, biota, climate, and human civilizations through time. Topics include human impacts on biodiversity, landscape processes, and resources from pre-history to modern societies, and their future outlook. Instructor: Baker. 3 units. C-L: Environment 507S

508. Climate History. Climate variation during the entire scope of Earth history. Coupling between climate evolution and biological evolution. Methods for reconstructing climate history. Implications of past climate change for future climate. Scientific and mathematical literacy assumed, but no specific prerequisites. Mid-term and final exams plus short term papers. Instructor: Baker. 3 units.

509S. Paleoclimate. Nature and mechanisms of climate variability throughout Earth history. Topics include general theory of climate, paleoclimate modeling and comparisons with observations, methodologies of reconstructing past climate variations, the observational record of paleoclimate extending from the Precambrian through the Ice Ages and Holocene to present, and the impact paleoclimate on biotic evolution/paleogeography and human cultural history. Consent of instructor required. Instructor: Baker. 3 units.

510S. Paleoenvironmental Analysis. Methods of paleoenvironmental and paleoclimatic analysis. Includes radiometric and other methods of dating, stable isotopes, trace elements, paleobiotic and other methods of reconstructing climate, hydrology and environment of the past. Also includes approaches to modeling paleoenvironmental data. Instructor: Baker. 3 units.

511. The Climate System. Components of the climate system: observed climate change, concept of energy balance, basic circulation of the atmosphere and ocean, introduction to climate models, sample applications of climate models, interactions between the atmosphere/ocean/ and biosphere, land surface, cryosphere (snow and ice), and chemistry of the atmosphere. Prerequisite: consent of instructor. Instructor: Li. 3 units.

512. Climate Change and Climate Modeling. Course aims to provide knowledge and understanding of physics of climate system and Earth system modeling for scientists, engineers and policy students with physics and mathematics background. Fundamental principles controlling physical and dynamic structure of climate system; discussion of relative roles of natural climate variability and external forces and anthropogenic influences. Explore numerical methods, develop computing skills, and deal with data handing as a means to an end of quantifying climate system behavior. Prerequisite: Earth and Ocean Sciences 511. Instructor: Li. 3 units.

513. Groundwater and the Environment. An introduction to the principles of groundwater flow, development, and protection, with an emphasis on aquifer and groundwater evaluation and management. Topics include: baseflow analyses; stream-groundwater interactions; aquifer and vadose zone characterization; groundwater hydraulics and recharge; field hydrogeological data; groundwater modeling; water quality; and groundwater management. Open only to students who have taken at least one college-level natural science course (e.g., earth science, chemistry, physics, biology). Instructor: Staff. 3 units. C-L: Environment 513

515. Mountain Ecohydrology Field Course - Montana. Study of watershed ecohydrology and the interactions and feedback among hydrological and ecological processes in the western United States. Includes required pre-semester week-long field trip to Montana (with required fee), where participants visit active research watersheds, some of the most intensively instrumented ecohydrological research sites in the country. Students learn techniques to collect hydrologic and ecological field data and work with instructors to collect a comprehensive suite of ecohydrological data, to be interpreted and presented during series of follow-up class meetings. Prerequisite: General background in Earth and Environmental Sciences. Instructor: McGlynn. 3 units.

520. Introduction to Fluid Dynamics. Conservation equations for mass, momentum and heat, with an emphasis on large temporal and spatial scales; application to the earth, ocean, and environmental sciences. Some background in differential equations highly recommended. Instructor: Staff. 3 units.

524. Water Quality Health. Explore basic concepts of water quality and human health with focus on the global water cycle, global water demand and availability, chemical properties of water, contaminants in water, health implications, and environmental isotope hydrology. Highlights relationships between human activities, water scarcity, water quality degradation, and ecological and health consequences. Addresses some policy implications related to conflicts over water resources and impact of energy production on water resources. Prerequisites: prior knowledge of introductory calculus and chemistry or consent of instructor. Instructor: Vengosh. 3 units. C-L: Environment 524, Global Health 534, Energy 524

525. Fundamentals of Water Biogeochemistry and Pollution. Course is designed to present students with a comprehensive

introduction to the sources and impacts of pollution in marine and freshwater environments. Fundamental concepts and principles of aquatic biogeochemistry will first be introduced: marine and freshwater chemistry, primary production and food webs. Topics to be covered include biological (e.g. pathogens, invasive species), physical (e.g. thermal, plastics), and chemical (e.g. nutrient loading, oil, pesticides, metals) pollutants. Instructor: Cassar. 3 units.

526S. Water Forum Speaker Series. Seminar including visiting scholars covering a broad array of issues on water including water quality, hydrogeology, biogeochemistry, water management, water treatment, ecology, water economy, and water policy and law at both the national and international levels. Instructor: Vengosh. 3 units.

527. International Water Resources. Overview of the hydrology, hydrogeology, water quality, and management of major international water resources. Focus on cross-boundary international rivers and aquifers, up-stream versus down-stream water users, the politics of water sharing and disputes, the role of science in water management, and prospects and implications for future utilization of contaminated rivers and stressed aquifers. Examples from international rivers such as the Tigris, Euphrates, Nile, Jordan, Colorado, Indus, Ganges, and Mekong and international aquifer systems such as the Mountain aquifer, Gaza Strip, Disi, and Nubian basins in northern Africa. Instructor: Vengosh. 3 units.

528S. Biological-Physical Couplings in Coastal Environments; Responses to Changing Forcing. Focus on select examples of biological-physical couplings that shape coastal environments (i.e. coastal "ecomorphodynamics") and help determine how those environments respond to changing climate and land use. Environments include: barrier islands, tidal wetlands. Grading based on in-class presentations, and a final project (in the form of a research proposal). Instructor consent required. Instructor: Murray. 3 units.

530. Remote Sensing in Coastal Environments. Introduction to the field of remote sensing and image processing with focus on applications to coastal monitoring and currently open research questions. Students will acquire an operational knowledge of various remote-sensing tools and data types, with emphasis on their application in coastal areas. Content will include theory, in-class laboratory exercises, and projects with environmental applications. Prerequisite: introductory or AP physics preferred or permission of instructor. Instructor: Silvestri. 3 units. C-L: Environment 530, Civil and Environmental Engineering 574

540. Introduction to Modeling in the Earth Sciences. Elementary methods for quantitatively modeling problems in the earth sciences. Formulation and solution of classical equations that express fundamental behaviors of fluids, sediments, and rocks. Examples from different fields of geology. Simple modeling exercises, including a final project. Instructors: Staff. 3 units.

542S. New Perspectives and Methods in Surface Process Studies. Nonlinear dynamics and related approaches to understanding, modeling, and analyzing physical systems, with emphasis on applications in geomorphology. Consent of instructor required. Instructor: Murray. 3 units.

550. Climate and Society. Advanced, interdisciplinary course on causes, consequences, and future trajectory of climate change. Course will cover physical observations of past climate change, role of human activities in driving climate change to date, and impacts of climate change on human and natural systems. Course will analyze how socioeconomic choices affects future climate as well as factors influencing those choices, including risk analyses, geoengineering proposals, intergenerational equity, climate metrics and the media. Instructor: Shindell. 3 units. C-L: Environment 552

550D. Climate and Society. Advanced, interdisciplinary course on causes, consequences, and future trajectory of climate change. Course will cover physical observations of past climate change, role of human activities in driving climate change to date, and impacts of climate change on human and natural systems. Course will analyze how socioeconomic choices affects future climate as well as factors influencing those choices, including risk analyses, geoengineering proposals, intergenerational equity, climate metrics and the media. Instructor: Shindell. 3 units. C-L: Environment 552D

551S. Global Environmental Change. Topics in the seminar will include climate change, earth surface alteration, prediction, water and carbon cycling, sea-level rise and coastal erosion, biodiversity, fossil fuels and energy resources, water resources, soil fertility, human impact on coastal zone ecosystems. Prerequisite: consent of instructor. Instructor: Baker. 3 units.

567. Analyzing Time and Space Series. Ways to extract information from data; methods for probing time or spatial series including spectral and wavelet analyses, correlation techniques, and nonlinear-dynamics approaches for determining how deterministic and linear the processes producing the data are, and for reconstructing and quantitatively comparing state-space plots. Instructor: Murray. 3 units.

568S. Integrated Assessment Modeling—Examining Strategies for Meeting Energy and Environmental Goals. The primary objective is to provide students with a hands-on opportunity to use one such Integrated Assessment Model—the Global Change Assessment Model with state-level resolution (GCAM-USA)—to examine the air quality and GHG implications of new and emerging energy system technologies. To facilitate the use of GCAM-USA, students will use the GLIMPSE decision support software being developed at EPA. GLIMPSE provides a user interface for GCAM, which facilitates developing and running scenarios as well as visualizing results. Team projects - examinations of electric vehicles, renewable electricity, energy efficiency in buildings and potentially other topics of interest to students. Instructor: Shindell. 3 units. C-L: Environment 568S

569. Thermodynamics of Geological Systems. Introductory thermodynamics applied to geologic problems through understanding of phase equilibrium. Prerequisites: Earth and Ocean Sciences 201; and Mathematics 122 or consent of instructor. Instructor: Boudreau. 3 units.

571. Isotopes in Earth and Environmental Sciences. The use of stable and radioactive isotopes in earth and environmental sciences, with applications to processes including climate change, hydrology, oceanography, geology and biology. Recommended prerequisite: Introductory college chemistry and calculus. Instructor: Baker. 3 units. C-L: Civil and Environmental Engineering 551, Environment 570

573S. Analytic Techniques. An introduction to advanced analytic procedures used in the earth sciences: such as electron microbeam techniques (scanning electron microscopy, electron microprobe analysis) and plasma emission/absorption spectroscopy. Consent of

instructor required. Instructor: Boudreau. 3 units.

575S. Mineral Resources. Introduction to the mineralogy, geological setting, and genesis of metallic and non-metallic deposits (gold, copper, iron, aluminum, gypsum, phosphates, diamonds, e.g.). Includes methods of mineral exploration and exploitation, and the environmental consequences of utilizing mineral resources. An introductory geology course background useful but not required. Instructor: Boudreau. 3 units.

578. Tropical Climate and Paleoclimate. Thermodynamics of tropical climate. Nature and mechanisms of climate variability in the tropics on time scales from daily to multi-millennial. Impact of climatic variability on the tropical biota. Effects of anthropogenic changes of the environment on future climatic change in the tropics and potential extratropical teleconnections. Prerequisite: Earth and Ocean Sciences 101 or 102. Instructor: Baker. 3 units.

579LA. Biological Oceanography. Variable credit. C-L: see Environment 579LA; also C-L: Biology 579LA

590. Special Topics in Earth and Ocean Sciences. Content to be determined each semester. Consent of instructor required. Instructor: Staff. Variable credit.

590S. Special Topics in Earth and Ocean Sciences. Content to be determined each semester. Consent of instructor required. Instructor: Staff. Variable credit.

701S. Research Orientation Seminar. Introduction to resources, skills, and practices for conducting research in earth and ocean sciences, with emphasis on written and oral communication. Required of all entering graduate students in earth and ocean sciences. Consent of director of graduate studies required. Instructors: Staff. 3 units.

704LA. Biological Oceanography. 4 units. C-L: see Biology 704LA; also C-L: Environment 704LA

710S. Bio-geomorphology: The Biophysical Processes Shaping the Earth's Surface. Course examines recent literature contributions shedding light on the two-way interactions among the biosphere, the atmosphere, the hydrosphere, and the litosphere. Emphasis will be placed on the general emergent properties of coupled bio-physical systems, such as multistability, critical behavior, optimality, etc. Topics will include tidal bio-geomorphology, fluvial eco-hydrology, eco-hydrology of arid ecosystems, coastline dynamics, global biogeochemical cycles. Instructor: Marani. 1 unit.

711S. Cenozoic Climate, Environment, and Mammalian Evolution in the New World. Recent advances in the methodologies of molecular genetics, paleoclimate analysis and modeling, and paleoaltimetry have resulted in a host of important discoveries in their respective fields. How does the evolution of the physical environment (climate, mountain uplift, hydrology, biogeochemistry) influence or, in some cases, even control the biological evolution of mammals. The geographic focus will be on the New World. The temporal focus will extend throughout the entire Cenozoic. Course will bring together a diverse set of scholars across campus to read, discuss, and formulate strategies for future research. Instructor: Baker, Kay, Roth. 3 units. C-L: Biology 710S, Evolutionary Anthropology 711S

715. Introduction to Coastal Environmental Change Processes. Nearshore physical processes responsible for the evolution of beaches and barrier islands. Various problems and possible solutions arising from human development of retreating shorelines. Involves a field trip and research paper. Instructor: Murray. 3 units.

716A. Beach and Island Geological Processes. Field seminar on the evolution of beaches and barrier islands with emphasis on the interactions between nearshore processes and human development. Prerequisite: Earth and Ocean Sciences 315/515 or consent of instructor. Also taught as Earth and Ocean Sciences 316A. Instructor: Murray. 2 units.

722. Hydrologic and Environmental Data Analysis. Course will focus on acquisition of skills necessary to extract information from observations of hydrological and environmental processes, connect the extracted information with the physical processes generating the data, and estimate physical quantities at ungauged location/times. Emphasis on process understanding via data analysis techniques. Applications used as a way to understand the general concepts, with examples drawn from water science. Prerequisites: Basic computer skills, Algebra, Calculus are required. Experience with computational software (e.g. Matlab or R) is helpful but not required. Instructor: Marani. 3 units. C-L: Environment 722, Civil and Environmental Engineering 761

723. Hydrology. An introduction to hydrology by examining how rainfall and snowmelt become streamflow, evapotranspiration, and groundwater with emphasis on hydrological processes inside watersheds. Topic areas include: hydrologic cycle and water balances, evapotranspiration and snow energy balances, vadose zone hydrology, hydrogeology, hyporheic zones, riparian zones, streamflow generation mechanisms, biogeochemical budgets, and field measurement techniques. Linkages between physical hydrology and broader ecological and environmental sciences will be highlighted. Includes local field trips. Instructor: McGlynn. 3 units.

723D. Hydrology. An introduction to hydrology by examining how rainfall and snowmelt become streamflow, evapotranspiration, and groundwater with emphasis on hydrological processes inside watersheds. Topic areas include: hydrologic cycle and water balances, evapotranspiration and snow energy balances, vadose zone hydrology, hydrogeology, hyporheic zones, riparian zones, streamflow generation mechanisms, biogeochemical budgets, and field measurement techniques. Linkages between physical hydrology and broader ecological and environmental sciences will be highlighted. Includes local field trips. Instructor: McGlynn. 3 units.

729S. The Water-Energy Nexus. Course presents emerging issues related to the water-energy nexus, including unconventional and conventional energy exploration, hydraulic fracturing, coal mining, coal combustion and disposal of coal ash, oil sand, oil shale, hydropower, and others. Reading and critically evaluating published scientific reports as part of the discussion is required. Instructor consent required. Instructor: Vengosh. 1 unit. C-L: Energy 729S

785DS. Analyzing Current Contributions in Earth, Atmospheric and Ocean Sciences. 2 units.

785S. Analyzing Current Contributions in Earth, Atmospheric and Ocean Sciences. Analyzing and discussing journal articles about a range of timely topics across the Earth and ocean sciences. Each paper is associated with the research to be presented by the upcoming speaker in the Earth and Ocean Sciences (EOS) seminar series. Faculty and senior graduate students rotate to provide background lectures needed to understand the paper/seminar, which will expose students to basic concepts from the wide range of

research sub-fields represented within the Earth and Ocean Sciences program. Meets twice per week, with one class meeting devoted to each EOS seminar (approximately every second week). Consent of director of graduate studies required. Instructor: Murray. 2 units.

790. Special Topics in Earth and Ocean Sciences. Content to be determined each semester. Consent of instructor required. Instructor: Staff. Variable credit.

790S. Advanced Topics in Geology. Topics, instructors, and credits to be arranged each semester. Instructor: Staff. Variable credit.

791. Independent Study. Consent of instructor required. Instructor: Staff. Variable credit.

791-1. Independent Study. Half credit version of EOS 791. Consent of instructor required. Instructor: Staff. 0.5 units.

792S. Microgrid Seminar. 1.5 units.

820. Earth and Ocean Science College Teaching Practicum. Course for doctoral students to gain practical skills and knowledge while teaching. Reserved for Earth and Ocean Science Doctoral Students. Instructor: Staff. 3 units.

890A. Advanced Topics in Earth and Ocean Sciences. To meet the individual needs of graduate students for independent study. Instructor: Staff. Variable credit.

990A. Advanced Topics in Earth and Ocean Sciences. To meet the individual needs of graduate students for independent study. Instructor: Staff. Variable credit.

East Asian Studies

Professor Troost, *Director of Graduate Studies*; Professors Allison, Chow, Duara, Gao, Gereffi, Grieco, Keister, Kim, Lee, Lian, Liu, Manion, Niou, Rojas, Troost, Weisenfeld, Wong, and Zeng; Associate Professors Abe, Ching, Hong, Jaffe, Kim, Ku, Kwon, Litzinger, Malesky, Mazumdar, Merli, Wilson, and Zanalda; Assistant Professors Barnes and Xu; Visiting Professor Need; Visiting Associate Professor Chow; Visiting Assistant Professor Price; Professor Emeritus McKean

A certificate and a master's degree in East Asian studies are available in this program.

Duke's East Asian Studies Program offers comprehensive coverage of East Asian politics, societies, history, and cultures, with particular strengths in politics and society; literature; modern history; comparative history and culture; film, media and visual studies; comparative studies of capitalism; and religious studies. Duke's interdepartmental concentrations in Japanese history and East Asian colonialism, and in modern Chinese literature, film and cultural studies are among the deepest in the nation. Duke also has close ties with East Asia faculty at The University of North Carolina at Chapel Hill (UNC), and students can receive credit for courses at either institution.

Degree Requirements

The master's degree requires ten courses (30 semester hours—including an integrated core course), of which at least eight courses (24 semester hours) must be in East Asian studies, drawn from two or more departments or programs. Each student, after consulting with his/her advisor, will submit a substantial, original research paper produced in a capstone course taken during the program, to their capstone committee, composed of three faculty, at least two of whom must be from the APSI core faculty list. The degree is dependent on the acceptance of the research paper by the graduate committee and successful completion of an oral examination on this paper by the capstone committee. At the conclusion of the program, students must have attained advanced proficiency in one East Asian language, equivalent to three years of college level study. It is strongly recommended that applicants complete at least one year of language study before beginning the program at Duke. Students whose native tongue is an East Asian language are encouraged to take one year (two semesters) of another East Asian language.

Joint JD/MA Program

The department also offers a joint JD/MA program with the Duke School of Law; contact the Law School Admissions Office at (919) 613-7200 for more information.

Certificate in East Asian Studies

The certificate requires completion of four courses from an approved list of courses relating to this region, as well as minimum language proficiency (two years) in an East Asian language.

For more information, visit https://asianpacific.duke.edu/.

Course in East Asian Studies (EAS)

700. East Asian Studies Core Course: Fields and Methods. A graduate-level introduction to the study of East Asia. Students will survey a variety of disciplinary approaches to East Asian studies. The course will be directed by the director of graduate studies or the institute director. Units of the course will be taught by core faculty of the Asian/Pacific Studies Institute and visiting lecturers. Discipline approaches to be addressed include anthropology, art history, economics, history, literary studies, political science, religious studies, and sociology. Department consent required. Instructor: Jaffe, Partner, or staff. 3 units. C-L: Religion 700, History 707

701K. International Political Econ. This course is an introduction to international political economy, the study of how and why international economic policies are formed, and how the international economy influences domestic politics and economic performance. Course will include a significant amount of economic theory. We will examine the development of the international political-economic order since the 18th century and simultaneously compare "lessons from history" to present-day issues. This course corresponds with POLECON 201 at DKU. Graduate students enrolled in this course are required to complete additional readings and assignments as determined by the instructor. Instructor: Landry. 3 units.

702K. Field Methods. This course explores the history and practice of ethnographic field research and engages central debates about ethnographic method. The readings prompt deeper reflection on doing field research, and challenges students to think about anthropological ways of knowing. Students will be required to carry out field research, define and design a project, recording (through

field notes or other methods) every step of the way. This course corresponds with CULANTH 302 at DKU. Graduate Students enrolled in this course will be assigned additional work and held to graduate-level standards in terms of assessment. Instructor: Rodd. 3 units.

703K. Policy Choice as Value Conflict. People disagree about public policy not only because they disagree about empirical matters but also because they hold different understandings of familiar political concepts and they assign different weightings to competing political values. This course aims both to illustrate these general propositions and, more importantly, to introduce the tools and techniques with which one can construct and critique reasoned arguments about the political concepts and values that underpin policy choice. This course corresponds with PUBPOL 303 at DKU. Graduate students enrolled in this course are required to complete additional readings and assignments as determined by the instructor. Instructor: Bowman. 3 units.

706K. The Ethnography of China. The course provides a critical overview to the anthropology and ethnography of contemporary China. This course corresponds with CULANTH 206 at DKU. Graduate students enrolled in this course will be required to complete additional readings and assignments as determined by the instructor. Instructor: Wu. 3 units.

791. Reading Topics: Independent Study. These courses allow for independent study on specific topics on an individual basis with instructors. Consent of instructor required. Instructor: Staff. 3 units.

792K. Research Independent Study. Requires students to meet with instructor once per week to discuss and integrate topics covered in other courses. A major essay is required. Instructor: Miller. 3 units.

802K. Sociology of Culture. This course will allow students to engage in and contribute to this conversation in an effort to develop their understanding of culture and related changes in social processes over time. This course exposes students to the unique approaches the sociologists take to understanding culture and introduces them to many of the major theorists of culture. By the end of the course, students will have a basic toolkit for understanding society culturally. This course corresponds with SOCIOLOGY 202 at DKU. Graduate students enrolled in this course are required to complete weekly additional readings as assigned by the instructor. A final research paper is required for graduate students. Instructor: Rogers. 3 units.

902K. China in Global Perspective 2: The Internationalization of Modern China. In this course we explore how modern Chinese culture comes into being and keeps refreshing itself in the everlasting interactions with international cultures. We will focus on three critical historical moments: the end of the "long nineteenth century" (roughly the early Republican period in China), the global 60s, and the turn of the new century. In each period, we study how the world was brought home on the one hand, and trace how Chinese cultural elements went onto the global stage on the other. This course corresponds with HIST 302 at DKU. Graduate students enrolled in this course are required to complete additional readings and assignments as determined by the instructor. Instructor: Feng. 3 units.

Courses in East Asian Studies Offered by Departments and Professional Schools

Art History (ARTHIST)
548S. Japanese Design in a Global World
590S-6. Topics in Chinese Art
590S-7. Topics in Japanese Art
716S. Fascism East and West: The Visual Culture of Japan, Germany, and Italy
722S. Curatorial Practices in a Global Context
790-1. Topics in Japanese Art
Arts of the Moving Image (AMI)
641. Documentary and East Asian Cultures
Asian & Middle Eastern Studies (AMES)
502S. Translation Studies and Workshop
503. Asian & Middle Eastern Studies
503S. Asian & Middle Eastern Studies
504S. East Asia's Twentieth Century
505S. Seminar in Asian and Middle Eastern Cultural Studies
511. Documentary and East Asian Cultures
515S. Interethnic Intimacies: Production and Consumption
518S. Approaches and Practices in Second Language Pedagogy
531S. Culture and Environment in Modern Chinese History
532S. Research and Writing About Contemporary Chinese Culture
533. Traffic in Women: Cultural Perspectives on Prostitution in Modern China
535. Chinese Media and Pop Culture
539S. Queer China
561. Anime: Origins, Forms, Mutations
563S. Nightmare Japan
565. The World of Japanese Pop Culture
566. Imaging a Nation: Japanese Visual Culture 1868-1945
605. East Asian Cultural Studies
610S. Trauma and Space in Asia
611. Melodrama East and West
631. Modern Chinese Cinema
631S. Seminar on Modern Chinese Cinema
632S. Literati/Literature Culture: Pre Modern Chinese Literature
661. Japanese Cinema
665. Girl Culture, Media, and Japan
669S. Minor Japan
671. World of Korean Cinema
673. Trauma and Passion in Korean Culture
690S. Special Topics in Asian & Middle Eastern Studies
709. Chinese Im/Migration: Chinese Migrant Labor and Immigration to the US
738. Theories of Minority Discourse
750. CAH Pro Seminar: Topics in Critical Asian Studies
Cultural Anthropology (CULANTH)
530S. Millennial Capitalisms: Global Perspectives.

590S. Seminar in Selected Topics (Ethnography of China)
791. Environmentalism in China
793. Global Tibet
Documentary Studies (DOCST)
511. Documentary and East Asian Cultures
Economics (ECON)
542S. Social Change, Markets, and Economy in China
548S. Political Economy of Growth, Stabilization, and Development
History (HISTORY)
502S. Japan since 1945
504S. East Asia's Twentieth Century
507. Introduction to Asian Studies
507S. Asian Studies: Critical Introduction to Knowledge Fields and Methodologies
514S. Culture/Environment in Modern China
518S. East Asian Treaty Ports
530S. Camera Asia
582S. Narrative, History, and Historical Fiction
791. Globalization, Women, and Development: China, South Korea, and India
890S-01. Research Topics in African and Asian History
890S-05. Research in Global Connections
Japanese (JPN)
771S. Topics in Classical Japanese
Law (LAW)
508. Chinese Law and Society
509. Chinese Legal History
605. Chinese for Legal Studies
650. Japanese for Legal Studies
665. Korean for Legal Studies
Literature (LIT)
571. East Asian Cultural Studies
Political Science (POLSCI)
555S. Politics of Market Competition
619. Media and Social Change
645S. Political Economy of Growth, Stabilization, and Development
721. Authoritarian Institutions
751S. Empirical Investigation of Governance
Public Policy (PUBPOL)
598. Economic Growth and Development Policy
676. Media and Social Change
820. Globalization and Governance
Religion (RELIGION)
680S. Buddhist Thought and Practice
780. The Christian Movement: China
781. Protestantism and the Making of Modern China
782. The Next Christendom: The Rise of Christianity Outside the West
783. Christianity's Encounter with Other Religions and Cultures: The Case for East Asia
790. Readings in Buddhist Texts
916. Topics in the Study of Japanese Religions
999-05. Asian Religions; Transnationalism and Modernity
Slavic and Eurasian Studies (SES)
773S. Between Moscow, Beijing, Delhi
Sociology (SOCIOL)
541. The United States and the Asian Pacific Region
650S. Global Responses to the Rise of China
651S. Social Change, Markets, and Economy in China
690S. Seminar in Selected Topics (Chinese Economic Development in Comparative Perspective)
690S. Seminar in Selected Topics (US-China Relations)
730S. Topics in Comparative and Historical Sociology: Globalization and Comparative Development
755S. Proseminar in Economic Sociology: Social Capital
Tibetan (TIBETAN)
701. Elementary Tibetan I
702. Intermediate Tibetan I
Visual and Media Studies (VMS)
523S. Imaging a Nation: Japanese Visual Culture 1868-1945
535S. Camera Asia

Ecology, University Program in

Professor Donohue, *Director of Graduate Studies*; Professors Alberts (Biology), Baker (Earth and Ocean Sciences), Bernhardt (Biology), Christensen (Environment), Clark (Environment), Donohue (Biology), Doyle (Environment), Drea (Evolutionary Anthropology), Glander (Evolutionary Anthropology), Katul (Environment), Marani (Civil and Environmental Engineering), McGlynn (Environment), Mitchell-Olds (Biology), Morris (Biology), Nowicki (Biology), Nunn (Evolutionary Anthropology), Oren (Environment), Pimm (Environment), Porporato (Civil and Environmental Engineering), Pusey (Evolutionary Anthropology), Rausher (Biology), Read (Marine Science and Conservation), Reynolds (Environment), Richardson (Environment), Richter (Environment), Rittschof (Marine Science and Conservation), Urban (Environment), Vilgalys (Biology), Willis (Biology), and Yoder (Biology); Associate Professors Cassar (Earth and Ocean Sciences), Gunsch (Civil and Environmental Engineering), Halpin (Marine Science and Conservation), Johnson (Marine Science and Conservation), Nowacek (Marine Science and Conservation), Silliman (Marine Science and Conservation), Tung (Evolutionary Anthropology), Wernegreen (Environment), Wilson (Biology), and Wright (Biology); Assistant Professors David (Molecular Genetics and Microbiology), Gibert (Biology), Heffernan (Environment), Hunt (Marine Science and Conservation), Lowe (Molecular Genetics and Microbiology), and Poulsen (Environment); Associate Professor of the Practice Swenson (Environment); Assistant Professor of the Practice Reid (Environment)

A PhD is available in this program.

The University Program in Ecology (UPE) is an interdepartmental PhD program comprising faculty from the Nicholas School of the Environment, Arts and Sciences (biology and evolutionary anthropology departments), The Pratt School of Engineering (department of civil and environmental engineering), and the Medical School (department of molecular genetics and microbiology). The UPE Program offers training toward a PhD in ecology.

The UPE provides interdisciplinary training in all aspects of ecology, including physiological and behavioral ecology; population and evolutionary ecology; community and landscape ecology; biogeochemistry; and ecosystem and global-change ecology. The program serves to integrate an exceptionally broad and diverse collection of faculty expertise found in various departments and schools at Duke. The UPE is a rigorous, research-oriented graduate program with an excellent record of scholarly publications by the program's students. All students participate in a two-semester, graduate-level core course that focuses on both historical and contemporary foundations of ecology (theory, principles, and research); any additional coursework is tailored to each student's specific interests and needs. Students organize and run a weekly seminar series and participate in readings groups, symposia, and other activities run by the program.

Special facilities for study and research include the Marine Lab (https://nicholas.duke.edu/marinelab/), Duke Forest (https://dukeforest.duke.edu/), Duke Wetlands Center (https://nicholas.duke.edu/wetland/), the Organization for Tropical Studies (https://tropicalstudies.org/), plus an extraordinary array of major analytical equipment and additional resources (https://nicholas.duke.edu/marinelab/about/facilities, https://biology.duke.edu/research-areas).

For information on other courses available to UPE students, visit https://ecology.duke.edu/.

Degree Requirements

- Complete two semesters of core courses on historical and contemporary foundations of ecology (UPE 701, 702).
- Complete coursework appropriate to the specialty of the research program.
- PhD committee includes at least four faculty members, two of which are UPE faculty members

For more information on degree requirements and timeline, visit https://ecology.duke.edu/degree-requirements/.

Courses in the University Program in Ecology (UPE)

559S. Foundations of Behavioral Ecology. 3 units. C-L: see Biology 559S

701. Ecological Perspectives: Evolution to Ecosystems. This course surveys core concepts in evolutionary and ecosystems ecology, and it challenges students to develop intersections and creative syntheses across those disciplines. Instructor: Staff. 4 units. C-L: Biology 841, Environment 841, Evolutionary Anthropology 741

702. Ecological Perspectives: Individuals to Communities. This course surveys core concepts in Physiological/Behavioral/Population Ecology and Community Ecology, and it challenges students to develop intersections and creative syntheses across those disciplines. Instructor: Staff. 4 units. C-L: Biology 842, Environment 842, Evolutionary Anthropology 742

703S. Ecology Seminar. Presentation of current research by invited speakers, faculty, and students in the University Graduate Program in Ecology. Instructor: Staff. 1 unit.

Economics

Professor Burnside, *Chair*; Associate Professor Bugni, *Director of Graduate Studies (PhD)*; Professor Kimbrough, *Director of Graduate Studies (Master's)*; Professors Abdulkadiroglu, Adler, Ambrus, Anton, Arcidiacono, Ariely, Bansal, Bayer, Bollerslev, Burnside, Clotfelter, Cohen, Coleman, Collard-Wexler, Conitzer, Darity, Field, Frakes, Frankenberg, Hoover, Hotz, Hsieh, Kimbrough, Kramer, Kranton, Kuran, Lewis, Lopomo, Marx, McAdams, McElroy, Munger, Nechyba, Newell, Pattanayak, Patton, Peretto, Petters, Pfaff, Pizer, Rampini, Ridley, Rosen, Sanders, Sarver, Smith, Tauchen, Taylor, Thomas, Timmins, Tower, Viswanathan, Xu, and Yildirim; Associate Professors Ananat, Bennear, Berger, Bianchi, Bugni, Conrad, Daley, Dix-Carneiro, Ilut, Leventoglu, Li, Mohanan, Roberts, Sadowski, and Suarez Serrato; Assistant Professors Bardhi, Garlick, Harding, Jurado, Kehrig, Komisarow, Lanteri, Macartney, Masten, Maurel, Rangel, Sexton, Sidibe, Wang, and Weller; Professors Emeriti Burmeister, Cook, De Marchi, Grabowski, Graham, Ladd, Sloan, Toniolo, Wallace, and Weintraub; Research Professors Becker, Caldwell, and Medema; Associate Research Professors Boyd and Zanalda; Professors of the Practice Connolly, Fullenkamp, Leachman, Leven, Rasiel, and Ridley; Associate Professor of the Practice Kim; Assistant Professor of the Practice Levonmaa

A master's degree and a PhD are available in this department.

The Department of Economics offers graduate programs leading to the MA and PhD in economics.

Students preparing to enter these programs will find an undergraduate background in mathematics, engineering, computer science, statistics, and economics to be very helpful.

Requirements for the PhD in economics include obtaining high grades in the first year classes of microeconomics, macroeconomics, and econometrics. Advanced study is offered in economic theory, macroeconomics, applied microeconomics (including industrial organization, labor economics, public economics, and development economics), econometrics, history of political economics, and certain fields outside the economics department such as finance. The standard time to completion of the PhD is five to six years.

The MA program requires a minimum of 30 graded course credits in economics and related fields. Students' course selections are based on their specific interests and on recommendations made by their academic advisors in order to meet their longer-run goals. Courses offered through The Graduate School, listed as "GS" courses, do not count toward the 30-course credit requirement.

All MA students must complete a minimum of three courses (9 course credits) in microeconomics and macroeconomics. Any combination of three courses in micro and/or macro at the 600 level or higher offered by the Economics Department satisfies this requirement. Students must complete 3 courses in micro and/or macro from the following list courses: 601, 602, 605, 606, 613 (which can also count as econometrics, but cannot count as both a micro and an econometrics course), 620, 652, 656, 701, 702, 705, and 706. In addition, 881, 882, and 885 courses may also count toward this requirement, pending approval. They also are required to complete a

minimum of three courses (9 course credits) in econometrics, computational methods, computer science, mathematics, and/or statistics with at least one course in econometrics. The one required econometrics course can be Econ 608, 612, 613 (which can also count as a micro course, but cannot count as both a micro and an econometrics), 623, 672, 690 Microeconometrics Tools, 703, 707, or 883 Special Topics in Econometrics (with approval). Any computational methods or cross-listed math courses at the 600 level or higher offered by the Economics Department count toward the computational, computer science, math, and statistics part of the requirement. Courses in computer science, mathematics, and statistics at the 500 level or higher also satisfy this requirement. Effective Fall 2018, undergraduate courses (499 or lower) do not count toward the MA degree or a student's GPA. Undergraduate courses taken before Fall 2018 do count toward the MA degree (given a grade of B- or better) and GPA. A graduate-level course paired with an undergraduate-level course may count toward the MA degree and a student's GPA only if the graduate-level version has a separate, more rigorous syllabus for graduate students. It is the student's responsibility to verify that this is the case before enrolling in any paired courses. At least five courses (15.0 course credits) must be in economics. This includes the courses mentioned above. At least one course (3.0 course credits) must be an approved capstone, and students are required to receive a B grade or better in this course. Any course substitutions must be approved by the director of MA studies.

MA students must pass a final exam administered by their committee covering a portfolio of learning and research activities carried out during their master's studies. The portfolio must include the following items: all student (final) papers and slides from oral or written presentations as applicable; updated résumé/CV; when applicable, the research output from those courses; and a capstone course paper in economics, describing a mature project with research content.

For additional information, please visit https://econ.duke.edu/.

Courses in Economics (ECON)

502S. Law, Economics, and Organizations. 3 units. C-L: see Public Policy 602S

503S. Microeconomics of International Development Policy. 3 units. C-L: see Public Policy 603S

505. International Trade and Policy. 3 units. C-L: see Public Policy 605

506. Macroeconomic Policy and International Finance. 3 units. C-L: see Public Policy 606

507. The Uses of Economics. The various ways economics is used in contemporary society: in the scholarly community, government, private sector, civil society, other disciplines, and popular culture. Readings in original texts and interpretative commentaries. Combined with Economics 311, this course may yield a written product suitable for submission for graduation with distinction. Graduate pairing for Econ 313; graduate students will receive additional writing assignments. Instructor: Staff. 3 units.

511. History of Economic Thought. Approaches to economic problems from Aristotle to Keynes, emphasizing certain models and doctrines—their origins, relevance, and evolution. Readings from Mun, Quesnay, Adam Smith, Malthus, Ricardo, Marx, Walras, Veblen, and Keynes. Graduate version of Economics 313; graduate students will receive additional writing assignments. Instructor: Medema. 3 units.

512. Equity Valuation and Financial Statement Analysis. High-level course for those who have previously had experience in corporate finance and accounting. Designed to give the student a deeper insight into important concepts relating to equity valuation and financial statement analysis, including such topics as international standards conversion, tax implications, long term liabilities and leases, and employee compensation. Prerequisites: Economics 174, and either Economics 372 or Economics 373. Instructor: Staff. 3 units.

513. Structuring Venture Capital and Private Equity Transactions. Design and implementation of corporate merger and acquisition transactions, including acquisitions of stock and assets of non-public corporations and acquisitions of publicly-held corporations in negotiated and hostile transactions. Covers federal securities law and state corporate law issues, including important forms of private ordering, such as poison pills, lock-ups, earn outs and the allocation of risks by the acquisition agreement. Relevant accounting, tax and antitrust issues and various regulatory considerations will also be covered. Prerequisites: Economics 174, and either Economics 372 or Economics 373. Instructor: Staff. 3 units.

515. Introduction to Law & Economics. 3 units. C-L: see Law 359

521. Evaluation of Public Expenditures. 3 units. C-L: see Public Policy 596; also C-L: Environment 532

521D. Evaluation of Public Expenditures. 3 units. C-L: see Public Policy 596D; also C-L: Environment 532D

522S. Seminar in Applied Project Evaluation. 3 units. C-L: see Public Policy 597S

523. Microfinance. Microfinancing, in which small loans are given to those who are impoverished/lack collateral, has been credited for alleviating poverty/raising the incomes of millions of people in developing countries. Is it really so successful? Course focuses on historical/theoretical basis of microfinance. Students engage in a critical assessment of microfinance. Overall, students gain factual/historical information concerning the "microfinance revolution", learn the basic theoretical/analytical tools needed to design microfinance programs, and engage in critical thinking regarding recent debates in the field. Graduate pairing for Econ 323; graduate students will receive additional writing assignments. Instructor: Staff. 3 units.

527. Regulation and Deregulation in Public Utilities. Class explores historical basis for regulation of public utilities from an economic/legal perspective. Application of standard monopoly microeconomics leading to rate of return regulation is developed. This background sets stage for evolution of economic thought on electric power system economics and changes in some states, to "deregulate," the electricity markets. Class will explore case studies of developments in these markets, including evolution of regional market clearing entities like PJM, the basis for location marginal pricing, measures of market power, and pricing of capacity/reliability. Graduate pairing for Econ 328; graduate students will receive additional writing assignments. Instructor: Staff. 3 units.

529S. Medical Malpractice. Seminar will focus on each of four medical malpractice "system" markets. Students will write a term paper on one aspect of one market. A book will be assigned and readings from journal articles. The seminar will be of interest to anyone who wants to learn more about medical malpractice, tort, how legal markets and insurance operate, and the political economy of "tort

reform." Graduate pairing for Econ 329S; graduate students will receive additional writing assignments. Instructor: Staff. 3 units.

530. Resource & Environmental Economics I. 1.5 units. C-L: see Environment 520; also C-L: Public Policy 576, Energy 520

530D. Resource & Environmental Economics I. 1.5 units. C-L: see Environment 520D; also C-L: Public Policy 575D, Energy 520D

530L. Resource and Environmental Economics. 3 units. C-L: see Environment 520L; also C-L: Public Policy 575L

531. Resource & Environmental Economics II. Variable credit. C-L: see Environment 521; also C-L: Public Policy 584

531D. Resource & Environmental Economics II. Variable credit. C-L: see Environment 521D; also C-L: Public Policy 584D

541S. Global Inequality Research Seminar. 3 units. C-L: see Public Policy 645S; also C-L: African & African American Studies 642S, Sociology 642S, Political Science 642S, Human Rights Program-Franklin Humanities Institute 642S

542S. Social Change, Markets, and Economy in China. 3 units. C-L: see Sociology 651S

544S. Computer Modeling. Introduction to the use of computer techniques in economic policy evaluation; policy applications to international economics, public finance and development economics; computer analysis of linearized and nonlinear models using Excel and GAMS. Students required to complete a major modeling project. Graduate pairing for Econ 344S; graduate students will receive additional writing assignments. Instructor: Staff. 3 units.

547S. Economy, Society, and Morality in Eighteenth-Century Thought. 3 units. C-L: see Political Science 675S

548S. Political Economy of Growth, Stabilization and Distribution. 3 units. C-L: see Political Science 645S

550S. Global Responses to the Rise of China. 3 units. C-L: see Sociology 570S

553. Labor Economics. Demand for and supply of labor, including human fertility, human capital, hours of work, and labor force participation. Effects of family structure, marriage laws, taxes and transfers (welfare, earned income tax credit) on labor supply and the distribution of income across families and individuals. Labor market discrimination, unions, Background in microeconomics and econometrics recommended. Similar to Economics 433, but intended for MA students. Instructor: Staff. 3 units.

554. Urban Economics. Introduction to urban and spatial economics. Neoclassical monocentric city spatial model, patterns of land values, property prices, residential density and impact of distressed communities on broader development. Systems of cities and regional growth, role of cities in economic development. United States urban features: ethical and socio-economic effects of housing segregation and implications for discrimination. Tradeoffs between efficiency and fairness in housing resource allocation. Business location theory, impact of innovations in transportation, and technology's effect on work patterns. Same as Economics 345, but requires additional work. Not open to students who have taken Economics 345. Instructor: Staff. 3 units.

555S. International Trade. International trade, investment and migration, commercial policy, and the political economy of trade. Prerequisite: Economics 205D; and Economics 210D. Instructor: Staff. 3 units.

556. Economic History and Modernization of the Islamic Middle East. Economic development of the Middle East from the rise of Islam to the present. Transformation of the region from an economically advanced area into part of the underdeveloped world. Role of religion in economic successes and failures. Obstacles to development today. Topics: Islamic economic institutions, economic roles of Islamic law, innovation and change, political economy of modernization, interactions with other regions, economic consequences of Islamism. This is the graduate only pairing for Econ 134 which requires additional course work. Instructor: Staff. 3 units.

557S. International Macroeconomics. Analysis of the determinants of international capital movements, trade imbalances, and nominal and real exchange rates. Policy debates such as the foreign indebtedness of the United States, emerging market debt crises, exchange-rate-based inflation stabilization, and balance-of-payment crises. Same as Economics 455 but with additional work. This course is not open to students who have taken Economics 455. Prerequisites: Economics 205D and 210D. Instructor: Staff. 3 units.

558. Islam and the State. Introduction to political history of Middle East. Four objectives: (1) become familiar with institutions responsible for political development in region, (2) examine transformations/cases of inertia to derive lessons about mechanisms that govern political development, including democratization, (3) investigate how religion shaped the region's political trajectory, (4) identify social forces, especially economic, driving contemporary reinterpretation of Islam's political organization and requirements, by both Islamists and secular political actors. Not open to students who have taken Economics 326. Graduate students only. Instructor consent required. Instructor: Staff. 3 units.

561. African Economic Development. Same as undergraduate course of the same name but requires an additional paper. This course will seek to provide students with a realistic picture of African economies and societies today, emphasizing their heterogeneity and accomplishments, as well as focusing on reasons for continued widespread poverty throughout the continent. The course develops behavioral models that can be used to explain and predict household, market, and government behaviors and outcomes. Students are expected to quickly acquire basic stylized facts and economic models, and then analyze one of the many data sets now available. Instructor: Staff. 3 units.

564. Competitive Strategy and Industrial Organization. Foundations of the field of industrial organization, including the theory of the firm, models of competition, market structure, pricing and dynamic models. Emphasis on theory with support from specific industries, including telecommunications, retail and airlines. Similar to Economics 464, but requires additional assignment. Not open to students who have taken Economics 464. Instructor: Staff. 3 units.

567S. Computer Modeling. Introduction to the use of computer techniques in economic policy evaluation; policy applications to international economics, public finance and development economics; computer analysis of linearized and nonlinear models using Excel and GAMS. Students required to complete a major modeling project. Prerequisites: Economics 205D and 210D. Instructor: Staff. 3 units.

568S. Current Issues in International and Development Economics. Issues of income distribution within and between countries, vehicles for growth, regional development, the role of politics in economic policy, multinational institutions. Cross-country and cross-time comparisons. Emphasis on individual research projects. Prerequisite: Economics 205D and Economics 210D. Instructor: Staff. 3 units. C-L: International Comparative Studies 512S

570. International Finance. Analysis of the determinants of international capital movements, trade imbalances, and nominal and real exchange rates. Policy debates such as the foreign indebtedness of the United States, emerging market debt crises, exchange-rate-based inflation stabilization, and balance-of-payment crises. Graduate pairing for Econ 455; graduate students will receive additional writing assignments. Instructor: Staff. 3 units.

571. Financial Markets and Investments. Same as Economics 471, but requires an additional paper. Prerequisite: Economics 205D; Economics 210D; and Statistical Science 101, 111, 230,130 or 250, or Mathematics 230 or 342. Instructor: Weller or staff. 3 units.

572. Asset Pricing & Risk Management. Integrates micro and macro economics with topics in finance. Utility maximization within mean variance framework for portfolio analysis and capital asset pricing model. Corporate valuation and discounted cash flow analysis. Capital structure and principal-agent problem will lead into a discussion of the Efficient Markets Hypothesis and underlying assumptions. Market pricing, forecasting, and financial crises. Graduate pairing for Economics 372; graduate students will receive additional writing assignments. Prerequisite: Economics 101 (or Economics 21 and Economics 22); Statistical Science 111, 130, 230, 210, or 250, or BME 244L; and Economics 205D or Mathematics 212. Instructor: Staff. 3 units.

580. Law and Economics. A qualitative and quantitative introduction to economic analysis of legal issues and legal reasoning. Case studies in accident law, product liability, and the value of life. Other topics include contracts, property, affirmative action, civil procedure, and the economics of criminal behavior. Some models examined include a calculus-based approach. Graduate pairing for Econ 463; graduate students will receive additional writing assignments. Instructor: Staff. 3 units.

581. Investment Strategies. Course examines issues in personal investment strategies. Topics include behavioral finance, closed-end and open-end mutual funds, data-mining, diversification, efficient market hypothesis, equity premium, exchange-traded funds, expenses and transaction costs, life cycle investing, market timing, passive versus active investing, survivorship bias, tax managed investing, time zone arbitrage, Robert Shiller's CAPE, Tobin's Q.Prerequisite: Economics 201D. Instructor: Staff. 3 units.

590. Selected Topics in Economics. Instructor: Staff. 3 units.

590S. Selected Topics in Economics. Seminar version of Economics 590. 3 units.

591. Independent Study. Individual non-research, directed reading, or individual project in a field of special interest under the supervision of a faculty member. Consent of instructor and director of graduate studies or MA program director required. Instructor: Staff. Variable credit.

593. Research Independent Study. Individual research in a field of special interest under the supervision of a faculty member, the central goal of which is a substantive paper or written report containing significant analysis and interpretation of a previously approved topic. Consent of instructor and director of graduate studies or MA program director required. Instructor: Staff. Variable credit.

597. Economic Science Studies. Application of techniques of science and technology studies to problems in the history, philosophy, methodology and sociology of economics. Addresses modern economics as a illustrative case of issues arising in Studies of Scientific Knowledge. What counts as "fact" in economics? Who decides, and by what processes of negotiation? Does accepting that knowledge in economics as a construct reduce the usefulness of that knowledge and affect the notion of progress in economic science? Why has mathematical economics enjoyed such success in recent decades? Close readings in texts across the sciences and in modern economics, and the history of mathematics, culminating in a research project. (Similar in context to Economics 318S, but requires an additional assignment. Not open to students who have taken Economics 318S) Prerequisites: Economics 205D; and Economics 210D or 248; and consent of instructor. Instructor: Staff. 3 units.

601D. Microeconomics. Topics include theory of consumer choice, demand, uncertainty, competitive and imperfectly competitive firms, factor markets, producer theory, and general equilibrium. Intended for master's students. Prerequisites: Intermediate microeconomics and multivariate calculus necessary. Matrix algebra and differential equations useful. Instructor: Staff. 3 units.

602. Macroeconomic Theory. Micro-founded dynamic general equilibrium models have become the standard tool for macroeconomic analysis. Course provides guidance on how to work with these models. Our baseline New Keynesian model will feature sticky prices combined with monopolistic competition. We will show that the result in framework is appealing from an empirical point of view and we will use it to assess the desirability of alternative arrangements for the conduct of monetary policy. Prerequisite: Economics 601. Instructor: Staff. 3 units.

604. Mathematical Economics. Topics include a review of differential and integral calculus; overview of matrix algebra, comparative statics, constrained optimization; introduction to differential equations and difference equations. Prerequisite: basic knowledge of differential and integral calculus. Instructor: Staff. 3 units.

605. Advanced Microeconomic Analysis. Topics include consumption, production, investment, uncertainty and information. Instructor: Staff. 3 units.

606. Advanced Macroeconomics II. This course will briefly introduce you to some of the most widely used core models of modern macroeconomics. At the same time, it will provide a strong theoretical and practical background that can be helpful if you want to pursue further studies in (macro-)economics. In particular, we will build, step-by-step, one of the standard workhorses to study the business cycles, the real business cycles (RBC) model. We will start from its ancestor, the Solow growth model, we will pass by its origins, the deterministic neoclassical growth model, and we will work all the way up to its current dynamic stochastic general equilibrium (DSGE) model version. Instructor: Staff. 3 units.

608D. Introduction to Econometrics. Data collection, estimation, and hypothesis testing. Use of econometric models for analysis and policy. (Same as Economics 208D but requires additional term paper; not open to students who have taken Economics 208D.)

Economics MA's only. All other students require permission number. Prerequisites: Economics 21 and 22 or 201D; Mathematics 212 (co-requisite); Statistical Science 101, 111, 230, 130 or 250, or Mathematics 230 or 342. Instructor: Staff. 3 units.

612. Time Series Econometrics. Empirical research in macroeconomics and international finance, providing students with a series of econometric tools for empirical analysis of time-series and an introduction to the current empirical research in macroeconomics, international finance, and forecasting. Small project and simple empirical research required. Prerequisites: Satisfactory performance (as judged by the instructor) in Econometrics (Economics 208D) plus a course in Linear Algebra or consent of the instructor. A course in macroeconomics (Economics 210D) is very useful but not strictly enforced. Instructor: Staff. 3 units.

613. Applied Econometrics in Microeconomics. Empirical research in microeconomics, with emphasis on three main sub-fields: labor economics, public economics, and industrial organization. Focus on current empirical research in these areas and student independent analysis of current research using statistical software. Same as Economics 411, but additional work required. Not open to students who have taken Economics 411. Prerequisite: Economics 208D or 608D. Instructor: Staff. 3 units.

620. Game Theory with Applications of Economics and other Social Sciences. Game theory is a way of thinking about strategic situations. On one hand its content is normative: it provides guidelines for decision makers to predict others' actions and to recognize good and bad strategies. On the other hand its content is positive: it helps the social scientist to understand the nature of social interaction in various applications, in economics, political science, sociology and anthropology. We will learn new concepts, methods and terminology. Course will emphasize examples and applications. We will also play some games in class. Instructor: Staff. 3 units.

621. Non-Market Valuation. This course will cover non-market valuation techniques typically used to measure the value of local public goods and (dis)amenities. These techniques are used to determine the "benefits" side in a cost-benefit analysis, and are central to the formulation of regulatory policy in the US. In addition, they play an important role in local public finance, urban, and environmental economic analysis. Papers will be both theoretical and applied. Applications will focus on questions in public finance, as well as urban and environmental economics, with a strong focus on the latter. MA Micro Theory is recommended. Instructor: Timmins. 3 units.

623. Forecasting Financial Markets. Introduces statistical models for financial price and risk. ARMA, GARCH, Value-at-Risk. Covers both theory underlying these models and practical implementation using statistical software (MATLAB). Prerequisite: Economics 608D or 672. Instructor: Patton. 3 units.

624. International Trade. This is a semester-long course in international trade. The objective of the course is to introduce students to current research topics on international trade as well as the tools and methodologies that are prevalent in the field. Instructor: Dix-Carneiro and Xu. 3 units.

627. Soviet and Post-Soviet Economic History. This course traces economic factors leading to the downfall of the Russian Empire and the rise of the USSR, followed by an assessment of the collapse of the USSR. Particular attention is devoted to the NEP period, earlier Soviet economic models, the famine of the 1930s, the impact of the Great Patriotic War (WWII), industrialization and urbanization, Soviet planning, and declining productivity growth and life expectancy in the in the 1970s and 1980s. The course then explores the economic consequences of the USSR's collapse as well as the nature of recovery in various countries that followed. Prerequisite: Economics 201D and (Economics 208D or 204D, either of which can be taken concurrently). Instructor: Becker. 3 units. C-L: History 627, Russian 627

627D. Soviet and Post-Soviet Economic History. This course traces economic factors leading to the downfall of the Russian Empire and the rise of the USSR, followed by an assessment of the collapse of the USSR. Particular attention is devoted to the NEP period, earlier Soviet economic models, the famine of the 1930s, the impact of the Great Patriotic War (WWII), industrialization and urbanization, Soviet planning, and declining productivity growth and life expectancy in the in the 1970s and 1980s. The course then explores the economic consequences of the USSR's collapse as well as the nature of recovery in various countries that followed. Prerequisite: Economics 201D and (Economics 208D or 204D, either of which can be taken concurrently). Instructor: Becker. 3 units. C-L: History 627D, Russian 627D

650. Labor Economics. The goal of this class is to acquaint students with topics in labor economics. After reviewing basic facts about labor markets around the world (participation rates, unemployment, wages, etc.), we will cover theories of labor supply, labor demand, wages, and human capital. Additional topics include wage discrimination, unemployment, and labor market policies. There will an emphasis on the interplay between theory and empirical exercises. Instructor: Staff. 3 units.

652. Economic Growth. Old and recent developments in search for broader, sharper explanations of variation in market structure, technological development and living standards observed across time, countries, and industries. Historical study of writings of Smith, Ricardo, Marx, Malthus and Schumpeter. Study of modern growth theory and its implications. Background in intermediate macroeconomics and microeconomics recommended. Instructor: Staff. 3 units.

656S. International Monetary Economics. Financial aspects of growth and income determination, and macroeconomic policy in open economies. Applications to exchange rate determination, capital markets, fluctuations in the trade balance and current account, monetary and fiscal policies in open economies, currency crises, and monetary reform. Significant research component required. Economics MA students only. Instructor: Staff. 3 units.

664. Industrial Organization. This class provides a graduate level introduction to Industrial Organization, covering theoretical and empirical work dealing with the structure, behavior, and performance of firms and markets. There will be more focus on empirical methods and applications. Topics include the organization of the firm, monopoly, price discrimination, oligopoly, auctions, vertical market structures, market entry. The course integrates theoretical models and empirical studies. It also presumes that students have a familiarity with intro micro theory, some basic game theory and some econometrics. Prerequisites: Economics 205, Econ 208, Econ 601. Instructor: Staff. 3 units.

665. Market Power and Public Policy. The purpose of antitrust laws is to control how firms attain and maintain their market position, presumably for the betterment of consumers, or at least for the benefit of society. Using a rigorous set of tools from

microeconomic and game theory, this class will investigate the underpinnings of policies meant to deal with market power broadly defined, such as antitrust laws, the regulation of public utilities, the regulation of financial markets, and anti-dumping rules. The graduate section of this class will have additional assignments doing structural evaluation of mergers. This will involve a combination of estimation techniques and computational work for merger simulations. Prerequisite: Economics 608D. Instructor: Staff. 3 units.

667. Computer Modeling. Introduction to the use of computer techniques in economic policy evaluation; policy applications to international economics, public finance and development economics; computer analysis of linearized and nonlinear models using Excel and GAMS. Students required to complete a major modeling project. Prerequisites: Economics 205D and 210D. Instructor: Staff. 3 units.

671. Financial Markets and Investments. The structure and workings of financial markets. Topics include risk-return relationships, portfolio selection, the capital asset pricing model, the arbitrage pricing theory, fixed income analysis, and aspects of derivatives. This is an advanced version of Economics 571 intended primarily for students in the Master's in Quantitative Financial Economics program. It employs a more mathematically rigorous and theoretically advanced approach than Economics 471 and 571. Instructor: Staff. 3 units.

672. Empirical Methods in High Frequency Financial Econometrics. Focus is on understanding and applying principal results with emphasis on substantive applications. Topics generally include jump diffusions, semi-martingales, jump-robust volatility estimation, realized beta, jump regressions, local volatility estimation, diffusive beta, and measurement error (noise). Instructor: Staff. 3 units.

673. Mathematical Finance. 3 units. C-L: see Mathematics 581

674. Financial Derivatives. 3 units. C-L: see Mathematics 582

675. Corporate Finance Theory: Governance, Incentives and Valuation. Course uses tools of contract theory (information economics, mechanism design, and game theory) to analyze key features of corporate structure, performance, and valuation. Investigates critical interactions among stakeholders in a modern business enterprise (directors, executives, management, labor, financiers, shareholders, and regulators) in achieving goals and objectives of the corporation. Topics include: reform of corporate governance and auditing; role of private equity, financial markets, and takeovers; efficient determination of leverage, dividends, liquidity, and risk management, and design of managerial incentive packages. Prerequisite: Economics 205D. Instructor: Staff. 3 units.

676. Empirical Asset Pricing. This course develops, examines, and applies models for portfolio decisions by investors and the pricing of securities in capital markets. While developing portfolio theory, we will study the extensive empirical work that characterizes movements in security prices, evaluates alternative investment and asset pricing models, and attempts to test those models and interpret the implications of those tests. This is a research-oriented course with practical implementation of quantitative methods in finance, aimed at highly motivated and technically proficient undergraduate and master's students. Prerequisite: Economics 372 or 572 or 471 or 571. Instructor: Staff. 3 units.

677. Fixed Income Markets and Quantitative Methods. The areas of focus will include: the value of money and discounted cash flow concepts, statistics, probability concepts, correlation & regression, understanding risks associated with bonds, and bonds with embedded options, and mortgages and the mortgage markets. Prerequisite: Economics 372. Instructor: Staff. 3 units.

678. Derivatives for Speculation and Risk Management. A rigorous introduction to financial derivatives focused on their use for hedging/risk management, establishing trades to reflect market outlooks and a means to create leverage. Students will learn theoretical underpinnings of derivative products and understand advantages and pitfalls they offer for traders and hedgers. Topics include: basics of bond and swap valuation, difference and overlap of forwards and futures, use and pricing of basic and exotic options, Black-Scholes-Merton formula, Value-at-Risk (VAR). Emphasis on markets-based implementation of technical material and real world examples of market disruption. Recommended prerequisite: Economics 608D or equivalent; multivariable calculus. Instructor: Leven. 3 units.

690. Selected Topics in Economics. Instructor: Staff. 3 units.

690-82. Topics in Mathematical Finance. 3 units. C-L: see Mathematics 690-82

690S. Selected Topics in Economics. Seminar version of Economics 690. Instructor: Staff. 3 units.

695S. Master's Research Seminar 1. Provides introduction to empirical research in applied microeconomics, macroeconomics, and financial economics. Students work in teams of 2-4 led by participating faculty supervisors. Broad project areas will be determined in advance, and students will be invited to sign up based on their interest and available space. Projects may continue into a second semester (Econ 696) based on mutual agreement between faculty supervisor and student(s). Projects may relate to participating faculty supervisors' current research or may be in an area of student(s) interest, subject to a faculty member being willing to supervise. Prerequisite: Economics 608D. Instructor: Kimbrough. 1.5 units.

696S. Master's Research Seminar 2. Students will complete the work they began on their research project in Economics 695S. Each student or team will present to the class during the semester; students not presenting will provide comments and feedback. Efforts will be focused on helping teams to implement, improve, and extend empirical methodology and interpret the results. Towards the end of the semester the focus will shift to editing and improving students' final research paper. Prerequisite: ECON 608D and ECON 695S. Instructor: Kimbrough. 1.5 units.

699. Internship. Open to students engaging in practical or governmental work experience during the summer or a regular semester. A faculty member in the department will supervise a program of study related to the work experience, including a substantive paper on an economics-related topic, maintaining significant analysis and interpretation. Consent of director of graduate studies required. Instructor: Staff. Variable credit.

700. Mathematics for Economists. Topics include linear and matrix algebra, topology, multivariate calculus, optimization and dynamic systems. For Economics incoming PhD students only. Instructor: Staff. 3 units.

701. Microeconomic Analysis I. Review of contemporary theory relating to consumer choice, production, the firm, and income distribution in competitive and imperfectly competitive markets. Restricted to PhD students in economics except with consent of instructor and director of graduate studies. Instructor: Staff. 3 units.

701D. Microeconomic Analysis I. Same in content as Economics 701, but with weekly discussion section. Econ PhD students only. Instructor: Staff. 3 units.

702. Macroeconomic Analysis I. Intertemporal models of consumption and labor supply; implications of these models for the behavior of macroeconomic aggregates, fiscal policy, and monetary policy; money demand and inflation; economic growth. Restricted to Ph.D. students in economics except with consent of instructor and director of graduate studies. Instructor: Staff. 3 units.

702D. Macroeconomic Analysis I. Same in content as Economics 702, but with weekly discussion section. Econ PhD students only. Instructors: Staff. 3 units.

703. Econometrics I. Matrix algebra, probability theory, and statistics used to develop methods for multiple regression analysis. Covers material up to generalized least squares estimation. Restricted to PhD students in economics with consent of instructor. Instructor: Staff. 3 units.

703D. Econometrics I. Same in content as Economics 703, but with weekly discussion section. Econ PhD students only. Instructors: Staff. 3 units.

704. First Year Introduction to Research. Discuss and analyze in detail recent papers drawn from literature relevant to various areas of Economics. Workshop serves as formal environment in which outside speakers present cutting edge research papers and Duke Ph.D. students present and evaluate their research on a regular basis. Participants required to make presentations as directed by instructor and play active role in discussions. Instructor: Staff. 3 units.

705. Microeconomic Analysis II. An introduction to game theory and information economics with applications such as oligopoly, bargaining, auctions, and reputations. Prerequisite: Economics 701. Instructor: Staff. 3 units.

705D. Microeconomic Analysis II. Same in content as Economics 705, but with weekly discussion section. Prerequisites: Econ 701D. This course is only open to Econ PhD Students. Instructor: Staff. 3 units.

706D. Macroeconomic Analysis II. Same in content as Economics 706, but with weekly discussion section. Instructors: Staff. 3 units.

707. Econometrics II. Advanced multivariate regression analysis. Topics include panel data models, systems, limited dependent variables, discrete choice, and nonlinear estimation. Prerequisite: Economics 703. Instructor: Staff. 3 units.

707D. Econometrics II. Same in content as Economics 707, but with weekly discussion section. Prerequisites: Econ 703D. Open to Econ PhD Students only. Instructor: Staff. 3 units.

747S. Monitoring, Evaluation, and Learning for Development (MELD) Seminar. 3 units. C-L: see Political Science 727S

751. The Political Economy of Institutions. Provides survey of institutional analysis, focusing on recent developments in economics, political science and legal studies. Emphasis is on analysis of institutional change and the functions of institutions. Explores mechanisms by which constitutions, laws, customs and conventions undergo transformations. Topics include pace of institutional transformation, latent change, social inertia, political revolutions, links between beliefs/behaviors, and the social functions of laws, customs and conventions. Readings and case studies reflect the interdisciplinary characteristic of field. Prerequisites: Econ 701D and 705D or Econ 601 and Econ 605 and must be Econ PhD or PolSci PhD or instructor consent. Instructor: Staff. 3 units. C-L: Political Science 762

752. Sustainability and Renewable Resource Economics. 3 units. C-L: see Environment 752

753. Natural Resource Economics. 3 units. C-L: see Environment 829

753D. Natural Resource Economics. 3 units. C-L: see Environment 829D

756. Health Economics: Supply. Semester-long survey course designed for students considering PhD research in health economics. Topics will include the economics of hospital care, physicians' services, pharmaceuticals and vaccines and long-term care, including nursing home care. Literature from general economics journals is emphasized. Studies are based on U.S. data and data from other countries at all levels of economic development. Prerequisite: Either Economics 601 or 605 or 701 or 705, plus either Economics 608 and 703, or Economics 707. Instructor: Staff. 3 units.

757. Health Economics: Demand. Graduate level course in the Economics of Health. Emphasis on acquiring a set of tools and a framework within which to organize empirical analysis. Focus on decisions made by household members and the market for health insurance. Relevance for students interested in broader empirical microeconomic research. Prerequisite: Either Economics 601 or 605 or 701 or 705, plus either Economics 608 and 703, or Economics 707. Instructor: Staff. 3 units.

790. Writing & Presenting in Economics. Writing and presenting are crucial for professional success, but often are not done effectively by economists. In part, this is because economics graduate students aren't explicitly taught how to write and present. This module is designed to fill this gap by teaching basic principles of communication for young economists. Over 3 intensive weeks, you will learn foundational principles of writing and presenting, and then apply these concepts in brief but rigorous assignments that will require students to write and make presentations. Instructor: Staff. 1.5 units.

791. Independent Study. Individual non-research directed study in a field of special interest on a previously approved topic, under the supervision of a faculty member, resulting in an academic product. Consent of instructor and director of graduate studies required. Instructor: Staff. 3 units.

799. Internship. Open to students engaging in practical or governmental work experience during the summer or a regular semester. A faculty member in the department will supervise a program of study related to the work experience, including a substantive paper

on an economics-related topic, maintaining significant analysis and interpretation. Consent of director of graduate studies required. Instructor: Staff. Variable credit.

801. Writing & Presenting in Economics. Writing and presenting are crucial for professional success, but often are not done effectively by economists. In part, this is because economics graduate students aren't explicitly taught how to write and present. This course is designed to fill this gap by teaching basic principles of communication for young economists. You will learn foundational principles of writing and presenting, and then apply these concepts in brief but rigorous assignments that will require you to write and make presentations. Instructor: Staff. Variable credit.

821. Non-Market Valuation. This course will cover non-market valuation techniques typically used to measure the value of local public goods and (dis)amenities. These techniques are used to determine the "benefits" side in a cost-benefit analysis and are central to the formulation of regulatory policy in the US. In addition, they play an important role in local public finance, urban and environmental economic analysis. Papers will be both theoretical and applied Applications will focus on questions in public finance, urban and environmental economics, with a strong focus on the latter. Prerequisite: MA Micro Theory is recommended. Instructor: Timmins. 3 units.

823. Forecasting Financial Markets. Introduces statistical models for financial price and risk. ARMA, GARCH, Value-at-Risk. Covers both theory underlying these models and practical implementation using statistical software (MATLAB). Instructor: Patton. 3 units.

824. International Trade. This is a semester-long course in international trade. The objective of the course is to introduce students to current research topics on international trade as well as the tools and methodologies that are prevalent in the field. Instructor: Dix-Carneiro and Xu. 3 units.

825. Industrial Organization. This class is meant to introduce key concepts and tools in Industrial Organization. We will start by presenting demand estimation, include discrete choice models of demand such as Berry, Levinsohn, and Pakes (1995). The we will look at methods to estimate production and cost functions, including control function methods such as Olley and Pakes (1996). The class will cover IO theory models of competition, such as Salop and Cournot models of competition. Finally, we will discuss topics in vertical markets, such as double marginalization and bilateral bargaining. Instructor: Collard-Wexler. 3 units.

826. Partial Identification: Theory and Applications in Industrial Organization. Focus on the use of partially identifying models for applications in industrial organization, investigating a mix of methodological, theoretical, econometric and applied issues. Particular areas of application in the IO literature will comprise a selection of research employing various models of auctions, entry, matching, and demand estimation. For each area of application, we will cover both the econometric theory underlying the partial identification analysis employed, as well as the motivation for the use of the partially identifying model in empirical practice. Instructor: Collard-Wexler. 3 units.

872. Empirical Methods in High Frequency Financial Econometrics. Focus is on understanding and applying principal results with emphasis on substantive applications. Topics generally include jump diffusions, semi-martingales, jump-robust volatility estimation, realized beta, jump regressions, local volatility estimation, diffusive beta, and measurement error (noise). Paired with Economics 672. PhD students will be required to do additional work. Instructor: Tauchen. 3 units.

881. Special Topics in Applied Microeconomics. Prerequisites: Econ 301D (701D), 302D (705D), 320D (702D), 322D (706D), 341D (703D) and 342D (707D). Open to Econ PhD students only. Instructor: Staff. Variable credit.

882. Special Topics in Macro International Finance. Prerequisites: Econ 301D (701D), 302D (705D), 320D (702D), 322D (706D), 341D (703D) and 342D (707D). Open to Econ PhD students only. Instructor: Staff. Variable credit.

883. Special Topics in Econometrics. Prerequisites: Econ 301D (701D), 302D (705D), 320D (702D), 322D (706D), 341D (703D) and 342D (707D). Open to Econ PhD students only. Instructor: Staff. Variable credit.

885. Special Topics in Economic Theory. Prerequisites: Econ 301D (701D), 302D (705D), 320D (702D), 322D (706D), 341D (703D) and 342D (707D). Open to Econ PhD students only. Instructor: Staff. Variable credit.

887. Special Topics in Financial Econometrics. Prerequisites: Econ 701D, 705D, 702D, 706D, 703D and 707D. Open to Econ Ph.D. students only. Open to Econ PhD students only. Instructor: Staff. Variable credit.

890. Special Topics in Economics. Prerequisites: Econ 701D, 702D, 703D, 705D, 706D, 707D. Only open to Econ PhD Students. Instructor: Staff. Variable credit.

890S. Special Topics in Economics. Prerequisites: Econ 701D, 702D, 703D, 705D, 706D, 707D. Only open to Econ PhD Students. Instructor: Staff. 3 units.

898. Directed Research. Consent of the director of graduate studies and instructor required. Instructor: Staff. Variable credit.

899. Internship. Open to students engaging in practical or governmental work experience during the summer or a regular semester. A faculty member in the department will supervise a program of study related to the work experience, including a substantive paper on an economics-related topic, maintaining significant analysis and interpretation. Consent of director of graduate studies required. Instructor: Staff. Variable credit.

901. Applied Microeconomics Workshop. Discuss and analyze in detail recent papers drawn from literature relevant to applied microeconomics. Workshop serves as formal environment in which outside speakers present cutting edge research papers and Duke PhD students present and evaluate their research on a regular basis. Participants required to make presentations as directed by instructor and play active role in discussions. Open to PhD Students Only. Instructor: Staff. 3 units.

902. Macroeconomics and International Economics Workshop. Discuss and analyze in detail recent papers drawn from literature relevant to macroeconomics and international economics. Workshop serves as formal environment in which outside speakers present cutting edge research papers and Duke PhD students present and evaluate their research on a regular basis. Participants

required to make presentations as directed by instructor and play active role in discussions. Pre-req: Students are required to have completed Econ 701D, 702D, 703D, 705D, 706D, and 707D. Open to Econ PhD students only Instructor: Staff. 3 units.

903. Econometrics Workshop. Discuss and analyze in detail recent papers drawn from literature relevant to Econometrics. Workshop serves as formal environment in which outside speakers present cutting edge research papers and Duke Ph.D. students present and evaluate their research on a regular basis. Participants required to make presentations as directed by instructor and play active role in discussions. Pre-req: Students are required to have completed Econ 701D, 702D, 703D, 705D, 706D, and 707D. Open to Econ Ph.D. students only Instructor: Staff. 3 units.

905. Microeconomic Theory Workshop. Discuss and analyze in detail recent papers drawn from literature relevant to microeconomic theory. Workshop serves as formal environment in which outside speakers present cutting edge research papers and Duke Ph.D. students present and evaluate their research on a regular basis. Participants required to make presentations as directed by instructor and play active role in discussions. Instructor: Staff. 3 units.

908. Economic History Workshop. Discuss and analyze in detail recent papers drawn from literature relevant to economic history. Workshop serves as formal environment in which outside speakers present cutting edge research papers and Duke Ph.D. students present and evaluate their research on a regular basis. Participants required to make presentations as directed by instructor and play active role in discussions. Instructor: Staff. 3 units.

909. Economic Thought and History of Political Economy Workshop. Discuss and analyze in detail recent papers drawn from literature relevant to Economic Thought/Hope. Workshop serves as formal environment in which outside speakers present cutting edge research papers and Duke Ph.D. students present and evaluate their research on a regular basis. Participants required to make presentations as directed by instructor and play active role in discussions. Instructor: Staff. 3 units.

911. Applied Microeconomics Development. Discuss and analyze in detail recent papers drawn from literature relevant to applied microeconomics. Workshop serves as formal environment in which outside speakers present cutting edge research papers and Duke PhD students present and evaluate their research on regular basis. Participants required to make presentations as directed by instructor and play active role in discussions. Open to PhD students only. Instructor: Thomas. 3 units.

951S. Applied Microeconomics Research. For students anticipating working on thesis in area of Applied Microeconomics. Emphasis on reading and critiquing state of the art empirical work in microeconomics and presenting ongoing graduate student research. Students expected to contribute to discussion and present on regular basis. Prerequisite: Economics 901, 902, 903, 905, 908, or 909 concurrently. Instructor: Staff. 1.5 units.

952S. Macroeconomics International Finance Research. Discuss and analyze in detail recent papers on Macroeconomics and International Finance. Serves as formal environment in which students present and evaluate research on a regular basis. Participants required to make presentations as directed by instructor and play active role in discussions. Prerequisite: Economics 901, 902, 903, 905, 908, or 909 concurrently. Instructor: Staff. 1.5 units.

953S. Research Seminar in Microeconometrics. Facilitate research in applied microeconomics. Students and faculty present paper by leading research. Emphasis places on those papers that combine sophisticated techniques from econometrics and that integrate theory and empirical work. Participants encourages to present early version of own research. Prerequisite: Economics 901, 902, 903, 905, 908, or 909 concurrently. Instructor: Staff. 1.5 units.

954. Applied Microeconomics Development Research. Discuss and analyze in detail recent papers drawn from literature relevant to applied microeconomics. Workshop serves as formal environment in which outside speakers present cutting edge research papers and Duke PhD students present and evaluate their research on regular basis. Participants required to make presentations as directed by instructor and play active role in discussions. Open to PhD students only. Instructor: Thomas. 3 units. C-L: Public Policy 954

955S. Research Seminar in Economics Theory. Student's own field and research papers will be used as basis for developing modeling skills in microeconomic theory including Contract Theory, Decision Theory, Game Theory, General Equilibrium, Industrial Organization, Mechanism Design, political economy, and Public Economics. Explore and develop methods and techniques for deriving economically interesting implications of assumptions on primitives. Write and refine original research papers, present work, and evaluate fellow students in route to dissertation prospectus. Prerequisite: Economics 901, 902, 903, 905, 908, or 909 concurrently. Instructor: Staff. 1.5 units.

957S. Research Seminar in Financial Econometrics. For students anticipating working on thesis in the area of financial econometrics. Emphasis on research that combines sophisticated statistical and econometric techniques with current ideas and issues in asset pricing finance. Students expected to contribute to discussions and present ongoing research on a regular basis. Prerequisites: Field Examinations in Econometrics and Finance, Economics 901, 902, 903, 905, 908, or 909 concurrently. Instructor: Staff. 1.5 units.

Economics and Computation

Professor Chase and Research Professor Becker, *Directors of Graduate Studies*

Faculty in Computer Science: Professors Agarwal, Calderbank, Carin, Chase, Conitzer, Cummings, Donald, Groh, Hartemink, Kim, Lebeck, Maggs, Marinos, Mukherjee, Munagala, Parr, Reif, Rudin, Sapiro, Sorin, Sun, Tarokh, Tomasi, Trivedi, and J. Yang; Associate Professors Bartesaghi, Board, Farsiu, Hilton, Lee, Li, Machanavajjhala, Panigrahi, Schmidler, and X. Yang; Assistant Professors Carson, Ge, Gordân, Gorlatova, Heller, Pajic, Randles, Roy, Steorts, Wills, and Zavlanos; Professors Emeriti Biermann, Ellis, Loveland, and Starmer; Associate Professors of the Practice Emeriti Lucic and Ramm; Professors of the Practice Astrachan and Rodger; Associate Professors of the Practice Daily and Forbes; Assistant Professors of the Practice Stephens-Martinez; Adjunct Associate Professor Pitsianis; Adjunct Assistant Professor Konidaris; Adjunct Professors Baldin, Hsu, Kaltofen, Labean, and Patel; Assistant Research Professor Fain; Executive in Residence Quan; Senior Lecturer Duvall

Faculty in Economics: Professors Abdulkadiroglu, Adler, Ambrus, Anton, Arcidiacono, Ariely, Bansal, Bayer, Bollerslev, Burnside, Clotfelter, Cohen, Coleman, Collard-Wexler, Conitzer, Darity, Field, Frakes, Frankenberg, Hoover, Hotz, Hsieh, Kimbrough, Kramer, Kranton, Kuran, Lewis, Lopomo, Marx, McAdams, McElroy, Munger, Nechyba, Newell, Pattanayak, Patton, Peretto, Petters, Pfaff, Pizer, Rampini, Ridley, Rosen, Sanders, Sarver, Smith, Tauchen, Taylor, Thomas, Timmins, Tower, Viswanathan, Xu, and Yildirim; Associate Professors Ananat, Bennear, Berger, Bianchi, Bugni, Conrad, Daley, Dix-Carneiro, Ilut, Leventoglu, Li, Mohanan, Roberts, Sadowski, and Suarez Serrato; Assistant Professors Bardhi, Garlick, Harding, Jurado, Kehrig, Komisarow, Lanteri, Macartney, Masten, Maurel, Rangel, Sexton, Sidibe, Wang, and Weller; Professors Emeriti Burmeister, Cook, De Marchi, Grabowski, Graham, Ladd, Sloan, Toniolo, Wallace, and Weintraub; Research Professors Becker, Caldwell, and Medema; Associate Research Professors Boyd and Zanalda; Professors of the Practice Connolly, Fullenkamp, Leachman, Leven, Rasiel, and Ridley; Associate Professor of the Practice Kim; Assistant Professor of the Practice Levonmaa

A master's degree is available in this program.

The Master's Program in Economics and Computation is a joint program between the departments of computer science and economics. Students preparing to enter this program will find an undergraduate background in mathematics, engineering, computer science, statistics, or economics to be helpful. It is designed to train and develop computational skills linked to economics, finance, policy, and related areas to prepare graduates for PhD studies or related professions. Students complete coursework in both computer science and economics. Graduates will be awarded an MS in economics and computation as their degree.

Students must complete a minimum of 30 course credits: 12 course credits in computer science courses numbering 500 or above, 12 course credits in select economics courses (Economics 601, 602, 605, 606, 608D, 612, 613, 652, 701, 702, 703, 705, 706, 707, or approved substitutes, with no more than 6 course credits from any one of the subfields of Microeconomics, Macroeconomics, and Econometrics), and 6 course credits in computer science, economics, or other relevant disciplines subject to approval by the MSEC directors. Effective Fall 2018, undergraduate courses (499 or lower) do not count toward the MSEC degree or a student's GPA. Undergraduate courses taken before Fall 2018 do count toward the MA degree (given a grade of B- or better) and GPA. Courses that are cross-listed as both undergraduate- and graduate-level courses count toward the MSEC degree and a student's GPA only if they are taken at the graduate level.

The student must pass a final exam administered by the student's committee covering a portfolio of learning and research activities carried out during their master's studies. The portfolio must include one of the following two items: a capstone course in either computer science or economics, or a project paper on an approved topic developed via independent study with one or more computer science and/or economics faculty advisors if available. This document is expected to describe a mature project with research content.

Computer Science Courses (COMPSCI)

510. Operating Systems. 3 units.
512. Distributed Information Systems. 3 units.
514. Computer Networks and Distributed Systems. 3 units.
515. Wireless Networking and Mobile Computing. 3 units.
516. Data-Intensive Computing Systems. 3 units.
520. Numerical Analysis. 3 units.
524. Nonlinear Dynamics. 3 units.
527. Introduction to Computer Vision. 3 units.
528. Introduction to Computational Science. 3 units.
531. Introduction to Algorithms. 3 units.
532. Design and Analysis of Algorithms. 3 units.
534. Computational Complexity. 3 units.
550. Advanced Computer Architecture I. 3 units.
553. Compiler Construction. 3 units.
554. Fault-Tolerant and Testable Computer Systems. 3 units.
555. Probability for Electrical and Computer Engineers. 3 units.
561. Computational Sequence Biology. 3 units.
570. Artificial Intelligence. 3 units.
571. Machine Learning. 3 units.
579. Statistical Data Mining. 3 units.
590. Advanced Topics in Computer Science. 3 units.
624. Nanoscale and Molecular Scale Computing. 3 units.
630. Randomized Algorithms. 3 units.
632. Approximation Algorithms. 3 units.
634. Geometric Algorithms. 3 units.
636. Computational Topology. 3 units.
650. Advanced Computer Architecture II. 3 units.
662. Computational Systems Biology. 3 units.
663. Algorithms in Structural Biology and Biophysics. 3 units.
664. Computational Structural Biology. 3 units.
673S. Computer Models and the Treatment of Psychiatric Disorders. 3 units.
710. Topics in Operating Systems. 3 units.
724. Advanced Topics in Nonlinear and Complex Systems. 3 units.
734. Theory of Computation. 3 units.
770S. Seminar in Artificial Intelligence. 3 units.
776. Advanced Topics in Artificial Intelligence. 3 units.

Economics Courses (ECON)

601. Microeconomics. 3 units.
602. Macroeconomic Theory. 3 units.
605. Advanced Microeconomic Analysis. 3 units.
606. Advanced Macroeconomics II. 3 units.
608D. Introduction to Econometrics. 3 units.
612. Time Series Econometrics. 3 units.
613. Applied Econometrics in Microeconomics. 3 units.
652. Economic Growth. 3 units.
690. Selected Topics in Economics (Structural Modeling and Computation). 3 units.
701. Microeconomic Analysis I. 3 units.
705. Microeconomic Analysis II. 3 units.
702. Macroeconomic Analysis I. 3 units.

706. Macroeconomic Analysis II. 3 units.
703. Econometrics I. 3 units.
707. Econometrics II. 3 units.

Engineering

The Pratt School of Engineering offers programs of study and research leading to the MS and PhD in biomedical engineering, civil and environmental engineering, electrical and computer engineering, and mechanical engineering and materials science. Additional information may be obtained by visiting https://pratt.duke.edu/grad/phd.

Courses in Engineering (EGR)

505. Oral English Communications for Engineers. Designed for graduate engineering students who are non-native English speakers. Gain the skills necessary to confidently navigate the use of oral English. Learn social and academic norms needed for academic success and build interactional competence. Learn to deliver a self-introduction, brief overview of research/degree program/professional experience, and navigate small talk and social interactions through the development of cultural contexts and an understanding of conversational mechanics. Build the skills needed to actively participate in classes, seek help from multiple sources, and navigate productive interactions with faculty. Open only to Pratt graduate students. Instructor: Fletcher, Bowers. 3 units.

506. Introductory English Writing for Engineers. This writing course is designed for graduate engineering students who are non-native English speakers. The focus will be on writing and revising such that the results are clear and concise. Students will produce a variety of academic and professional documents pertinent to engineers. Additionally, students will analyze the written work of peers and provide relevant feedback. Open only to Pratt graduate students.. 3 units.

590. Special Topics in Engineering. Subjects of an interdepartmental nature in engineering tailored to the advanced undergraduate student or first- or second-year graduate student. Instructor consent is required. Half course or one course. Instructor: Staff. Variable credit.

590-1. Special Topics in Engineering. Subjects of an interdepartmental nature in engineering tailored for entry-level graduate students. Instructor: Staff. Variable credit.

705. Academic English Presentations for Engineers. Course designed for graduate engineering students who are non-native English speakers. Gain the skills necessary to deliver successful engineering-specific presentations. Through feedback, you will learn your strengths and weaknesses and will develop as a successful speaker. Practice delivering both short-form presentations and longer form formal presentations, as required by your particular field of study in engineering. Where possible, presentation practice in class will be related to your engineering course work. Instructor: Mathias. 3 units.

706. Intermediate English Writing for Engineers. This writing course is designed for graduate engineering students who are non-native English speakers. The focus will be on writing and revising that result in clear, effective and concise products. Students will produce a variety of academic and professional documents pertinent to engineers. Additionally, students will analyze the written work of their peers and provide them with relevant feedback. Instructor: Matos-Garner. 3 units.

790. Special Topics in Engineering. General engineering topics intended for graduate students only, and interdepartmental in nature. Instructor consent is required. Quarter course, half course, or one course. Instructor: Staff. Variable credit.

790-1. Special Topics in Engineering. Subjects at an intermediate or advanced level in engineering that are interdepartmental in nature. Courses tailored to graduate students that have the introductory knowledge required. Variable Credit. Instructor: Staff. Variable credit.

790S. Special Topics in Engineering for Graduate Students. Study arranged on broad engineering topics in which the faculty have a particular interest and competence as a result of research or professional activities. Instructor consent is required. Instructor: Staff. Variable credit.

Biomedical Engineering

Professor Chilkoti, *Chair*; Professor Collier, *Director of Graduate Studies (PhD)*; Professor Yuan, *Director of Graduate Studies (Master's)*; Professors Barr, Bellamkonda, A. Brown, Bursac, Chilkoti, Collier, Collins, Dewhirst, Dobbins, Driehuys, Erickson, Gall, Ginsburg, Grill, Henriquez, Huang, Izatt, Johnson, Katz, Kraus, Layton, MacFall, Marszalek, Myers, Neu, Nicolelis, K. Nightingale, Ramanujam, Reichert, Samei, Sampson, Sapiro, Smith, Song, Stamer, Therian, Toth, Trahey, Truskey, Varghese, Vo-Dinh, von Ramm, Warren, West, Woods, Yuan, Zalutsky, Zauscher, and Zhong; Associate Professors Badea, Collier, DeFrate, Farsiu, Gersbach, Idriss, Klitzman, Lo, Peterchev, Segars, Shen, Sommer, Tornai, Wolf, Yellen, and You; Assistant Professors Beck, David, Dzirasa, Field, Gong, Hoffman, Kuo, Lynch, Randles, Reddy, Tadross, Viventi, Wood, and Yao; Professors Emeriti H. Clark, Friedman, and McElhaney; Associate Research Professors Bass and R. Nightingale

A master's degree and a PhD are available in this department.

Biomedical engineering is the discipline in which the physical, mathematical, and engineering sciences and associated technology are applied to biology and medicine. Contributions range from modeling and simulation of physiological systems through experimental research to solutions of practical clinical problems. The goal of the Graduate Program in Biomedical Engineering is to combine training in advanced engineering, biomedical engineering, and the life sciences so that graduates of the program can contribute at the most advanced professional level. The doctoral dissertation should demonstrate significant and original contributions to an interdisciplinary topic, accomplished as an independent investigator. The major, current research areas of the department are: bioelectric engineering, biomaterials, biomechanics and mechanobiology, biomedical imaging and biophotonics, biosensors and bioinstrumentation, computational modeling of biological systems, drug and gene delivery, immune engineering, neural engineering, synthetic and systems

biology, and tissue engineering and regenerative medicine. Every biomedical engineering PhD student is required to serve as a teaching assistant as part of their graduate training.

Courses in Biomedical Engineering (BME)

502. Neural Signal Acquisition (GE, IM, EL). This course will be an exploration of analog and digital signal processing techniques for measuring and characterizing neural signals. The analog portion will cover electrodes, amplifiers, filters and A/D converters for recording neural electrograms and EEGs. The digital portion will cover methods of EEG processing including spike detection and spike sorting. A course pack of relevant literature will be used in lieu of a textbook. Students will be required to write signal-processing algorithms. Prerequisite: Biomedical Engineering 354L. Instructor: Wolf. 3 units. C-L: Neuroscience 502

503. Computational Neuroengineering (GE, EL). This course introduces students to the fundamentals of computational modeling of neurons and neuronal circuits and the decoding of information from populations of spike trains. Topics include: integrate and fire neurons, spike response models, homogeneous and inhomogeneous Poisson processes, neural circuits, Weiner (optimal) adaptive filters, neural networks for classification, population vector coding and decoding. Programming assignments and projects will be carried out using MATLAB. Prerequisites: Biomedical Engineering 301L or equivalent. Instructor: Henriquez. 3 units. C-L: Neuroscience 503

504. Fundamentals of Electrical Stimulation of the Nervous System (GE, EL). This course presents a quantitative approach to the fundamental principles, mechanisms, and techniques of electrical stimulation required for non-damaging and effective application of electrical stimulation. Consent of instructor required. Instructor: Grill. 3 units. C-L: Neuroscience 504

505L. Biopotential Amplifiers and Implant Devices (GE, EL, IM). Prerequisite: BME 301L or graduate standing. Instructor: Viventi. 3 units.

506. Measurement and Control of Cardiac Electrical Events (GE, EL, IM). Design of biomedical devices for cardiac application based on a review of theoretical and experimental results from cardiac electrophysiology. Evaluation of the underlying cardiac events using computer simulations. Examination of electrodes, amplifiers, pacemakers, and related computer apparatus. Construction of selected examples. Prerequisites: Biomedical Engineering 301L; 354L or instructor consent. Instructor: Wolf. 3 units.

507. Cardiovascular System Engineering, Disease and Therapy (GE, BB, EL). Introductory and advanced topics in anatomy, physiology, pathophysiology, and modeling of the cardiovascular system. Theoretical and bioengineering concepts of heart electrical and mechanical function and circulatory system at cellular, tissue, and organ level. Computational models of cardiac electrical and mechanical activity and pressures and volumes within circulatory system. Contemporary cell, gene, and device-based therapies for treatment of cardiac and cardiovascular disease. The course enhances students' knowledge of cardiovascular system function with the emphasis of underlying engineering principles. Prerequisites: two of Biomedical Engineering 301L, 302L, 307 or graduate standing in BME. Instructor: Bursac. 3 units.

510. Bayesian Analysis in Biomedical Engineering (GE, EL). The application of Bayesian statistics to questions in BME broadly with a focus on electrotrocardiography. Topics include a brief history of Bayesian math in biology and medicine, use of likelihood functions and prior distributions, the Bayesian outlook toward medical diagnosis, the work of Cornfield, Pipberger, and Dunn on the classification of electrocardiograms, and a Bayesian framework for the cardiac inverse problem. The approaches used for these topics can be adapted to many other BME situations. Prerequisites: Senior or graduate standing. Instructor: Barr. 3 units.

511L. Intermediate Bioelectricity (GE, EL). Study of the origins of clinically-relevant electrical signals, such as EEG, ECG, or EMG. Generation of biopotentials by active cells, fibers, and tissues. Transmission of biopotentials to the measuring electrodes through intervening tissues; effects of inhomogeneities and anisotropy. Students develop models of biopotentials and learn numerical and mathematical tools for solving and analyzing these models. Laboratory exercises based on computer simulations, with emphasis on quantitative behavior. Readings from original literature. Prerequisite: BME 301L or consent of the instructor. Instructor: Barr or Henriquez. 4 units. C-L: Neuroscience 511L

512L. Cardiac Bioelectricity (GE, EL). Electrophysiological behavior of cardiac muscle. Emphasis on quantitative study of cardiac tissue with respect to propagation and the evaluation of sources. Effect of junctions, inhomogeneities, anisotropy, and presence of unbounded extracellular space. Bidomain models. Study of models of arrhythmia, fibrillation, and defibrillation. Electrocardiographic models and forward simulations. Laboratory exercises based on computer simulation, with emphasis on quantitative behavior and design. Readings from original literature. Prerequisite: Biomedical Engineering 301L or equivalent. Instructor: Barr or Henriquez. 4 units.

515. Neural Prosthetic Systems (GE, EL, IM). Covers several systems that use electrical stimulation or recording of the nervous system to restore function following disease or injury. For each system, the underlying biophysical basis for the treatment, the technology underlying the treatment, and the associated clinical applications and challenges are examined. Systems to be covered include cochlear implants, spinal cord stimulation of pain, vagus nerve stimulation for epilepsy, deep brain stimulation for movement disorders, sacral root stimulation for bladder dysfunction, and neuromuscular electrical stimulation for restoration of movement. Prerequisite: BME 301L or ECE 110L. Instructor: Grill. 3 units. C-L: Neuroscience 515

517. Neuronal Control of Movement (GE, EL). Course for graduate and upper-level undergraduate students to provide them with an understanding of the neuronal circuits that move our bodies and with techniques for analysis, simulation, and modification of these circuits by neural engineers. Topics start in the periphery with muscles, the spine, and functional electrical stimulation; then proceed centrally to subcortical circuits, deep brain stimulation, and forward models; and conclude with cerebral cortical networks and population decoding. Students are expected to have background in bioelectricity and Matlab programming. Prerequisites: BME 301L or consent of the instructor. Instructor: Sommer. 3 units. C-L: Neuroscience 507

518L. Modern Neuroscience Tools (GE, IM, EL). This course introduces students to the various modern tools used to study the function of the brain, and the underlying biophysics of these tools. Content will focus on novel technologies and techniques that employ electrophysiology and optogenetics. Prerequisite: BME 301L. Instructor: Gong. 3 units.

521. Biomaterials: Interfaces between Materials and Biology (GE, MC, BB). An examination of the processes that occur when biomaterials are placed into physiological contexts. The course will focus first on processes that occur on the surfaces of materials when exposed to any biological media: surface energy and wettability, protein adsorption, fouling, and biofilm formation. Topics dealing with the performance of biomaterials in humans will then be presented in order of increasing complexity: blood clotting and thrombogenesis, fibrous encapsulation of bioinert materials, inflammatory processes, macrophage polarization, innate immunity, and adaptive immunity. Prerequisite: BME 302L, 307, or graduate student standing. Instructor: Staff. 3 units.

522. Advanced Biomaterials (GE, BB). This course will provide students with advanced knowledge of biomaterials and biocompatibility and their application in medical devices. Topics covered will include how non-covalent interactions drive protein adsorption and self-assembly of materials, cell-material interactions, bioactive biomaterials, smart materials, microfabrication, and nanotechnology. We will explore application materials in areas such as cardiovascular devices, orthopedic implants, tissue engineering and drug delivery. Prerequisite: BME 302L, graduate standing, or consent of instructor. Instructor: West. 3 units.

523. Biomedical Polymers (GE, BB, MC). Course covers applications of polymers in medicine, particularly drug delivery, gene delivery, and tissue engineering. Most recent advances in the field will be discussed. Students' critical understanding of the concepts covered in the class will be evaluated through written and oral presentations. This is course primarily intended for seniors and graduate students. Prerequisites: BME 302L; graduate students need consent of the instructor. Instructor: Staff. 3 units.

524. Nanotechnology in Medicine (GE, BB, MC). Nanomedicine impacts biomedical sciences by applying nanotechnology to develop devices with nanoscale features for applications in therapeutics, diagnostics, and molecular tools. The course covers the application of nanotechnology to advance drug therapy, gene therapy, immunotherapy, and cell therapy and discusses engineering design and fabrication strategies for practical implementation. Most recent advances in the field will be discussed. Student's critical understanding will be evaluated through written or oral presentations. Prerequisite: BME 302L or BME 307 or permission of the instructor. Instructor: West. 3 units.

525. Biomedical Materials and Artificial Organs (GE, BB). Chemical structures, processing methods, evaluation procedures, and regulations for materials used in biomedical applications. Applications include implant materials, components of ex vivo circuits, and cosmetic prostheses. Primary emphasis on polymer-based materials and on optimization of parameters of materials which determine their utility in applications such as artificial kidney membranes and artificial arteries. Prerequisites: ME 221L or graduate standing in BME or ME; BME 302L recommended. Instructor: Staff. 3 units. C-L: Mechanical Engineering and Materials Science 518

526. Elasticity (GE, BB). 3 units. C-L: see Civil and Environmental Engineering 521

527. Cell Mechanics and Mechanotransduction (GE, BB, MC). An examination of the mechanical properties of cells and forces exerted by cells in biological processes of clinical and technological importance, and the processes by which mechanical forces are converted into biochemical signals and activate gene expression. Topics include measurement of mechanical properties of cells, cytoskeleton mechanics, models of cell mechanical properties, cell adhesion, effects of physical forces on cell function, and mechanotransduction. Students critically evaluate current literature and analyze models of cell mechanics and mechanotransduction. Prerequisites: BME 302L or BME 307; knowledge of cell biology. Instructor: Hoffman or Truskey. 3 units.

528. Biofluid Mechanics (GE, BB, MC). Methods and applications of fluid mechanics in biological and biomedical systems including: Governing equations and methods of solutions, (e.g. conservation of mass flow and momentum), the nature of biological fluids, (e.g. non Newtonian rheological behavior), basic problems with broad relevance, (e.g. flow in pipes, lubrication theory), applications to cells and organs in different physiological systems, (e.g. cardiovascular, gastrointestinal, respiratory, reproductive and musculoskeletal systems), applications to diagnosis and therapy, (e.g. drug delivery and devices). Prerequisite: Biomedical Engineering 307 or graduate student standing. Instructor: Katz. 3 units.

529. Theoretical and Applied Polymer Science (GE, BB). 3 units. C-L: see Mechanical Engineering and Materials Science 514

530. Introduction to Tissue Biomechanics (GE, BB). Introduction to the mechanical behaviors of biological tissues, cells and molecules of the musculoskeletal and cardiovascular systems. Topics to be covered include static force analysis and nonlinear optimization theory; linearly elastic models for stress-strain analysis and solutions to relevant problems in bioelasticity; models of active structures (e.g., muscles); and introductory theory for finite element analysis. Emphasis will be placed on modeling stress-strain relations with relevance to biological tissues, including experimental means to measure stress and strain in these structures. Prerequisites: Engineering 201 or equivalent; Biomedical Engineering 302 or equivalent; Mathematics 353. Instructor: Staff. 3 units.

531. Intermediate Biomechanics (GE, BB). Introduction to solid and orthopaedic biomechanical analyses of complex tissues and structures. Topics to be covered include: spine biomechanics, elastic modeling of bone, linear and quasi-linear viscoelastic properties of soft tissue (for example, tendon and ligament), and active tissue responses (for example, muscle). Emphasis will be placed on experimental techniques used to evaluate these tissues. Student seminars on topics in applied biomechanics will be included. Prerequisite: Engineering 201L; Mathematics 353. Instructor: Myers, J. Luck. 3 units.

535. Biomedical Aspects of Blast and Ballistics (GE, BB). Introduction to the biomechanical basis and medical consequences of human injury from blast and ballistics. Exploration of blast and ballistics injuries in both biomechanics and medicine covering the etiology and state-of-the-art analytic and biomechanical models of human injury. Evolution of medical opinion compared to contemporary knowledge of ballistics and blast. Focus on injuries to the head, neck, thorax, abdomen and extremities, and associated medical consequences, including shock, immune system response, traumatic brain injury (TBI) and posttraumatic stress disorder (PTSD). Prerequisite: Biomedical Engineering 302L, graduate standing, or consent of instructor. Instructor: Bass and Capehart. 3 units.

542. Principles of Ultrasound Imaging (GE, IM). Propagation, reflection, refraction, and diffraction of acoustic waves in biologic media. Topics include geometric optics, physical optics, attenuation, and image quality parameters such as signal-to-noise ratio, dynamic range, and resolution. Emphasis is placed on the design and analysis of medical ultrasound imaging systems. Prerequisites: Biomedical Engineering 303; Engineering 103L; or instructor consent. Instructor: K. Nightingale, von Ramm, or Trahey. 3 units.

543L. Cardiac Ultrasound Imaging and Function (GE, IM). Course combines medical instrumentation with a contrasting

engineering and clinical perspective, with a focus on ultrasound cardiac imaging and measurement. The classroom aspect covers the physical basis of ultrasound cardiac imaging and measurements. The clinical component consists of cardiac anatomy and physiology, case studies, and clinical observations. The course includes two cardiac dissections and a hands-on experience in the Human Anatomy Lab. Students are required to develop image analysis software from supplied clinical 3D images to automatically determine quantitative physical descriptors of cardiac function. Prerequisite: Biomedical Engineering 354L or instructor consent. Instructor consent required. Instructor: von Ramm. 3 units.

545. Acoustics and Hearing (GE, EL, IM). The generation and propagation of acoustic (vibrational) waves and their reception and interpretation by the auditory system. Topics under the heading of generation and propagation include free and forced vibrations of discrete and continuous systems, resonance and damping, and the wave equation and solutions. So that students may understand the reception and interpretation of sound, the anatomy and physiology of the mammalian auditory system are presented; and the mechanics of the middle and inner ears are studied. Prerequisites: Biomedical Engineering 271 or equivalent; Mathematics 353. Instructor: Trahey. 3 units. C-L: Electrical and Computer Engineering 584

546. Magnetic Resonance Imaging: Physical Principles and Sequence Design (GE, IM). An in-depth exploration of the physics and engineering in developing Magnetic Resonance Imaging (MRI). Topics covered include Gradient Recalled Echo, Spin Echo, Inversion Recovery, field of view and resolution constraints/requirements, signal processing, image artifacts, the Bloch Equation, fat suppression techniques, and the derivation of MR signal equation. Prerequisite: Biomedical Engineering 303 or consent of instructor. Instructor: Bucholz. 3 units.

547. Medical Software Design (GE, IM). Software is critical in many medical devices, including device control, feedback and signal processing. This course focuses on software development skills that are ubiquitous in the medical device industry, including software version control, unit testing, fault tolerance, continuous integration testing and documentation. Experience will be gained in Python and JavaScript. The course will be structured around a project, done in small student groups, to build an Internet-connected medical device that measures and processes a biosignal, sends it to a web server, and makes those data accessible to a web client/mobile application. Prerequisite: Biomedical Engineering 271, Biomedical Engineering 271A, or graduate student standing. Instructor: Palmeri, Ward, or Wax. 3 units.

548L. Machine Learning and Imaging (GE, IM). Deep learning is rapidly changing how we interpret image data. A large amount of research is now examining how we can use new machine learning tools to automatically interpret microscope, ultrasound and x-ray images, and MRI and CT scans, for example, to aid with diagnostic tasks. In this class, we will review how these machine learning tools work, with a particular focus on how they might be used in a diagnostic setting. This class will also investigate the specific question of how deep learning algorithms can be used to design imaging system hardware to improve performance, which will be the primary focus of the course final project. Prerequisite: BME 303L or graduate standing. Instructor: Horstmeyer. 3 units.

551L. Biomedical Optical Spectroscopy and Tissue Optics (GE, IM). This course is designed to provide students with a working knowledge of the theoretical and experimental principles underlying the application of optical spectroscopy and tissue optics in biological and biomedical engineering. Topics covered in this course include: Absorption Spectroscopy; Scattering Spectroscopy; Fluorescence Spectroscopy; Tissue Optics; Monte Carlo Modeling; Diffusion Modeling; Spectroscopic System Design and Signal to Noise Analysis; and Molecular Imaging. This course also includes labs for each topic that is covered, journal article review on emerging technologies and a term project. Prerequisite: Physics 152L. Instructors: Izatt, Ramanujam, or Wax. 4 units. C-L: Molecular Cancer Biology 551L

552. Advanced Optics. 3 units. C-L: see Physics 621; also C-L: Electrical and Computer Engineering 541

555. Advances in Photonics (GE, IM). Overview of photonics techniques and their applications. The course will enhance students' understanding and knowledge of advanced techniques and introduce them to a variety of applications in photonics, the science and technology associated with interactions of light with matter. Photonics techniques include: advanced luminescence, Raman and SERS, optical coherence, advanced microscopy, near-field and confocal methods, remote sensing, and optical biosensing. Applications include: environmental sensing, medical diagnostics, assays using optical detection, optics in multispectral imaging, photonics and solar cells, and nanophotonics. Prerequisite: senior or graduate standing in BME or Chemistry. Instructor: Vo-Dinh. 3 units. C-L: Chemistry 630

560. Molecular Basis of Membrane Transport (GE, EL, MC). Transport of substances through cell membranes examined on a molecular level, with applications of physiology, drug delivery, artificial organs and tissue engineering. Topics include organization of the cell membrane, membrane permeability and transport, active transport and control of transport processes. Assignments based on computer simulations, with emphasis on quantitative behavior and design. Prerequisites: BME 260L or instructor consent, Mathematics 216 or equivalent. Instructor: Staff. 3 units. C-L: Neuroscience 560

561L. Genome Science and Technology Lab (GE, MC). Study of the basic principles of epigenetics, genomics, and human stem cell biology as applied to medical diagnostics and tissue engineering. Focus on engineering of living systems will include collaboration with clinicians, laboratories on DNA/RNA isolation, genotyping, qPCR and stem cell culture; overview of organ on a chip technology and statistical approach to large data towards risk prediction, early detection and disease prevention. Oral and written lab reports required; select projects may be continued as independent study. Instructor consent required. Instructor: Staff. 3 units. C-L: Computational Biology and Bioinformatics 561L

562. Biology by Design (GE, MC). Engineering biological systems emphasizing synthetic biology and the application of biological/chemical principles to the design of new biomolecules and cellular pathways. Review of primary scientific literature, highlighting contemporary research in this area, including artificial amino and nucleic acids, gene regulatory systems, directed molecular evolution, recombinant antibodies, novel biosynthesis pathways, cell communication, and the design of minimal organisms. Topics are presented with applications such as drug design, discovery, productions, regenerative medicine, and bioremediation. Prerequisite: Biomedical Engineering 244L. Organic chemistry or biochemistry suggested. Instructor consent required. Instructor: Gersbach. 3 units.

563. Transport Processes in HIV Transmission and Prevention (GE, BB, MC). Application of transport theory to analyze

processes of HIV migration to target cells in the mucosa of the lower female reproductive tract. Analysis of the introduction, transport and bioactivity of molecules that inhibit these HIV-infection processes, including those acting topically (microbicides) and those introduced in a variety of drug delivery vehicles: semi-solid materials (gels, films) and solid materials (intravaginal rings). A succession of mathematical models will describe elements of the fundamental biology of this system and analyze the performance of specific products that act prophylactically against HIV infection. Prerequisite: Biomedical Engineering 307 or graduate student standing. Instructor: Katz. 3 units.

565L. Environmental Molecular Biotechnology (GE, MC). 3 units. C-L: see Civil and Environmental Engineering 661L

566. Transport Phenomena in Cells and Organs (GE, MC). Applications of the principles of mass and momentum transport to the analysis of selected processes of biomedical and biotechnological interest. Emphasis on the development and critical analysis of models of the particular transport process. Topics include: reaction-diffusion processes, transport in natural and artificial membranes, dynamics of blood flow, pharmacokinetics, receptor-mediated processes and macromolecular transport, normal and neoplastic tissue. Prerequisite: Biomedical Engineering 307 or equivalent. Instructor: Truskey or Yuan. 3 units.

567. Biosensors (GE, IM, MC). Theory and applications of biosensors. Basic principles of interactions between analytes and bioreceptors and various transduction techniques: optical, electrochemical, ion-selective electrode-based, voltametric, conductometric, and mass-sensitive techniques as well as novel nanotechnology-based biosensing systems including nanosensors, plasmonic nanoprobes, quantum dots, carbon nanotubes, molecular beacons, and molecular sentinel systems. Applications in chemical, environmental, biological and medical sensing. Paired with Chemistry 601. Prerequisites: senior or graduate standing in BME or instructor's consent. Instructor: Vo-Dinh. 3 units.

568. Laboratory in Cellular and Biosurface Engineering (GE, MC). Introduction to common experimental and theoretical methodologies in cellular and biosurface engineering. Experiments may include determination of protein and peptide diffusion coefficients in alginate beads, hybridoma cell culture and antibody production, determination of the strength of cell adhesion, characterization of cell adhesion or protein adsorption by total internal reflection fluorescence, and Newtonian and non-Newtonian rheology. Laboratory exercises are supplemented by lectures on experiment design, data analysis, and interpretation. Prerequisites: Biomedical Engineering 307 or equivalent. Instructor: Truskey. 3 units.

569. Cell Transport Mechanisms (GE, MC). Analysis of the migration of cells through aqueous media. Focus on hydrodynamic analysis of the directed self-propulsion of individual cells, use of random walk concepts to model the nondirected propulsion of individual cells, and development of kinetic theories of the migrations of populations of cells. Physical and chemical characteristics of the cells' environments that influence their motion, including rheologic properties and the presence of chemotactic, stimulatory, or inhibitory factors. Cell systems include mammalian sperm migration through the female reproductive tract, protozoa, and bacteria. Emphasis on mathematical theory. Experimental designs and results. Prerequisites: Biomedical Engineering 307 and consent of instructor. Instructor: Katz. 3 units.

570L. Introduction to Biomolecular Engineering (GE, BB, MC). Techniques of molecular biology through linked lectures and laboratory exercises with emphasis on molecular tools to manipulate and analyze DNA and RNA for specific molecular bioengineering applications. Lectures cover the genetic code, replication, transcription, translation, cloning vectors for E. coli, enzymatic manipulation of DNA, gene cloning, synthetic gene design and assembly, DNA sequencing, polymerase chain reaction, site-directed mutagenesis, overexpression and purification of recombinant proteins. Laboratory exercises, linked to lectures, cover cloning, mutagenesis and recombinant protein expression and purification. Prerequisites: BIO 201L or BME 260L or graduate standing in BME. Instructor: Chilkoti. 3 units.

571L. Biotechnology and Bioprocess Engineering (GE, BB, MC). Introduction to the engineering principles of bioprocess engineering. Topics include: introduction to cellular and protein structure and function; modeling of enzyme kinetics, DNA transcription, metabolic pathways, cell and microbial growth and product formation; bioprocess operation, scale-up, and design. Class includes a design project. A modern biotechnology process or product is identified, the specific application and market are described (for example, medical, environmental, agricultural) along with the engineering elements of the technology. Prerequisite: Mechanical Engineering 221L. Instructor: Chilkoti. 3 units.

572L. Cancer and Stem Cell Technology. This course introduces advanced topics in cancer and stem cell biology as well as emerging areas for clinical applications. Topics include: cancer genetics/epigenetics, signaling and regulatory pathways, tumor microenvironment, cancer metabolism, bioinformatics, precision medicine, immunotherapy, development, embryonic stem cells, adult tissue stem cells, and organoids.Students will learn to perform cancer/stem cell-related molecular and cellular assays. The course comprises lectures, student presentations, computational dry lab, and wet lab experiments. Prerequisite: BME 307. Instructor: Shen. 3 units.

574. Modeling and Engineering Gene Circuits (GE, MC). This course discusses modeling and engineering gene circuits, such as prokaryotic gene expression, cell signaling dynamics, cell-cell communication, pattern formation, stochastic dynamics in cellular networks and its control by feedback or feedforward regulation, and cellular information processing. The theme is the application of modeling to explore "design principles" of cellular networks, and strategies to engineer such networks. Students need to define an appropriate modeling project. At the end of the course, they're required to write up their results and interpretation in a research-paper style report and give an oral presentation. Prerequisites: Biomedical Engineering 260L or consent of instructor. Instructor: You. 3 units. C-L: Computational Biology and Bioinformatics 574

577. Drug Delivery (GE, BB, MC). Introduction to drug delivery in solid tumors and normal organs (for example, reproductive organs, kidney, skin, eyes). Emphasis on quantitative analysis of drug transport. Specific topics include: physiologically-based pharmacokinetic analysis, microcirculation, network analysis of oxygen transport, transvascular transport, interstitial transport, transport across cell membrane, specific issues in the delivery of cells and genes, drug delivery systems, and targeted drug delivery. Prerequisite: Biomedical Engineering 307 and (Engineering 103L or Computer Science 201); or graduate standing. Instructor: Yuan. 3 units.

578. Quantitative Cell and Tissue Engineering (GE, BB, MC). This course will serve as an overview of selected topics and problems in the emerging field of tissue engineering. General topics include cell sourcing and maintenance of differentiated state, culture scaffolds, cell-biomaterials interactions, bioreactor design, and surgical implantation considerations. Specific tissue types to be reviewed include cartilage, skin equivalents, blood vessels, myocardium and heart valves, and bioartificial livers. Prerequisite: Biomedical Engineering 302L or 307 or PhD student standing. Instructor: Bursac. 3 units.

590. Special Topics in Biomedical Engineering. Special subjects related to programs within biomedical engineering tailored to fit the requirements of a small group. Consent of instructor required. Instructor: Staff. 3 units.

590D. Special Topics with Discussion. To be used as a generic course number for any special topics course with discussion sections. Instructor consent required. Instructor: Staff. 3 units.

590DL. Special Topics with Lab and Discussion. To be used as a generic course number for any special topics course with lab and discussion sections. Instructor consent required. Instructor: Staff. 3 units.

590L. Special Topics with Lab. To be used as a generic course number for any special topics course with lab sections. Instructor consent required. Instructor: Staff. 3 units.

601L. Introduction to Neural Engineering. Introduction to neural engineering with emphasis on the electrophysiology of neurons from a quantitative perspective. Topics include the ionic basis of action potentials, the Hodgkin-Huxley model, impulse propagation, source-field relationships, and an introduction to functional electrical stimulation. Not open to students who have taken BME 244L, 301L, 302L, 303L, or 307. Instructor: Sommer or Grill. 4 units.

609. Optics and Photonics Seminar Series. 1 unit. C-L: see Electrical and Computer Engineering 549; also C-L: Physics 549

671L. Signal Processing and Applied Mathematics. This introductory applied mathematics course for graduate students covers the basics of linear systems theory including convolutions, Fourier Series, Fourier Transforms, and Laplace Transforms with emphasis on application to biomedical systems. Students will also get a basic understanding of how to program in MATLAB as they apply the course material to process sounds, images, and other biological signals. Not open to students who have taken BME 271. Instructor: Bucholz. 4 units.

690. Advanced Topics in Biomedical Engineering. Advanced subjects related to programs within biomedical engineering tailored to fit the requirements of a small group. Consent of instructor required. Instructor: Staff. 3 units.

701S. BME Graduate Seminars. This course is a weekly seminar required of all 2nd year BME PhD students. The seminar series will focus on preparation for the written portion of the preliminary exam with workshops and lectures, interleaved with seminars on career development. Writing instruction will include a seminar on creating clear and effective prose and discussions by BME faculty of each section of the document. Students will draft each section, and conduct peer-reviews in small groups. The career seminars with include methods to explore career options, networking, and internships. Students will be required to actively participate and provide feedback on seminars. More than two absences results in a failing grade. Instructor: Wax. 0 units.

702S. BME Graduate Seminars. Two semester, weekly seminars series required of all BME graduate students. Students are exposed to the breadth of research topics in BME via seminars given by BME faculty, advanced graduate students, and invited speakers. At the end of each semester students are required to write a synopsis of the seminars attended. More than three unexcused absences will result in a failing grade. Instructor: Staff. 0 units.

703S. Engineering Management Seminar for Master of Science Students. Current topics in applied engineering management and entrepreneurship. This course is offered to Master of Science students in BME who are interested in pursuing careers in industries. The course will consist of weekly seminar series through the EGRMGMT 501 course. Instructor: Staff. 1 unit.

711S. Biological Engineering Seminar Series (CBIMMS and CBTE). Seminar series featuring in alternate weeks invited speakers and pre-seminar discussions. Research topics in biological engineering, with emphasis on bioinspired materials and materials systems, biomolecular, and tissue engineering. Enrollment is required of all BIMMS and BTE certificate program students in their first and second year. Open to others for credit or audit. Instructor consent required. Instructors: Zauscher, Craig, and Reichert. 1 unit. C-L: Mechanical Engineering and Materials Science 717S

712S. Biological Engineering Seminar Series (CBIMMS and CBTE). Seminar series featuring in alternate weeks invited speakers and pre-seminar discussions. Research topics in biological engineering, with emphasis on bioinspired materials and materials systems, biomolecular, and tissue engineering. Enrollment is required of all BIMMS and BTE certificate program students in their first and second year. Open to others for credit or audit. Instructor consent required. Instructors: Zauscher, Craig, and Reichert. 1 unit. C-L: Mechanical Engineering and Materials Science 718S

717S. Seminars in Medical Physics. Medical physics is the application of the concepts and methods of physics and engineering to the diagnosis and treatment of human disease. This course consists of weekly lectures covering broad topics in medical physics including diagnostic imaging, radiation oncology, radiation safety, and nuclear medicine. Lectures will be given by invited speakers drawn from many university and medical center departments including Biomedical Engineering, radiology, physics, radiation safety, and radiation oncology. Prerequisites: background in engineering or physics. 1 CC (0.5 ES/0.5 ED). Consent of instructor required. Instructor: Lo and Samei. 1 unit.

728S. Teaching Seminar for New Teaching Assistants. This 3 credit seminar is for BME PhD students concurrently serving as a TA for the first time. It is mandatory for those entering the program in Fall 2015 and optional for all BME PhD students who entered the program before Fall 2015. Throughout this course, students will attend a series of seminars (5 minimum) designed to improve pedagogical training and support for teaching assistants. Students will practice concepts learned in the seminars during TAship. Teaching assistants will receive feedback through performance evaluations by the professor. Evaluations will be given twice per semester. The teaching assistants also complete an activity log to document time spent. Instructor: Wax. 3 units.

729S. Teaching seminar for repeat teaching assistants. This 3 credit seminar is for BME PhD students concurrently serving as

a TA for the second time or later. It is mandatory for those entering the program in Fall 2015 and optional for all BME PhD students who entered the program before Fall 2015. Throughout this course, students will participate in mentoring activities designed to improve pedagogical training and support for teaching assistants. Students will practice concepts learned in the seminars during TAship. Teaching assistants will receive feedback through performance evaluations by the professor. Evaluations will be given twice per semester. The teaching assistants also complete an activity log to document time spent. Instructor: Wax. 3 units.

733. Experimental Design and Biostatistics for Basic Biomedical Scientists. 2 units. C-L: see Pharmacology and Cancer Biology 733; also C-L: Neurobiology 733, Cell and Molecular Biology 733, Molecular Cancer Biology 733

740L. Fundamentals of Bioelectric Engineering. The electrophysiology of excitable cells from a quantitative perspective. Topics include ionic basis of action potentials, Hodgkin-Huxley model, impulse propagation, extracellular measurements, and introduction to functional electrical stimulation. Labs include stimulation and recording of nerve and heart potentials, optical imaging of excitation waves, and numerical modeling. In a final project, students design and perform their own experiments based on the classical literature and the skills they learned in the course. Not open to students who have taken BME 301L or equivalent. Prerequisites: recommended a circuits course and knowledge of ordinary and partial differential equations. Instructor: Henriquez,Neu,Sommer. 4 units. C-L: Neuroscience 740L

770. Transport Phenomena in Biological Systems. Consideration of the role of transport processes and the understanding and modeling of biological systems. Topics include the conservation of mass and momentum using differential and integral balances; rheology of Newtonian and non-Newtonian fluids; steady and transient diffusion in reacting systems; dimensional analysis; homogeneous versus heterogeneous reaction systems. Biological and biotechnological applications are presented. Prerequisites: Introductory coursework in fluid mechanics and in mass transport theory. Experience with solving ordinary and partial differential equations. Instructor: Katz, Truskey, or Yuan. 3 units.

785. Principles of Research Management. A survey of topics in modern research management techniques that will cover proven successful principles and their application in the areas of research lab organization, resource management, organization of technical projects, team leadership, financial accountability, and professional ethics. Instructor: Staff. 1 unit.

787. Leading Medical Devices: Innovation to Market. Interdisciplinary examination of the medical device landscape for business, engineering, and medicine. Provides core tools for individuals interested in product design and development. Includes market definition and modeling, financing, reimbursement, business plan modeling, and the global marketplace. Case-based and team-based learning including developing a business plan and 510K approval will augment core instruction and guest lecturers. Consent of instructor required. Instructor: Chopra. 3 units.

788. Invention to Application: Healthcare Research Commercialization. Interdisciplinary teams of students from engineering, medical science, business, and medicine work together to understand and evaluate the commercial potential of Duke faculty research innovations and develop a comprehensive research translation and business plan for one chosen opportunity. Learning includes understanding technology, product development, marketing, finance, regulatory requirements, and reimbursement. In addition to weekly lectures, students are mentored in this real world experience by a team including technology transfer experts, venture capitalists, researchers, physicians, and entrepreneurs. Prerequisites: none. Consent of instructor required. Instructor: Myers. 3 units.

789. Internship in Biomedical Engineering. Student gains practical biomedical engineering experience by taking a job in industry, and writing a report about this experience. Requires prior consent from the student's advisor and from the director of graduate studies. May be repeated with consent of the advisor and the director of graduate studies. Credit/no credit grading only. Instructor: Staff. Variable credit.

790. Advanced Topics for Graduate Students in Biomedical Engineering. Advanced subjects related to programs within biomedical engineering tailored to fit the requirements of a small group. Consent of instructor required. Instructor: Staff. 3 units.

790L. Advanced Topics with the Lab for Graduate Students in Biomedical Engineering. Advanced subjects related to programs within biomedical engineering tailored to fit the requirements of a small group. Consent of instructor required. Includes laboratory component. Instructor: Staff. 3 units.

791. Graduate Independent Study. First Independent Study course in advanced study and research areas of biomedical engineering. Approval of adviser is required. 3 units. Instructor: Staff. 3 units.

792. Continuation of Graduate Independent Study. Second independent study in advanced study and research areas of biomedical engineering. Approval of adviser is required. Instructor: Staff. 3 units.

804. Developments in Neural Engineering. The objective of this course is to provide in depth exposure to and critical analysis of current topics in neural engineering. Students will develop skills of critical reading and analysis, data synthesis and presentation, and discussion leadership. The course will serve the secondary purpose of providing exposure of our neural engineering faculty and students to leaders in the field. Instructor consent required. Instructor: Grill. 3 units.

834. Viscoelasticity. Viscoelasticity of hard and soft tissue solids and composite structures. Linear and nonlinear one-dimensional viscoelastic behavior, internal damping, and three-dimensional viscoelasticity. Approximation techniques for determination of viscoelastic constitutive equations from experimental data. Mathematical formulations for the characterization of the dynamic behavior of biologic structures. Consent of instructor required. Instructor: Myers. 3 units.

842. Medical Ultrasound Transducers. A study of the design, fabrication, and evaluation of medical ultrasound transducers. Topics include wave propagation in piezoelectric crystals, Mason and KLM circuit models, linear arrays and two-dimensional arrays, piezoelectric ceramic/epoxy composite materials, piezoelectric polymers, and photo-acoustic materials. Consent of instructor required. Instructor: S. Smith. 3 units.

844. Advanced Ultrasonic Imaging. This course provides students with a mathematical basis of ultrasonic imaging methods.

Topics include K-space, descriptions of ultrasonic imaging, ultrasonic beam-former design, tissue motion and blood flow imaging methods, and novel ultrasonic imaging methods. Students conduct extensive simulations of ultrasonic imaging methods. Prerequisite: Biomedical Engineeering 333. Instructor: Trahey. 3 units.

845. Elasticity Imaging. Theory and practical implementation of elasticity imaging techniques, including static, dynamic, physiologic and acoustic radiation force based methods; continuum mechanics; wave propagation in soft tissues; algorithms for quantifying wave speed; and material models employed in elasticity reconstruction methods (linearity, anisotropy, and viscoelasticity); simulations tools employed during system development will be introduced, including FEM modeling approaches and ultrasonic imaging simulation tools. Assignments include weekly readings and literature reviews, weekly homework (simulations/FEM modeling tools), and a final project. Prerequisites: BME 542 and BME 530 or instructor permission. Instructor: K. Nightingale. 3 units.

846. Biomedical Imaging. A study of the fundamentals of information detection, processing, and presentation associated with imaging in biology and medicine. Analysis of coherent and incoherent radiation and various image generation techniques. Design and analysis of modern array imaging systems as well as systems. Instructor: von Ramm. 3 units.

848L. Radiology in Practice. Designed to complement Biomedical Engineeering 333 Modern Diagnostic Imaging Systems. Review and real-life exercises on principles of modern medical imaging systems with emphasis on the engineering aspects of image acquisition, reconstruction and visualization, observations of imaging procedures in near clinical settings, and hands-on experience with the instruments. Modalities covered include ultrasound, CT, MRI, nuclear medicine and optical imaging. Prerequisite: Biomedical Engineeering 333 or equivalent. Instructor: Trahey. 3 units. C-L: Medical Physics 738

899. Special Readings in Biomedical Engineering. Individual readings in advanced study and research areas of biomedical engineering. Approval of director of graduate studies required. 1 to 3 units each. Instructor: Staff. Variable credit.

Civil and Environmental Engineering

Professor Wiesner, *Chair*; Associate Professor of the Practice Schaad, *Associate Chair*; Associate Professor Boadu, *Director of Graduate Studies (PhD)*; Associate Professor Borsuk, *Director of Graduate Studies (Master's)*; Professors Barros, Bergin, Deshusses, Gavin, Hsu-Kim, Hueckel, Petroski, Scovazzi, and Wiesner; Associate Professors Boadu, Borsuk, Ferguson, Gunsch, and Kabala; Professor of the Practice Nadeau; Assistant Professors Bragg, Carlson, Chaney, Guillemont, and Veveakis; Assistant Research Professors Hendren and Satterwhite; Lecturer Brasier; Associate Professor of the Practice Schaad; *Secondary Appointments*: Professors Aquino (Mechanical Engineering and Materials Science/Civil and Environmental Engineering), Di Giulio (environmental toxicology), Dolbow (Mechanical Engineering and Materials Science/Civil and Environmental Engineering), Doyle (river science and policy), Golden (sustainable systems analysis), Hench (oceanography), Hinton (environmental quality), Hunt (microbial ecology), Jeuland (public policy), Kasibhatla (atmospheric chemistry), Katul (hydrology and micrometeorology), Knio (computational fluid mechanics), Kumar (watershed hydrology), Li (climate), Mann (structural engineering), Marani (ecohydrology), Meyer (environmental toxicology), Oren (global change ecology), Richardson (wetland ecology), Stapleton (environmental chemistry), Vengosh (earth and ocean sciences), and Virgin (structural engineering); Adjunct Professors Albertson, Auffan, Avissar, Bottero, Elias, Germano, Hofmann, Kees, Laloui, Miller, Moes, Orlandini, Pierce, Plata, Porporato, Rose, Thornton, and Vallero; Professors Emeriti Medina, Peirce, Haff, and Peirce

A master's degree and a PhD are available in this department.

The Department of Civil and Environmental Engineering (CEE) at Duke University offers programs of study and research leading to the MS and PhD with a major in civil and environmental engineering. CEE pursues diverse research and educational activities to improve the fundamental safety, health, and quality of life in society. These activities focus on five broad areas: (1) Computational Mechanics and Scientific Computing; (2) Environmental Health Engineering; (3) Geomechanics and Geophysics for Energy & the Environment; (4) Hydrology and Fluid Dynamics; and (5) Systems, Risk and Decision.

Overlapping at times, these areas represent the three tracks of study offered by the department's graduate faculty. The specific areas include engineering mechanics, computational mechanics, geo-materials and environmental geo-mechanics, engineering and environmental geophysics, structural engineering, water resources engineering, hydrology, environmental fluid dynamics, and environmental process engineering aspects of water, atmosphere, and soil pollution.

Current research in these areas focuses on new computational paradigms for complex mechanical systems, including contact, fracture, and damage problems; environmental geomechanics and geophysics; adaptive materials and structures and their use in structural dynamics; microstructured materials; deterministic and stochastic water resources and contaminant hydrology; global and regional water cycle; ocean-land-atmosphere interactions; biological and chemical aspects of pollution and its remediation in water, air, and soil.

Courses in Civil and Environmental Engineering (CEE)

501. Applied Mathematics for Engineers. Advanced analytical methods of applied mathematics useful in solving a wide spectrum of engineering problems. Applications of linear algebra, calculus of variations, the Frobenius method, ordinary differential equations, partial differential equations, and boundary value problems. Prerequisites: Mathematics 353 or equivalent and undergraduate courses in solid and/or fluid mechanics. Instructor: Kabala. 3 units.

502. Engineering Data Analysis. Introduction to the statistical error analysis of imprecise data and the estimation of physical parameters from data with uncertainty. Interpolation and filtering. Data and parameter covariance. Emphasis on time series analysis in the time- and frequency-domains. Linear and nonlinear least squares. Confidence intervals and belts. Hypothesis testing. Introduction to parameter estimation in linear and nonlinear dynamic systems. Prerequisite: graduate standing or instructor consent. Instructors: Boadu, Gavin. 3 units.

511. Construction Management. This course is a broad overview of the roles and responsibilities of the construction management engineer. Included in this is an examination of: Project Management Planning, Cost Management, Time Management, Quality Management, Contract Administration, and Safety Management. Topics covered will include: defining the responsibilities and management structure of the project management team, organizing and leading by implementing project controls, defining roles and

responsibilities and developing communication protocols, and identifying elements of project design and construction likely to give rise to disputes and claims. Field trips. Instructor: Schaad. 3 units.

520. Continuum Mechanics. Tensor fields and index notation. Analysis of states of stress and strain. Conservation laws and field equations. Constitutive equations for elastic, viscoelastic, and elastic-plastic solids. Formulation and solution of simple problems in elasticity, viscoelasticity, and plasticity. Instructors: Hueckel or Nadeau. 3 units.

521. Elasticity (GE, BB). Linear elasticity will be emphasized including concepts of stress and strain as second order tensors, equilibrium at the boundary and within the body, and compatibility of strains. Generalized solutions to two and three dimensional problems will be derived and applied to classical problems including torsion of noncircular sections, bending of curved beams, stress concentrations and contact problems. Applications of elasticity solutions to contemporary problem in civil and biomedical engineering will be discussed. Prerequisites: Engineering 201L; Mathematics 353. Instructor: Staff. 3 units. C-L: Biomedical Engineering 526

525. Wave Propagation in Elastic and Poroelastic Media. Basic theory, methods of solution, and applications involving wave propagation in elastic and poroelastic media. Analytical and numerical solution of corresponding equations of motion. Linear elasticity and viscoelasticity as applied to porous media. Effective medium, soil/rock materials as composite materials. Gassmann's equations and Biot's theory for poroelastic media. Stiffness and damping characteristics of poroelastic materials. Review of engineering applications that include NDT, geotechnical and geophysical case histories. Prerequisite: Mathematics 353 or consent of instructor. Instructor: Boadu. 3 units.

530. Introduction to the Finite Element Method. Investigation of the finite element method as a numerical technique for solving linear ordinary and partial differential equations, using rod and beam theory, heat conduction, elastostatics and dynamics, and advective/diffusive transport as sample systems. Emphasis placed on formulation and programming of finite element models, along with critical evaluation of results. Topics include: Galerkin and weighted residual approaches, virtual work principles, discretization, element design and evaluation, mixed formulations, and transient analysis. Prerequisites: a working knowledge of ordinary and partial differential equations, numerical methods, and programming in FORTRAN or MATLAB. Instructor: Aquino, Dolbow, or Scovazzi. 3 units. C-L: Mechanical Engineering and Materials Science 524

531. Finite Element Methods for Problems in Fluid Mechanics. An extensive introduction to finite element methods for fluid flow problems, covering methods for general transport problems, the compressible Euler and Navier-Stokes equations, the incompressible Navier-Stokes equations, and subsurface flows in porous media. Knowledge on the foundations of numerical analysis and finite elements (i.e., structural mechanics or thermal transfer problems) is advisable but not a prerequisite. Taking this course in conjunction with CEE 530 (254) "Introduction to the Finite Element Method", CEE 630 (255) "Nonlinear Finite Element Analysis", or CEE 635 (256) "Computational Methods for Evolving Discontinuities" should also be considered by students. Instructor: Scovazzi. 3 units.

535. Engineering Analysis and Computational Mechanics. Mathematical formulation and numerical analysis of engineering systems with emphasis on applied mechanics. Equilibrium and eigenvalue problems of discrete and distributed systems; properties of these problems and discretization of distributed systems in continua by the trial functions with undetermined parameters. The use of weighted residual methods, finite elements, and finite differences. Prerequisite: senior or graduate standing. Instructor: Dolbow. 3 units.

541. Structural Dynamics. Formulation of dynamic models for discrete and continuous structures; normal mode analysis, deterministic and stochastic responses to shocks and environmental loading (earthquakes, winds, and waves); introduction to nonlinear dynamic systems, analysis and stability of structural components (beams and cables and large systems such as offshore towers, moored ships, and floating platforms). Instructor: Gavin. 3 units.

551. Isotopes in Earth and Environmental Sciences. 3 units. C-L: see Earth and Ocean Sciences 571; also C-L: Environment 570

560. Environmental Transport Phenomena. Principles of mathematical modeling of environmental systems. Mass balances, ideal reactor models for lakes, rivers, atmospheric systems, and population dynamics. Derivation of Navier-Stokes equations, advective diffusion equation, mass transfer and fluid dynamics. Conservation principles in the atmosphere and bodies of water, fundamental equations for transport in the atmosphere and bodies of water, scaling principles, simplification, turbulence, turbulent transport and boundary layers. Instructor: Wiesner. 3 units.

561L. Environmental Aquatic Chemistry. Principles of chemical equilibria and kinetics as applied in environmental engineering and science processes. Topics include acid-base equilibrium, the carbonate system, metal complexation, oxidation/reduction reactions, mineral phase solubility and surface sorption. Applied environmental systems include water treatment, soil remediation, air pollution and green engineering. Graduate-level requirements include specific laboratory work and written assignments. Open to graduate students; instructor consent required for undergraduates. Not open to students who have taken CEE 461L. Instructor: Ferguson, Hsu-Kim. 3 units. C-L: Environment 542L

562L. Applied Biological Principles and Processes in Environmental Engineering. Fundamentals of microbiology as it relates to biological environmental engineering processes. Topics include microbial metabolism, microbial kinetics and stoichiometry, and bioreactor models. Applications include unit processes in wastewater treatment, bioremediation, bioreactors, waste to bioenergy. Laboratory included. Graduate-level requirements include a term paper and/or a project. Open to graduate students; instructor consent required for undergraduates. Not open to students who have taken CEE 462L. Instructor: Deshusses, Gunsch. 3 units.

563. Chemical Fate of Organic Compounds. 3 units. C-L: see Environment 540

563D. Chemical Fate of Organic Compounds. 3 units. C-L: see Environment 540D

564. Physical Chemical Processes in Environmental Engineering. Theory and design of fundamental and alternative physical and chemical treatment processes for pollution remediation. Reactor kinetics and hydraulics, gas transfer, adsorption, sedimentation, precipitation, coagulation/flocculation, chemical oxidation, disinfection. Prerequisites: introductory environmental engineering, chemistry, graduate standing, or permission of instructor. Instructor: Wiesner. 3 units.

565. Environmental Analytical Chemistry. This course covers the fundamentals and applications of analytical chemistry as applied to detection, identification, and quantification of anthropogenic contaminants in environmental samples including air, water, soil, sediment, and biota. The topics include both sample preparation methods (i.e. wet chemistry) and instrumental analysis (e.g. mass spectrometry, chromatography, and optical spectroscopy). Particular emphasis is placed on current advancements in measurement science as applied to environmental chemistry. The material includes both theoretical and practical aspects of environmental analysis. Prerequisite: CHEM 131 or CHEM 151L or consent of instructor. Instructor: Ferguson. 3 units. C-L: Environment 566

566. Environmental Microbiology. Fundamentals of microbiology and biochemistry as they apply to environmental engineering. General topics include cell chemistry, microbial metabolism, bioenergetics, microbial ecology and pollutant biodegradation. Prerequisites: Civil and Environmental Engineering 462L or graduate standing or consent of the instructor. Instructor: Gunsch. 3 units.

569. Introduction to Atmospheric Aerosol. Atmospheric aerosol and its relationship to problems in air control, atmospheric science, environmental engineering, and industrial hygiene. Open to advanced undergraduate and graduate students. Prerequisites: knowledge of calculus and college-level physics. Consent of instructor required. Instructor: Staff. 3 units.

571. Control of Hazardous and Toxic Waste. Engineering solutions to industrial and municipal hazardous waste problems. Handling, transportation, storage, and disposal technologies. Biological, chemical, and physical processes. Upgrading abandoned disposal sites. Economic and regulatory aspects. Case studies. Consent of instructor required. Instructor: Staff. 3 units.

574. Remote Sensing in Coastal Environments. 3 units. C-L: see Earth and Ocean Sciences 530; also C-L: Environment 530

575. Air Pollution Control Engineering. The problems of air pollution with reference to public health and environmental effects. Measurement and meteorology. Air pollution control engineering: mechanical, chemical, and biological processes and technologies. Instructor: Staff. 3 units.

576L. Aerosol Measurement Techniques for Air Quality Monitoring and Research. Principles of measurements and analysis of ambient particulate matter (aerosol). Traditional and emerging measurements techniques currently used in air quality monitoring and homeland defense. Open to advanced undergraduate and graduate students interested in the science and engineering related to atmospheric aerosol. Consent of the instructor required. Instructor: Staff. 3 units.

581. Pollutant Transport Systems. Distribution of pollutants in natural waters and the atmosphere; diffusive and advective transport phenomena within the natural environment and through artificial conduits and storage/treatment systems. Analytical and numerical prediction methods. Prerequisite: Civil and Environmental Engineering 301L and Mathematics 353, or equivalents. Instructor: Staff. 3 units.

585. Vadose Zone Hydrology. Transport of fluids, heat, and contaminants through unsaturated porous media. Understanding the physical laws and mathematical modeling of relevant processes. Field and laboratory measurements of moisture content and matric potential. Prerequisites: Civil and Environmental Engineering 301L and Mathematics 353, or consent of instructor. Instructor: Kabala. 3 units.

621. Plasticity. Inelastic behavior of soils and engineering materials. Yield criteria. Flow rules. Concepts of perfect plasticity and plastic hardening. Methods of rigid-plasticity. Limit analysis. Isotropic and kinematic hardening. Plastic softening. Diffused damage. Thermo-plasticity. Visco-plasticity. Prerequisite: Civil and Environmental Engineering 520 or consent of instructor. Instructor: Hueckel. 3 units.

622. Fracture Mechanics. Theoretical concepts concerning the fracture and failure of brittle and ductile materials. Orowan and Griffith approaches to strength. Determination of stress intensity factors using compliance method, weight function method, and numerical methods with conservation laws. Cohesive zone models, fracture toughness, crack growth stability, and plasticity. Prerequisites: Civil and Environmental Engineering 520, or instructor consent. Instructor: Dolbow. 3 units.

623. Mechanics of Composite Materials. Theory and application of effective medium, or homogenization, theories to predict macroscopic properties of composite materials based on microstructural characterizations. Effective elasticity, thermal expansion, moisture swelling, and transport properties, among others, are presented along with associated bounds such as Voigt/Reuss and Hashin-Shtrikman. Specific theories include Eshelby, Mori-Tanaka, Kuster-Toksoz, self-consistent, generalized self-consistent, differential method, and composite sphere and cylinder assemblages. Tensor-to-matrix mappings, orientational averaging, and texture analysis. Composite laminated plates, environmentally induced stresses, and failure theories. Prerequisite: Civil and Environmental Engineering 520 or consent of instructor. Instructor: Nadeau. 3 units.

625. Intermediate Dynamics: Dynamics of Very High Dimensional Systems. 3 units. C-L: see Mechanical Engineering and Materials Science 541

626. Energy Flow and Wave Propagation in Elastic Solids. Derivation of equations for wave motion in simple structural shapes: strings, longitudinal rods, beams and membranes, plates and shells. Solution techniques, analysis of systems behavior. Topics covered include: nondispersive and dispersive waves, multiple wave types (dilational, distortion), group velocity, impedance concepts including driving point impedances and moment impedances. Power and energy for different cases of wave propagation. Prerequisites: Engineering 244L and Mathematics 353 or consent of instructor. Instructor: Franzoni. 3 units. C-L: Mechanical Engineering and Materials Science 543

627. Linear System Theory. Construction of continuous and discrete-time state space models for engineering systems, and linearization of nonlinear models. Applications of linear operator theory to system analysis. Dynamics of continuous and discrete-time linear state space systems, including time-varying systems. Lyapunov stability theory. Realization theory, including notion of controllability and observability, canonical forms, minimal realizations, and balanced realizations. Design of linear feedback controllers and dynamic observers, featuring both pole placement and linear quadratic techniques. Introduction to stochastic control and filtering. Prerequisites: Electrical and Computer Engineering 382 or Mecahnical Engineering 344, or consent of instructor. Instructor: Staff. 3 units. C-L: Mechanical Engineering and Materials Science 627

628. Stochastic Systems. Analysis of continuous and discrete-time stochastic processes, with emphasis on application to mechanics. Time-and frequency-domain analysis of stationary linear stochastic systems. Optimal filtering and control of stochastic systems. Continuous-time Poisson counters and Wiener processes. Introduction to stochastic (Ito) calculus. Continuous-time nonlinear and nonstationary stochastic processes, and the Fokker-Plank equations. Failure analysis and first-passage reliability analysis for continuous-time dynamic systems. Introduction to approximate analysis of nonlinear stochastic systems. Prerequisites: Statistical Science 130 and Civil and Environmental Engineering 627. Instructor: Staff. 3 units.

629. System Identification. Numerical linear algebra for modeling and filtering data (FFT, SVD, QR, and PCA); ordinary least squares, total least squares, and recursive least squares; measurement noise and propagation of measurement error; regularization; optimal linear filtering; state-space models, eigensystem realization, deterministic and stochastic subspace identification through projections and canonical correlation. Applications drawn from engineering, natural sciences, and finance. Instructor: Gavin. 3 units.

630. Nonlinear Finite Element Analysis. Formulation and solution of nonlinear initial/boundary value problems using the finite element method. Systems include nonlinear heat conduction/diffusion, geometrically nonlinear solid and structural mechanics applications, and materially nonlinear systems (for example, elastoplasticity). Emphasis on development of variational principles for nonlinear problems, finite element discretization, and equation-solving strategies for discrete nonlinear equation systems. Topics include: Newton-Raphson techniques, quasi-Newton iteration schemes, solution of nonlinear transient problems, and treatment of constraints in a nonlinear framework. An independent project, proposed by the student, is required. Prerequisite: Civil and Environmental Engineering 530/Mechanical Engineering 524, or consent of instructor. Instructors: Aquino, Dolbow, or Scovazzi. 3 units. C-L: Mechanical Engineering and Materials Science 525

635. Computational Methods for Evolving Discontinuities. Presents an overview of advanced numerical methods for the treatment of engineering problems such as brittle and ductile failure and solid-liquid phase transformations in pure substances. Analytical methods for arbitrary discontinuities and interfaces are reviewed, with particular attention to the derivation of jump conditions. Partition of unity and level set methods. Prerequisites: Civil and Environmental Engineering 530, or 630, or instructor consent. Instructor: Dolbow. 3 units.

641. Advanced Soil Mechanics. Characterization of behavior of geomaterials. Stress-strain incremental laws. Nonlinear elasticity, hypo-elasticity, plasticity and visco-plasticity of geomaterials; approximated laws of soil mechanics; fluid-saturated soil behavior; cyclic behavior of soils; liquefaction and cyclic mobility; elements of soil dynamics; thermal effects on soils. Prerequisite: Civil and Environmental Engineering 302L or equivalent. Instructor: Hueckel. 3 units.

642. Environmental Geomechanics. The course addresses engineered and natural situations, where mechanical and hydraulic properties of soils and rocks depend on environmental (thermal chemical, biological) processes. Experimental findings are reviewed, and modeling of coupled thermo-mechanical, chemo-mechanical technologies are reviewed. Instructor: Hueckel. 3 units.

643. Environmental and Engineering Geophysics. Use of geophysical methods for solving engineering and environmental problems. Theoretical frameworks, techniques, and relevant case histories as applied to engineering and environmental problems (including groundwater evaluation and protection, siting of landfills, chemical waste disposals, roads assessments, foundations investigations for structures, liquefaction and earthquake risk assessment). Introduction to theory of elasticity and wave propagation in elastic and poroelastic media, electrical and electromagnetic methods, and ground penetrating radar technology. Prerequisite: Mathematics 353 or Physics 152L, or consent of instructor. Instructor: Boadu. 3 units.

644. Inverse Problems in Geosciences and Engineering. Basic concepts, theory, methods of solution, and application of inverse problems in engineering, groundwater modeling, and applied geophysics. Deterministic and statistical frameworks for solving inverse problems. Strategies for solving linear and nonlinear inverse problems. Bayesian approach to nonlinear inverse problems. Emphasis on the ill-posed problem of inverse solutions. Data collection strategies in relation to solution of inverse problems. Model structure identification and parameter estimation procedures. Prerequisite: Mathematics 353 or consent of instructor. Instructor: Boadu. 3 units.

645. Experimental Systems. Formulation of experiments; Pi theorem and principles of similitude; data acquisition systems; static and dynamic measurement of displacement, force, and strain; interfacing experiments with digital computers for data storage, analysis, and plotting. Students select, design, perform, and interpret laboratory-scale experiments involving structures and basic material behavior. Prerequisite: senior or graduate standing in engineering or the physical sciences. Instructor: Gavin. 3 units.

646. Plates and Shells. Differential equation and extremum formulations of linear equilibrium problems of Kirchhoffian and non-Kirchhoffian plates of isotropic and aelotropic material. Solution methods. Differential equation formulation of thin aelotropic shell problems in curvilinear coordinates; membrane and bending theories; specialization for shallow shells, shells of revolution, and plates. Extremum formulation of shell problems. Solution methods. Prerequisites: (Civil and Environmental Engineering 421L or Mechanical Engineering 321L) and Mathematics 353. Instructor: Virgin. 3 units. C-L: Mechanical Engineering and Materials Science 626

647. Buckling of Engineering Structures. An introduction to the underlying concepts of elastic stability and buckling, development of differential equation and energy approaches, buckling of common engineering components including link models, struts, frames, plates, and shells. Consideration will also be given to inelastic behavior, postbuckling, and design implications. Instructor: Virgin. 3 units. C-L: Mechanical Engineering and Materials Science 527

648. Multivariable Control. Synthesis and analysis of multivariable linear dynamic feedback compensators. Standard problem formulation. Performance norms. Full state feedback and linear quadratic Gaussian synthesis. Lyapunov and Riccati equations. Passivity, positivity, and self-dual realizations. Nominal performance and robust stability. Applications to vibration control, noise suppression, tracking, and guidance. Prerequisite: a course in linear systems and classical control, or consent of instructor. Instructor: Bushnell, Clark, or Gavin. 3 units. C-L: Mechanical Engineering and Materials Science 548

649. Structural Engineering Project Management. Apply project management tools and skills to a structural engineering design project. Implement changes in schedule, budget, and changing client and/or regulatory climate. Work with a design team of undergraduate students. Prerequisites: not open to students who have had Civil and Environmental Engineering 429, 469, or 679. Consent of instructor required. Instructor: Nadeau. 3 units.

661L. Environmental Molecular Biotechnology (GE, MC). Principles of genetics and recombinant DNA for environmental systems. Applications to include genetic engineering for bioremediation, DGGE, FISH, micro-arrays and biosensors. Laboratory exercises to include DNA isolation, amplification, manipulation and analysis. Prerequisites: Civil and Environmental Engineering 462L, Biology 20, Biology 201L, or graduate standing, or consent of instructor. Instructor: Gunsch. 3 units. C-L: Biomedical Engineering 565L

662. Physico-Bio-Chemical Transformations. Surveys of a selection of topics related to the interaction between fluid flow (through channels or the porous media) and physical, chemical, and biochemical transformations encountered in environmental engineering. Numerous diverse phenomena, including solute transport in the vicinity of chemically reacting surfaces, reverse osmosis, sedimentation, centrifugation, ultrafiltration, rheology, microorganism population dynamics, and others will be presented in a unifying mathematical framework. Prerequisites: Civil and Environmental Engineering 301L and Mathematics 353, or consent of instructor. Instructor: Kabala. 3 units.

665. Atmospheric Chemistry: From Air Pollution to Climate Change. 3 units. C-L: see Environment 739

666. Aquatic Geochemistry. Geochemistry of the water-solid interface of soils, minerals, and particles in earth systems. Topics will cover the chemical composition of soils, geochemical specalation, mineral weathering and stability, sorption and ion exchange, soil redox processes, and chemical kinetics at environmental surfaces. Prerequisites: CEE 461L or CEE 561L/ENVIRON 542L or permission of instructor. Instructor: Hsu-Kim. 3 units. C-L: Environment 666

667. Chemical Transformation of Environmental Contaminants. Mechanisms and principles underlying organic contaminant transformations in the ambient environment. Topics include hydrolysis, oxidation/reduction, direct and indirect photolysis, and reactions with disinfectant chemicals. Reactions will be considered in context of both natural (e.g. surface water and cloudwater) and engineered (e.g. drinking water, wastewater, and groundwater remediation) systems. Approaches will include both qualitative (reaction mechanism and product identification) as well as quantitative (reaction kinetics and stoichiometry) aspects of environmental reaction chemistry. Prerequisites: CEE 563/ENVIRON 540 or one semester of organic chemistry. Instructor: Ferguson. 3 units. C-L: Environment 667

671. Physicochemical Unit Operations in Water Treatment. Fundamental bases for design of water and waste treatment systems, including transport, mixing, sedimentation and filtration, gas transfer, coagulation, and absorption processes. Emphasis on physical and chemical treatment combinations for drinking water supply. Prerequisite: Civil and Environmental Engineering 462L. Instructor: Kabala. 3 units.

672. Solid Waste Engineering. Engineering design of material and energy recovery systems including traditional and advanced technologies. Sanitary landfills and incineration of solid wastes. Application of systems analysis to collection of municipal refuse. Major design project in solid waste management. Prerequisite: Civil and Environmental Engineering 462L, or consent of instructor. Instructor: Staff. 3 units. C-L: Environment 548

675. Introduction to the Physical Principles of Remote Sensing of the Environment. The course provides an overview of the radiative transfer principles used in remote-sensing across the electromagnetic spectrum using both passive and active sensors. Special focus is placed on the process that leads from theory to the development of retrieval algorithms for satellite-based sensors, including post-processing of raw observations and uncertainty analysis. Students carry on three hands-on projects (Visible and Thermal Infrared, Active Microwave, and Passive Microwave). Background in at least one of the following disciplines is desirable: radiation transfer, signal processing, and environmental physics (Hydrology, Geology, Geophysics, Plant Biophysics, Soil Physics). Instructor consent required. Instructor: Barros. 3 units.

676. Fundamentals and Applications of UV Processes in Environmental Systems. Ultraviolet light based processes as they relate to treatment of contaminants in water and air. Concepts in photochemistry and photobiology, fluence determination, UV disinfection, photodegradation processes for chemical containments, advanced oxidation processes, mathematical modeling and design of UV systems. Includes laboratory exercises. Prerequisites: Civil and Environmental Engineering 564, or consent of instructor. Instructor: Staff. 3 units.

679. Environmental Engineering Project Management. Apply project management tools and skills to an environmental engineering design project. Implement changes in schedule, budget, and changing client and/or regulatory climate. Work with a design team of undergraduate students. Consent of instructor required. Prerequisites: not open to students who have had Civil and Environmental Engineering 429, 469, or 649. Instructor: Schaad. 3 units.

681. Analytical Models of Subsurface Hydrology. Reviews the method of separation of variables, surveys integral transforms, and illustrates their application to solving initial boundary value problems. Three parts include: mathematical and hydrologic fundamentals, integral transforms and their philosophy, and detailed derivation via integral transforms of some of the most commonly used models in subsurface hydrology and environmental engineering. Discussion and use of parameter estimation techniques associated with the considered models. Prerequisite: Mathematics 353 and (Civil and Environmental Engineering 301L or 463L), or consent of instructor. Instructor: Kabala. 3 units.

682. Dynamic Engineering Hydrology. Dynamics of the occurrence, circulation, and distribution of water; climate, hydrometeorology, geophysical fluid motions. Precipitation, surface runoff and stream flow, infiltration, water losses. Hydrograph analysis, catchment characteristics, hydrologic instrumentation, and computer simulation models. Prerequisite: Civil and Environmental Engineering 301L, or consent of instructor. Instructor: Staff. 3 units.

683. Groundwater Hydrology and Contaminant Transport. Review of surface hydrology and its interaction with groundwater. The nature of porous media, hydraulic conductivity, and permeability. General hydrodynamic equations of flow in isotropic and anisotropic media. Water quality standards and contaminant transport processes: advective-dispersive equation for solute transport in saturated porous media. Analytical and numerical methods, selected computer applications. Deterministic versus stochastic models. Applications: leachate from sanitary landfills, industrial lagoons and ponds, subsurface wastewater injection, monitoring of groundwater contamination. Conjunctive surface-subsurface models. Prerequisite: Civil and Environmental Engineering 301L, or consent of instructor. Instructor: Kabala. 3 units.

684. Physical Hydrology and Hydrometeorology. The objective of this course is to introduce and familiarize graduate students with the fundamental physical processes in Hydrology and Hydrometeorology that control and modulate the pathways and transformations of water in the environment. The content of the course will be strongly oriented toward providing students with a specific basis for quantitative analysis of the terrestrial water cycle including land-atmosphere interactions and clouds and precipitation (rain and snow) processes. The course should be of interest to undergraduate and graduate students interested in Environmental Science and Engineering, and Atmospheric and Earth Sciences. Instructor: Barros. 3 units.

685. Water Supply Engineering Design. The study of water resources and municipal water requirements including reservoirs, transmission, treatment and distribution systems; methods of collection, treatment, and disposal of municipal and industrial wastewaters. The course includes the preparation of a comprehensive engineering report encompassing all aspects of municipal water and wastewater systems. Field trips to be arranged. Prerequisite: Civil and Environmental Engineering 462L, or consent of instructor. Instructor: Staff. 3 units.

686. Ecohydrology. This course provides the theoretical basis for understanding the interaction between hydrologic cycle, vegetation and soil biogeochemistry which is key for a proper management of water resources and terrestrial ecosystems especially in view of the possible intensification and alteration of the hydrologic regime due to climate change. Topics include: Probabilistic soil moisture dynamics; plant water stress; coupled dynamics of soil moisture, transpiration and photosynthesis; and infiltration, root uptake, and hydrologic control on soil biogeochemistry. Instructor: Staff. 3 units.

687. Hydrologic Modeling for Water Quantity and Quality Assessment. 3 units. C-L: see Environment 769

688. Turbulence 1. This is an introductory course on the subject of turbulence in fluids. The focus is on understanding the fundamental physical processes and mechanisms governing the behavior of turbulent flows. The course covers the following - overview of physical and mathematical properties of Navier-Stokes equation; kinematics, dynamics and energetics of turbulent flows; Kolmogorov theories of turbulence; Richardson energy cascade; wall-bounded turbulent flows; particle dispersion, clustering and collisions in turbulent flows. Prerequisite: ((CEE 301L or ME 336L) and Mathematics 353) or graduate standing. Recommended prerequisite: an introductory course on fluid mechanics, and a course on differential equations. Instructor: Bragg. 3 units. C-L: Mechanical Engineering and Materials Science 634

690. Advanced Topics in Civil and Environmental Engineering. A course on an advanced topic within the civil and environmental engineering department. Instructor: Staff. Variable credit.

691. Independent Study: Advanced Topics in Civil and Environmental Engineering. Study arranged on an advanced subject relating to programs within the civil and environmental engineering department tailored to fit the requirements of individuals or small groups. Consent of director of graduate studies required. Instructor: Staff. Variable credit.

692. Independent Study: Advanced Topics in Civil and Environmental Engineering. Study arranged on an advanced subject relating to programs within the civil and environmental engineering department tailored to fit the requirements of individuals or small groups. Consent of director of graduate studies required. Instructor: Staff. Variable credit.

701. Graduate Colloquium. Current topics in civil and environmental engineering theory and practice. Weekly seminar series. Instructor: Hsu-Kim. 0 units.

702. Graduate Colloquium. Current topics in civil and environmental engineering theory and practice. Weekly seminar series. Instructor: Hsu-Kim. 0 units.

761. Hydrologic and Environmental Data Analysis. 3 units. C-L: see Earth and Ocean Sciences 722; also C-L: Environment 722

780. Internship. Student gains practical experience in civil and environmental engineering by taking a job in industry, and writes a report about this experience. Requires prior consent from the student's advisor and from the director of graduate studies. Instructor: Staff. Variable credit.

890. Advanced Topics in Civil & Environmental Engineering. A course on an advanced topic within the civil and environmental engineering department. Instructor: Staff. Variable credit.

891. Independent Study: Advanced Topics in CEE. Special individual readings in a specific area of study in civil and environmental engineering. Approval of director of graduate studies required. Instructor: Staff. Variable credit.

892. Independent Study: Advanced Topics in CEE. Special individual readings in a specific area of study in civil and environmental engineering. Approval of director of graduate studies required. Instructor: Staff. Variable credit.

Electrical and Computer Engineering

Professor Chakrabarty, *Chair*; Professor of the Practice Huettel, *Associate Chair*; Associate Professor Franklin and Associate Professor of the Practice Hilton, *Directors of Graduate Studies*; Professors Brady, A. Brown, Calderbank, Carin, Chakrabarty, Collins, Cummer, Cummings, Curtarolo, Daubechies, Donald, Dunson, Fair, Glass, Grill, Joines, Jokerst, Kim, Krolik, Lebeck, X. Li, Liu, Lo, Maggs, Massoud, Nolte, Padilla, Reif, Samei, Sapiro, Smith, Sorin, Tarokh, and Trivedi; Associate Professors Board, Brooke, K. Brown, Chen, Cox, Farsiu, Franklin, Gehm, Hauser, Lee, H. Li, Mazurowski, Mikkelsen, Nowacek, Peterchev, Pfister, Rudin, Stiff-Roberts, Shen, and Yang; Assistant Professors Beck, Goetz, Gong, Heller, Marvian, Pajic, Reeves, and Zavlanos; Professors Emeriti Casey, George, Marinos, McCumber, and Paul Wang; Professor of the Practice Huettel; Associate Professors of the Practice Gustafson, Hilton, and Tantum; Assistant Professor of the Practice Bletsch; Research Professor Stoner; Associate Research Professor Marks; Assistant Research Professors Amsden, Greenberg, Malof, and Q. Qiu; Adjunct Professors Derby, J. Qiu, and Wilson; Adjunct Associate Professor Morizio; Adjunct Assistant Professors Fahmy, Goss, Hower, Jenkins, Knox, Larouche, Liao, Remus, Rogers, Stohl, Urzhumov, and Patrick Wang; Lecturing Fellow Kyle Bradbury

A master's degree and a PhD are available in this department.

Graduate study in the Department of Electrical and Computer Engineering (ECE) is intended to prepare students for leadership roles in academia, industry, and government that require creative technical problem solving skills. The department offers both PhD and MS degree programs with options for study in a broad spectrum of areas within electrical and computer engineering. Research and course offerings in the department are organized into four areas of specialization: computer engineering; engineering physics; microelectronics, photonics, and nanotechnology; signal and information processing. Detailed descriptions of course offerings, faculty research interests, and degree requirements may be found on the department's website at https://ece.duke.edu.

Interdisciplinary programs are also available that connect the above areas with those in other engineering departments, computer science, the natural sciences, and The School of Medicine. Students in the department may also be involved in research conducted in one of Duke's centers (e.g. the Fitzpatrick Institute for Photonics and Communications, the Center for Metamaterials and Integrated Plasmonics). Recommended prerequisites for graduate study in electrical engineering include knowledge of basic mathematics, statistics, and physics, electrical networks, electromagnetics, and system theory. Students with nonelectrical and/or computer engineering undergraduate degrees are welcome to apply but should discuss their enrollment and course requirement options with the director of graduate studies. The MS degree program includes thesis, project, or coursework options. A qualifying examination is required for the PhD program and must be taken by the beginning of the third semester of enrollment. The exam is intended to assess the student's potential for success as a researcher in their chosen sub-discipline. To ensure breadth of study, PhD students are required to take courses outside their area of specialization. There is no foreign language requirement.

Courses in Electrical and Computer Engineering (ECE)

511. Foundations of Nanoscale Science and Technology. 3 units. C-L: see Nanosciences 511; also C-L: Chemistry 611

512. Emerging Nanoelectronic Devices. Brief review of semiconductor device physics followed by coverage of the most prominent emerging nanoelectronic devices. Topics include: nanoelectronic logic devices (advanced silicon transistors, carbon nanotube transistors, spintronics, 2D FETs, NEMS, tunnel FETs, negative capacitance FETs and piezoelectronics), and nanoelectronic memory devices (phase change, spin transfer torque, nanomechanical, ferroelectric FET, and molecular memory). Students will understand basic operation, pros/cons of performance, and primary integration challenges. Students conduct case study project, culminating with class presentation. Prerequisite: ECE 230L or graduate student standing. Instructor: Franklin. 3 units.

521. Quantum Mechanics. Discussion of wave mechanics including elementary applications, free particle dynamics, Schrödinger equation including treatment of systems with exact solutions, and approximate methods for time-dependent quantum mechanical systems with emphasis on quantum phenomena underlying solid-state electronics and physics. Prerequisite: Mathematics 216 or equivalent. Instructor: Brady, Brown, or Stiff-Roberts. 3 units.

522. Introduction to Micro-Electromechanical Systems (MEMS). Design, simulation, fabrication, and characterization of micro-electromechanical systems (MEMS) devices. Integration of non-conventional devices into functional systems. Principles of fabrication, mechanics in micrometer scale, transducers and actuators, and issues in system design and integration. Topics presented in the context of example systems. Lab covers design, simulation, and realization of MEMS devices using commercially available foundry process. Prerequisite: Electrical and Computer Engineering 230L or Mechanical Engineering 344L or equivalent. Instructor: Kim. 3 units.

523. Quantum Information Science. Fundamental concepts and progress in quantum information science. Quantum circuits, quantum universality theorem, quantum algorithms, quantum operations and quantum error correction codes, fault-tolerant architectures, security in quantum communications, quantum key distribution, physical systems for realizing quantum logic, quantum repeaters and long-distance quantum communication. Prerequisites: Electrical and Computer Engineering 521 or Physics 464 or equivalent. Instructor: Kim or Marvian. 3 units. C-L: Physics 627

524. Introduction to Solid-State Physics. Discussion of solid-state phenomena including crystalline structures, X-ray and particle diffraction in crystals, lattice dynamics, free electron theory of metals, energy bands, and superconductivity, with emphasis on understanding electrical and optical properties of solids. Prerequisite: quantum physics at the level of Physics 264L or Electrical and Computer Engineering 521. Instructor: A. Brown or Teitsworth. 3 units.

525. Semiconductor Physics. A quantitative treatment of the physical processes that underlie semiconductor device operation. Topics include band theory and conduction phenomena; equilibrium and nonequilibrium charge carrier distributions; charge generation, injection, and recombination; drift and diffusion processes. Prerequisite: Electrical and Computer Engineering 330L or consent of instructor. Instructor: Staff. 3 units.

526. Semiconductor Devices for Integrated Circuits. Basic semiconductor properties (energy-band structure, effective density of states, effective masses, carrier statistics, and carrier concentrations). Electron and hole behavior in semiconductors (generation, recombination, drift, diffusion, tunneling, and basic semiconductor equations). Current-voltage, capacitance-voltage, and static and dynamic models of PN Junctions, Schottky barriers, Metal/Semiconductor Contacts, Bipolar-Junction Transistors, MOS Capacitors, MOS-Gated Diodes, and MOS Field-Effect Transistors. SPICE models and model parameters. Prerequisites: Electrical and Computer Engineering 330L. Instructor: Massoud. 3 units.

527. Analog Integrated Circuits. Analysis and design of bipolar and CMOS analog integrated circuits. SPICE device models and circuit macromodels. Classical operational amplifier structures, current feedback amplifiers, and building blocks for analog signal processing, including operational transconductance amplifiers and current conveyors. Biasing issues, gain and bandwidth, compensation, and noise. Influence of technology and device structure on circuit performance. Extensive use of industry-standard CAD tools, such as Analog Workbench. Prerequisite: Electrical and Computer Engineering 526. Instructor: Staff. 3 units.

528. Integrated Circuit Engineering. Basic processing techniques and layout technology for integrated circuits. Photolithography, diffusion, oxidation, ion implantation, and metallization. Design, fabrication, and testing of integrated circuits. Prerequisite: Electrical and Computer Engineering 330L or 331L. Instructor: Fair. 3 units.

529. Digital Integrated Circuits. Analysis and design of digital integrated circuits in deep submicron MOS technology. Brief review

of IC technology, MOSFETs, and interconnects. Switching characteristics (propagation delay) and power consumption in NMOS/CMOS devices and interconnects. Analysis of static and dynamic logic circuits (inverters, gates) and memory circuits (SRAMs, DRAMs, Flash). Influence of technology and device structure on performance and reliability of digital ICs. SPICE modeling. Memory array design project. Prerequisite: Electrical and Computer Engineering 331L or graduate student standing. Instructor: Massoud. 3 units.

531. Power Electronic Circuits for Energy Conversion. Efficient conversion of electrical energy is critical for electric and hybrid vehicles, wind and solar energy, power grids, computers, medical devices, and portables. This course teaches analysis and design of power electronic circuits for energy conversion, including circuit operation (converter topologies, steady-state modeling, switch realization), converter control (ac modeling, small-signal transfer functions, feedback), and magnetics (inductors, transformers). The course shares lectures with ECE/Energy Engineering 431, but has extended assignments. Prerequisite: ECE 230L or Engineering 224L or graduate student standing. Not open to students who have taken ECE 431 or Energy Engineering 431. Instructor: Peterchev. 3 units. C-L: Energy Engineering 531

532. Analog Integrated Circuit Design. Design and layout of CMOS analog integrated circuits. Qualitative review of the theory of pn junctions, bipolar and MOS devices, and large and small signal models. Emphasis on MOS technology. Continuous time operational amplifiers. Frequency response, stability and compensation. Complex analog subsystems including phase-locked loops, A/D and D/A converters, switched capacitor simulation, layout, extraction, verification, and MATLAB modeling. Projects make extensive use of full custom VLSI CAD software. Prerequisite: [(ECE 330L or 331L) and ECE 230L and 250D and 270DL and 280L and (Mathematics 353 or 356) and (Statistical Science 130L or Mathematics 230 or ECE 555 or ECE 380 or Statistical Science 240L or EGR 238L or Mathematics 340) and (Physics 152L or 26) and (Chemistry 101DL or 20 or 21)] or graduate-student standing. Instructor: Morizio. 3 units.

533. Biochip Engineering. A problem-solving course in which students consider technology options for a complete lab-on-a-chip design. Lectures cover the basics of analog flow microfluidic devices, digital microfluidic devices, fabrication technologies for discrete devices, system integration issues, and a significant emphasis on biological applications for analysis, sample preparation, and detection issues. Technologies covered will include microfluidic devices, electrophoresis, analytical methods used in genetics, sample preparation methods, and analyte detection. Prerequisites: Biology 201L, Chem 101DL, and Physics 152L (or equivalents). Instructor: Fair. 3 units.

534. CAD For Mixed-Signal Circuits. The course focuses on various aspects of design automation for mixed-signal circuits. Circuit simulation methods including graph-based circuit representation, automated derivation and solving of nodal equations, and DC analysis, test automation approaches including test equipment, test generation, fault simulation, and built-in-self-test, and automated circuit synthesis including architecture generation, circuit synthesis, tack generation, placement and routing are the major topics. The course will have one major project, 4-6 homework assignments, one midterm, and one final. Prerequisites: Electrical and Computer Engineering 331L. Permission of instructor required. Instructor: Staff. 3 units.

536. Synthesis and Verification of VLSI Systems. Algorithms and CAD tools for VLSI synthesis and design verification, logic synthesis, multi-level logic optimization, high-level synthesis, logic simulation, timing analysis, formal verification. Prerequisite: Electrical and Computer Engineering 350L or equivalent. Instructor: Chakrabarty. 3 units.

537. Radiofrequency (RF) Transceiver Design. Design of wireless radiofrequency transceivers. Analog and digital modulation, digital modulation schemes, system level design for receiver and transmitter path, wireless communication standards and determining system parameters for standard compliance, fundamentals of synthesizer design, and circuit level design of low-noise amplifiers and mixers. Prerequisites: Electrical and Computer Engineering 280L and Electrical and Computer Engineering 331L or equivalent. Instructor: Staff. 3 units.

538. VLSI System Testing. Fault modeling, fault simulation, test generation algorithms, testability measures, design for testability, scan design, built-in self-test, system-on-a-chip testing, memory testing. Prerequisite: Electrical and Computer Engineering 350L or equivalent. Instructor: Chakrabarty. 3 units.

539. CMOS VLSI Design Methodologies. Emphasis on full-custom digital ASIC design using CMOS technology. Extensive use of CAD tools for IC design, simulation, and layout verification. Includes techniques for designing high-speed, low-power, easily-testable circuits. Semester design project: Student groups design and simulate simple custom IC using Mentor Graphics CAD tools. Formal project proposal, written project report, and formal project presentation required. Prerequisite: [ECE 350L, 331L, 230L, 250D, 270DL, and 280L and (Mathematics 353 or 356) and (Statistical Science 130L or Statistical Science 240L or Mathematics 230 or Mathematics 340 or ECE 380 or ECE 555 or EGR 238L) and (Physics 152L or 26) and (Chemistry 101DL or 20 or 21)] or graduate-student standing. Instructor: Chakrabarty or Morizio. 3 units.

541. Advanced Optics. 3 units. C-L: see Physics 621; also C-L: Biomedical Engineering 552

545. Foundations of Nanoelectronics & Nanophotonics. Theory and applications of nanoelectronics and nanophotonics. Quantum dots and wells, metal nanoparticles, organic-inorganic interfaces, graphene, next generation transistors, light emitters, and sensors. Prerequisite: Electrical and Computer Engineering 230L and 270DL or equivalent. Instructor: Brown or Litchinitser. 3 units.

546. Optoelectronic Devices. Devices for conversion of electrons to photons and photons to electrons. Optical processes in semiconductors: absorption, spontaneous emission and stimulated emission. Light-emitting diodes (LEDs), semiconductor lasers, quantum-well emitters, photodetectors, modulators and optical fiber networks. Prerequisite: Electrical and Computer Engineering 526 or equivalent. Instructor: Jokerst or Stiff-Roberts. 3 units.

549. Optics and Photonics Seminar Series. Weekly seminar on the current research topics in the field of optics and photonics. Instructor: Staff. 1 unit. C-L: Biomedical Engineering 609, Physics 549

550D. Fundamentals of Computer Systems and Engineering. Fundamentals of computer systems and engineering for master's students whose undergraduate background did not cover this material. Topics covered include: Digital logic, assembly programming, computer architecture, memory hierarchies and technologies, IO, hardware implementation in VHDL, operating systems, and networking. Undergraduates may not take this course and should take ECE 250D, 353, and/or 356 instead. Corequisite: ECE 551D. Instructor: Hilton. 3 units.

550DK. Fundamentals of Computer Systems and Engineering. Fundamentals of computer systems and engineering for Master's students whose undergraduate background did not cover this material. Topics covered include: Digital logic, assembly programming, computer architecture, memory hierarchies and technologies, IO, hardware implementation in VHDL, operating systems, and networking. Taught at Duke Kunshan University in Kunshan, China. Corequisite: ECE 551DK. Instructor: Xin Li. 3 units.

551D. Programming, Data Structures, and Algorithms in C++. Students learn to program in C and C++ with coverage of data structures (linked lists, binary trees, hash tables, graphs), Abstract Data Types (Stacks, Queues, Maps, Sets), and algorithms (sorting, graph search, minimal spanning tree). Efficiency of these structures and algorithms is compared via Big-O analysis. Brief coverage of concurrent (multi-threaded) programming. Emphasis is placed on defensive coding, and use of standard UNIX development tools in preparation for students' entry into real world software development jobs. Not open to undergraduates. Instructor: Hilton. 3 units.

551DK. Programming, Data Structures, and Algorithms in C++. Students learn to program in C and C++ with coverage of data structures (linked lists, binary trees, hash tables, graphs), Abstract Data Types (Stacks, Queues, Maps, Sets), and algorithms (sorting, graph search, minimal spanning tree). Efficiency of these structures and algorithms is compared via Big-O analysis. Brief coverage of concurrent (multi-threaded) programming. Emphasis is placed on defensive coding, and use of standard UNIX development tools in preparation for students' entry into real world software development jobs. Taught at Duke Kunshan University in Kunshan, China. Instructor: Ivan Mura. 3 units.

552. Advanced Computer Architecture I. 3 units. C-L: see Computer Science 550

553. Compiler Construction. Covers the fundamentals of compiler design. Students will develop a working compiler, writing all stages required to take source code as input and produce working assembly as output: lexical analysis, parsing, type checking, translation to intermediate representation, instruction selection, liveness analysis, and register allocation. Students are expected to have a strong programming background prior to taking this course, as writing a compiler is a significant programming task. Prerequisites: Electrical and Computer Engineering 250L or Computer Science 250 or (ECE 550D and ECE 551D). Instructor: Hilton. 3 units. C-L: Computer Science 553

554. Fault-Tolerant and Testable Computer Systems. Technological reasons for faults, fault models, information redundancy, spatial redundancy, backward and forward error recovery, fault-tolerant hardware and software, modeling and analysis, testing, and design for test. Prerequisite: Electrical and Computer Engineering 250D or equivalent. Instructor: Sorin. 3 units. C-L: Computer Science 554

555. Probability for Electrical and Computer Engineers. Basic concepts and techniques used stochastic modeling of systems with applications to performance and reliability of computer and communications system. Elements of probability, random variables (discrete and continuous), expectation, conditional distributions, stochastic processes, discrete and continuous time Markov chains, introduction to queuing systems and networks. Prerequisite: Mathematics 216. Instructor: Trivedi. 3 units. C-L: Computer Science 555

556. Wireless Networking and Mobile Computing. Theory, design, and implementation of mobile wireless networking systems. Fundamentals of wireless networking and key research challenges. Students review pertinent journal papers. Significant, semester-long research project. Networking protocols (Physical and MAC, multi-hop routing, wireless TCP, applications), mobility management, security, and sensor networking. Prerequisites: Electrical and Computer Engineering 356 or Computer Science 310. Instructor: Staff. 3 units. C-L: Computer Science 515

557. Performance and Reliability of Computer Networks. Methods for performance and reliability analysis of local area networks as well as wide area networks. Probabilistic analysis using Markov models, stochastic Petri nets, queuing networks, and hierarchical models. Statistical analysis of measured data and optimization of network structures. Prerequisites: Electrical and Computer Engineering 356 and 555. Instructor: Trivedi. 3 units.

558. Advanced Computer Networks. 3 units. C-L: see Computer Science 514

559. Advanced Digital System Design. Fundamentals of advanced digital system design, and the use of a hardware description language, VHDL, for their synthesis and simulation. System examples include the arithmetic/logic unit, memory, and microcontrollers. Team-based project incorporates engineering standards and realistic constraints, and also considers most of the following: Cost, environmental impact, manufacturability, health and safety, ethics, social and political impact. Prerequisite: [ECE 350L, 230L, 250D, 270DL, and 280L and (Mathematics 353 or 356) and (Statistical Science 130L or Statistical Science 240L or Mathematics 230 or Mathematics 340 or ECE 380 or ECE 555 or EGR 238L) and (Physics 152L or 26) and (Chemistry 101DL or 20 or 21) and ECE 331L (prerequisite or corequisite)] or graduate-student standing. Instructor: Derby. 3 units.

560. Computer and Information Security. An intense trip through many facets of computer and information security. Includes discussion and practical exercises in risk management, threat modeling, applied cryptography, malicious software, network security, intrusion detection and prevention, software and OS security, auditing and forensics, reverse engineering, and social engineering. Includes many hands-on security assignments. Prerequisite: Computer Science 310, ECE 353, or ECE 650. Instructor: Bletsch. 3 units.

561. Datacenter Architecture. Advanced topics in data centers with emphasis on computer architecture and systems. Surveys recent advances in processor, memory, network, storage, and modern software systems that run in computing clouds. Discussion-oriented classes focus on in-depth analysis of readings. Students will learn to reason about datacenter performance and energy efficiency. Students will complete a collaborative research project. Prerequisite: ECE 250D or Computer Science 250D or ECE 550D. Instructor: Lee. 3 units.

562. Energy-Efficient Computer Systems. Advanced topics in energy-efficient computing with an emphasis on computer architecture and systems. Surveys recent advances in diverse platforms, ranging from high-performance, enterprise domains to low-power, mobile domains. Discussion-oriented classes focus on in-depth analysis of readings. Students will learn to reason about energy efficiency across the hardware/software interface and across a range of system components. Students will complete a collaborative research project. Prerequisite: ECE 250D or Computer Science 250D or ECE 550D. Instructor: Lee. 3 units.

563. Cloud Computing. In a seminar format, explore a number of the underlying technologies, business models, and innovations underpinning current widespread deployment of "cloud" computing systems, services, and applications. Each student will be expected to choose a relevant subject, identify appropriate advance readings for the class, and lead one discussion on topics of interest to the group. There will be a project component to the course; some projects may be in the form of literature reviews and papers, others will involve practical experience creating and deploying a useful service or application in a cloud environment. Instructor: Board. 3 units.

564. Mobile Application Development. Explores the world of mobile application development with focus on needs of engineers. Centered on Apple environment, with the development environment being on OS X and the target environment being an iOS device – iPad, iPhone, iPod Touch or Apple Watch. Real world context focused on the common programming "patterns" for engineers in academia or business – standalone apps, apps connected to other systems, apps connected to the cloud. Covers fundamentals essential to understanding all aspects of app development. Taught in a team environment. Students required to present their project proposals and deliver an app as a final project. Prerequisite: CompSci 307D or CompSci 308 or ECE 551D. Instructor: Telford. 3 units.

565. Performance Optimization & Parallelism. Analyzing and optimizing the performance of software, in both a single- and multi-threaded setting. Apply knowledge of hardware, programming, and assembly to both tasks. Single-threaded performance topics include code profiling & analysis, loop transformation, analysis of interaction of code & memory hierarchy, assembly level instruction scheduling impacts. Multi-threaded topics include scalability & load balance. For students with strong foundation of programming skills in high-level languages, assembly language, and computer architecture & design. Prerequisite: [(ECE/Computer Science 250D and [Computer Science 310 or ECE 353]) or (ECE 550D and ECE 551D)] and ECE 552 (may be taken concurrently). Recommended prerequisite: ECE 650. Instructor: Rogers. 3 units.

566. Enterprise Storage Architecture. Study the design and deployment of massive storage systems of the sort used in large enterprises (banks, major IT departments, service providers, etc.). Includes coverage of hard disk and flash design, RAID, SAN and NAS topologies, filesystem design, data center architectures for high availability, data deduplication, business continuity, and the economics of data storage with respect to cloud computing. Includes a few homeworks and a semester-long programming project. Prerequisite: graduate students: ECE 650; undergraduate students: Computer Science 310 or ECE 353. Instructor: Bletsch. 3 units.

567. Cyber-Physical System Design. Complex interactions between information technology and physical world in Cyber-Physical Systems (CPS) challenge standard design methods that ignore cross-cutting constraints. This course addresses CPS design challenges by exploiting theory and methods from embedded systems, controls, and formal methods. Course covers topics related to the integration of system modeling, analysis, and automatic synthesis into design frameworks that ensure closed-loop safety and performance under known and unknown operating conditions. Balances establishing a working knowledge of CPS design and analysis methods with understanding the theory behind them. Prerequisite: ECE 350L and Computer Science 310/ECE 353, or graduate-student standing. Instructor: Pajic. 3 units.

568. Engineering Robust Server Software. In this course, students learn about important principles in server software design and development. These principles include topics such as handling asynchronous behavior, design for failure, basic security principles, scalability, and resilience. Students will put these ideas into practices by developing software reflecting the ideas learned in class. Prerequisite: ECE 551D and corequisite ECE 650, or [(Computer Science 307D or Computer Science 308) and ECE 353 and ECE 356]. Instructor: Hilton or Rogers. 3 units.

571. Electromagnetic Theory. The classical theory of Maxwell's equations; electrostatics, magnetostatics, boundary value problems including numerical solutions, currents and their interactions, and force and energy relations. Three class sessions. Prerequisite: Electrical and Computer Engineering 270DL. Instructor: Carin, Joines, Liu, Padilla, or Smith. 3 units.

572. Electromagnetic Communication Systems. Review of fundamental laws of Maxwell, Gauss, Ampere, and Faraday. Elements of waveguide propagation and antenna radiation. Analysis of antenna arrays by images. Determination of gain, loss, and noise temperature parameters for terrestrial and satellite electromagnetic communication systems. Prerequisite: Electrical and Computer Engineering 270DL or 571. Instructor: Joines. 3 units.

573. Optical Communication Systems. Mathematical methods, physical ideas, and device concepts of optoelectronics. Maxwell's equations, and definitions of energy density and power flow. Transmission and reflection of plane waves at interfaces. Optical resonators, waveguides, fibers, and detectors are also presented. Prerequisite: Electrical and Computer Engineering 270DL or equivalent. Instructor: Joines. 3 units.

574. Waves in Matter. Analysis of wave phenomena that occur in materials based on fundamental formulations for electromagnetic and elastic waves. Examples from these and other classes of waves are used to demonstrate general wave phenomena such as dispersion, anisotropy, and causality; phase, group, and energy propagation velocities and directions; propagation and excitation of surface waves; propagation in inhomogeneous media; and nonlinearity and instability. Applications that exploit these wave phenomena in general sensing applications are explored. Prerequisite: Electrical and Computer Engineering 270DL. Instructor: Cummer. 3 units.

575. Microwave Electronic Circuits. Microwave circuit analysis and design techniques. Properties of planar transmission lines for integrated circuits. Matrix and computer-aided methods for analysis and design of circuit components. Analysis and design of input, output, and interstage networks for microwave transistor amplifiers and oscillators. Topics on stability, noise, and signal distortion. Prerequisite: Electrical and Computer Engineering 270DL or equivalent. Instructor: Joines. 3 units.

577. Computational Electromagnetics. Systematic discussion of useful numerical methods in computational electromagnetics including integral equation techniques and differential equation techniques, both in the frequency and time domains. Hands-on experience with numerical techniques, including the method of moments, finite element and finite-difference time-domain methods, and modern high order and spectral domain methods. Prerequisite: Electrical and Computer Engineering 571 or consent of instructor. Instructor: Carin or Liu. 3 units.

578. Inverse Problems in Electromagnetics and Acoustics. Systematic discussion of practical inverse problems in electromagnetics and acoustics. Hands-on experience with numerical solution of inverse problems, both linear and nonlinear in nature.

Comprehensive study includes: discrete linear and nonlinear inverse methods, origin and solution of nonuniqueness, tomography, wave-equation based linear inverse methods, and nonlinear inverse scattering methods. Assignments are project oriented using MATLAB. Prerequisites: Graduate level acoustics or electromagnetics (Electrical and Computer Engineering 571), or consent of instructor. Instructor: Liu. 3 units.

580. Introduction to Machine Learning. Introduction to core concepts in machine learning and statistical pattern recognition, with a focus on discriminative and generative classifiers (nearest-neighbors, Bayes, logistic regression, linear discriminant, support vector machine, and relevance vector machine). Dimensionality reduction and feature selection. Classifier performance evaluation, bias-variance tradeoff, and cross-validation. Prerequisite: (Mathematics 216, Mathematics 218, Mathematics 221, or ECE 586) and (Computer Science 201 or ECE 551D) and (ECE 480 or ECE 581). Not open to students who have taken Computer Science 671D. Instructor: Collins, X. Li, or Tantum. 3 units.

580K. Introduction to Machine Learning. Introduction to core concepts in machine learning and statistical pattern recognition, with a focus on discriminative and generative classifiers (nearest-neighbors, Bayes, logistic regression, linear discriminant, support vector machine, and relevance vector machine). Dimensionality reduction and feature selection. Classifier performance evaluation, bias-variance tradeoff, and cross-validation. Taught at Duke Kunshan University in Kunshan, China. Instructor: Xin Li. 3 units.

581. Random Signals and Noise. Introduction to mathematical methods of describing and analyzing random signals and noise. Review of basic probability theory; joint, conditional, and marginal distributions; random processes. Time and ensemble averages, correlation, and power spectra. Optimum linear smoothing and predicting filters. Introduction to optimum signal detection, parameter estimation, and statistical signal processing. Prerequisite: one of (STA 130L or STA 240L or Mathematics 230 or or Mathematics 340 or ECE 380 or ECE 555 or EGR 238L) or graduate student standing. Instructor: Collins or Nolte. 3 units.

581K. Random Signals and Noise. Introduction to mathematical methods of describing and analyzing random signals and noise. Review of basic probability theory; joint, conditional, and marginal distributions; random processes. Time and ensemble averages, correlation, and power spectra. Optimum linear smoothing and predicting filters. Introduction to optimum signal detection, parameter estimation, and statistical signal processing. Taught at Duke Kunshan University in Kunshan, China. Instructor: Ming Li. 3 units.

582. Digital Signal Processing. Introduction to fundamental algorithms used to process digital signals. Basic discrete time system theory, the discrete Fourier transform, the FFT algorithm, linear filtering using the FFT, linear production and the Wierner filter, adaptive filters and applications, the LMS algorithm and its convergence, recursive least-squares filters, nonparametric and parametric power spectrum estimation minimum variance and eigenanalysis algorithms for spectrum estimation. Prerequisite: Electrical and Computer Engineering 581 or equivalent with consent of the instructor. Instructor: Collins, Krolik, or Nolte. One course. 3 units.

584. Acoustics and Hearing (GE, EL, IM). 3 units. C-L: see Biomedical Engineering 545

585. Signal Detection and Extraction Theory. Introduction to signal detection and information extraction theory from a statistical decision theory viewpoint. Subject areas covered within the context of a digital environment are decision theory, detection and estimation of known and random signals in noise, estimation of parameters and adaptive recursive digital filtering, and decision processes with finite memory. Applications to problems in communication theory. Prerequisite: Electrical and Computer Engineering 581 or consent of instructor. Instructor: Nolte. 3 units.

586. Vector Space Methods with Applications. Covers key concepts from advanced linear algebra that are used regularly in ECE/CS journal papers on signal processing, communications, circuit design, and machine learning (e.g., logic, topology, vector spaces, optimization). Key mathematical ideas/proofs will be presented and applied. Uses application topics such as Markov chains, alternating projections, and pattern classification to illustrate important mathematical topics. Background in linear algebra, a high-level programming language, and probability is assumed. Prerequisite: [(Mathematics 216, 221, or 218) and (Engineering 103L or Computer Science 201) and (STA 130 or STA 240L or Mathematics 230 or Mathematics 340 or ECE 380 or ECE 555 or EGR 238L) and ECE 280L] or graduate student standing. Instructor: Pfister. 3 units.

586K. Vector Space Methods with Applications. Covers key concepts from advanced linear algebra that are used regularly in ECE/CS journal papers on signal processing, communications, circuit design, and machine learning (e.g., logic, topology, vector spaces, optimization). For each topic, key mathematical ideas/proofs will be presented and applied. The goal is to use application topics such as Markov chains, alternating projections, and pattern classification to illustrate important mathematical topics. Background in linear algebra, a high-level programming language, and probability is assumed. Taught at Duke Kunshan University in Kunshan, China. Instructor: Ming Li. 3 units.

587. Information Theory. Information theory is the science of processing, transmitting, storing, and using information. This course provides an introduction to mathematical measures of information and their connection to practical problems in communication, compression, and inference. Entropy, mutual information, lossless data compression, channel capacity, Gaussian channels, rate distortion theory, Fisher information. Useful for researchers in a variety of fields, including signal processing, machine learning, statistics, and neuroscience. Appropriate for beginning graduate students in electrical engineering, computer science, statistics, and math with a background in probability. Instructor: Reeves or Carin. 3 units. C-L: Statistical Science 563

588. Image and Video Processing: From Mars to Hollywood with a Stop at the Hospital. Intro to image formation, image compression, image enhancement & image segmentation. Covers geometric and non-geometric tools, as well as spatial and non-spatial operations. Extension to color images and video. Addresses recent progress in the area, including image inpainting (how to remove objects from images and video), image processing via sparse modeling & compressed sensing, geometric partial differential equations for image analysis, image processing for HIV & virus research, image processing for neurosurgery & other medical applications. Prerequisite: [ECE 280L and (Mathematics 216, 221, or 218) and (STA 130L or STA 240L or Mathematics 230 or Mathematics 340 or ECE 380 or ECE 555 or EGR 238L)] or graduate student standing. Instructor: Sapiro. 3 units.

590. Advanced Topics in Electrical and Computer Engineering. Opportunity for study of advanced subjects related to programs within the electrical and computer engineering department tailored to fit the requirements of a small group. Instructor consent required. Instructor: Staff. 3 units.

590-1. Advanced Topics in Electrical and Computer Engineering. Opportunity for study of advanced subjects in electrical and computer engineering. 1 unit. Instructor: Staff. 1 unit.

590D. Advanced Topics in Electrical and Computer Engineering. Opportunity for study of advanced subjects related to programs within the electrical and computer engineering department tailored to fit the requirements of a small group. Has discussion. Instructor: Staff. 3 units.

590K. Advanced Topics in Electrical and Computer Engineering. Opportunity for study of advanced subjects related to programs within the electrical and computer engineering department tailored to fit the requirements of a small group. Taught at Duke Kunshan University in Kunshan, China. Instructor: Kishor Trivedi. 3 units.

611. Nanoscale and Molecular Scale Computing. Students study the design and analysis of nanoscale computing systems. Topics include nanoelectronic devices (e.g., graphene and carbon nanotube transistors, quantum dots, etc.), computational paradigms (conventional von Neumann, quantum cellular automata, quantum computing, etc.), microarchitecture and instruction set design specific to nanoscale systems, defect and fault tolerance, fabrication techniques (e.g., self-assembly), modeling and simulation methods. This course relies on current literature and student discussion. Prerequisites: Electrical and Computer Engineering 350, Electrical and Computer Engineering 511. Instructor: Lebeck. 3 units. C-L: Computer Science 624

631. Analog and RF Integrated Circuit Design, Fabrication, and Test. For students who have some experience in analog circuit design and want to fabricate and test an IC under faculty supervision. Typically taken over three semesters (Fall, Spring, Summer, or Fall, Spring, Fall) to accommodate design-fabricate-test cycle. Design cycle: students use Cadence or Mentor IC layout tools, and HSPICE or ADS simulation tools. Fabrication cycle: a detailed test plan is developed. Test cycle: students access test facility appropriate for design and submit a report to the IC fabrication foundry. Co-requisite: ECE 539, or consent of instructor. Instructor: Brooke. Variable credit.

650. Systems Programming and Engineering. Focuses on a range of topics that are central to both the design of operating systems and the programming system-level software. Students will apply knowledge of basic concepts in operating systems, networking, and programming towards these two areas. Topics covered will include concurrency, process management, hypervisors, networking, security, databases, and file systems. Students will be expected to demonstrate their understanding in these areas through a series of programming assignments covering these topics. Prerequisite: ECE 550D and (ECE 551D or ECE 751D). Instructor: Younes. 3 units.

650K. Systems Programming and Engineering. Focuses on a range of topics that are central to both the design of operating systems and the programming system-level software. Students will apply knowledge of basic concepts in operating systems, networking, and programming towards these two areas. Topics covered will include concurrency, process management, hypervisors, networking, security, databases, and file systems. Students will be expected to demonstrate their understanding in these areas through a series of programming assignments covering these topics. Taught at Duke Kunshan University in Kunshan, China. Prerequisite: ECE 550DK and ECE 551DK. Instructor: Ivan Mura. 3 units.

651. Software Engineering. Teaches students about all steps of the software development lifecycle: requirements definition, design, development, testing, and maintenance. The course assumes students are skilled object-oriented programmers from prior courses, but will include a rapid introduction to Java. Students complete team-based semester-long software project which will progress through all phases of the software lifecycle. Prerequisite: ECE 551D. Instructor: Daily or Hilton. 3 units.

651K. Software Engineering. Teaches students about all steps of the software development lifecycle: requirements definition, design, development, testing, and maintenance. The course assumes students are skilled object-oriented programmers from prior courses, but will include a rapid introduction to Java. Students complete team-based semester-long software project which will progress through all phases of the software lifecycle. Taught at Duke Kunshan University in Kunshan, China. Prerequisite: ECE 551DK. Instructor: Ivan Mura. 3 units.

652. Advanced Computer Architecture II. 3 units. C-L: see Computer Science 650

675. Optical Imaging and Spectroscopy. Wave and coherence models for propagation and optical system analysis. Fourier optics and sampling theory. Focal plane arrays. Generalized and compressive sampling. Impulse response, modulation transfer function and instrument function analysis of imaging and spectroscopy. Code design for optical measurement. Dispersive and interferometric spectroscopy and spectral imaging. Performance metrics in optical imaging systems. Prerequisite: Electrical and Computer Engineering 270DL and 280L. Instructor: Brady. 3 units.

676. Lens Design. Paraxial and computational ray tracing. Merit functions. Wave and chromatic aberrations. Lenses in photography, microscopy and telescopy. Spectrograph design. Emerging trends in lens system design, including multiple aperture and catadioptric designs and nonimaging design for solar energy collection. Design project management. Each student must propose and complete a design study, including a written project report and a formal design review. Prerequisite: Electrical and Computer Engineering 340L or 375. Instructor: Brady. 3 units.

681. Pattern Classification and Recognition Technology. Theory and practice of recognition technology: pattern classification, pattern recognition, automatic computer decision-making algorithms. Applications covered include medical diseases, severe weather, industrial parts, biometrics, bioinformation, animal behavior patterns, image processing, and human visual systems. Perception as an integral component of intelligent systems. This course prepares students for advanced study of data fusion, data mining, knowledge base construction, problem-solving methodologies of "intelligent agents" and the design of intelligent control systems. Prerequisites: Mathematics 216, Statistical Science 130 or Mathematics 230, Computer Science 101, or consent of instructor. Instructor: Collins or Tantum. 3 units.

682D. Probabilistic Machine Learning. 3 units. C-L: see Statistical Science 561D; also C-L: Computer Science 571D

683. Digital Communication Systems. Digital modulation techniques. Coding theory. Transmission over bandwidth constrained channels. Signal fading and multipath effects. Spread spectrum. Optical transmission techniques. Prerequisite: Electrical and Computer Engineering 581 or consent of instructor. Instructor: Staff. 3 units.

684. Natural Language Processing. Introduction to algorithmic and analytic methods specific to textual data. Subject areas covered are speech recognition, optical character recognition, text parsing, and document analysis. Analysis tools taught include sentiment analysis/topic models, auto-correct, auto-complete, and translation systems. Applications to brain-computer interface communication systems, intelligent personal assistants, and plagiarism detection systems. Prerequisite: STA 130L, STA 240L, Mathematics 230, Mathematics 340, ECE 380, ECE 555, ECE 580, ECE 581, ECE 682D, EGR 238L, or ECE 551D. Instructor: Wang. 3 units.

685D. Introduction to Deep Learning. Provides an introduction to the machine learning technique called deep learning or deep neural networks. A focus will be the mathematical formulations of deep networks and an explanation of how these networks can be structured and "learned" from big data. Discussion section covers practical applications, programming, and modern implementation practices. Example code and assignments will be given in Python with heavy utilization of PyTorch (or Tensorflow) package. The course and a project will cover various applications including image classification, text analysis, object detection, etc. Prerequisite: ECE 580, ECE 681, ECE 682D, Statistical Science 561D, or Computer Science 571D. Instructor: Tarokh. 3 units.

686. Adaptive Filters. Adaptive digital signal processing with emphasis on the theory and design of finite-impulse response adaptive filters. Stationary discrete-time stochastic processes, Wiener filter theory, the method of steepest descent, adaptive transverse filters using gradient-vector estimation, analysis of the LMS algorithm, least-squares methods, recursive least squares and least squares lattice adaptive filters. Application examples in noise canceling, channel equalization, and array processing. Prerequisites: Electrical and Computer Engineering 581 and 582 or consent of instructor. Instructor: Krolik. 3 units.

687D. Theory and Algorithms for Machine Learning. 3 units. C-L: see Computer Science 671D; also C-L: Statistical Science 671D

688. Sensor Array Signal Processing. An in-depth treatment of the fundamental concepts, theory, and practice of sensor array processing of signals carried by propagating waves. Topics include: multidimensional frequency-domain representations of space-time signals and linear systems; apertures and sampling of space-time signals; beamforming and filtering in the space-time and frequency domains, discrete random fields; adaptive beamforming methods; high resolution spatial spectral estimation; optimal detection, estimation, and performance bounds for sensor arrays; wave propagation models used in sensor array processing; blind beamforming and source separation methods; multiple-input-multiple-output (MIMO) array processing; application examples from radar, sonar, and communications systems. Instructor: Krolik. 3 units.

02-G-B

721. Nanotechnology Materials Lab. 3 units. C-L: see Mechanical Engineering and Materials Science 711

722. Quantum Electronics. Quantum theory of light-matter interaction. Laser physics (electron oscillator model, rate equations, gain, lasing condition, oscillation dynamics, modulation) and nonlinear optics (electro-optic effect, second harmonic generation, phase matching, optical parametric oscillation and amplification, third-order nonlinearity, optical bistability.) Prerequisite Electrical and Computer Engineering 521, Physics 464, or equivalent. Instructors: Stiff-Roberts. One course. 3 units.

741. Compressed Sensing and Related Topics. 3 units. C-L: see Statistical Science 741

751D. Advanced Programming, Data Structures, and Algorithms in C++. Students learn C++, data structures (linked lists, balanced BSTs, hash tables, graphs), Abstract Data Types (Stacks, Queues, Maps, Sets), & algorithms (sorting, graph search, minimal spanning tree). Efficiency of such structures & algorithms compared via Big-O analysis. Students learn multi-threaded programming. Emphasis on defensive coding, and use of standard UNIX development tools in preparation for students' entry into real world software development jobs. Strong C programming skills required to enroll. Those without such skills should take Electrical and Computer Engineering 551D instead. Instructor consent required. Not open to students who have taken or are currently taking Electrical and Computer Engineering 551D. Instructor: Hilton or Lipp. 3 units.

781. Advanced Topics in Signal Processing. Instructor: Staff. 3 units.

784LA. Sound in the Sea: Introduction to Marine Bioacoustics. 4 units. C-L: see Environment 784LA; also C-L: Biology 784LA

891. Internship. Student gains practical electrical and computer engineering experience by taking a job in industry and writing a report about this experience. May be repeated with consent of the advisor and the director of graduate studies. A full-time internship is available to ECE graduate students if it allows them to gain practical experience in a work environment related to their academic training and enhances their overall academic experience and, for students on F-1 Visa, their employment prospects once they return to their home country. Requires prior consent from the student's advisor and from the director of graduate studies. Credit/no credit grading only. Instructor: Staff. Variable credit.

899. Special Readings in Electrical Engineering. Special individual readings in a specified area of study in electrical engineering. Approval of director of graduate studies required. 1 to 4 units. Instructor: Graduate staff. Variable credit.

01-G-K

550DK. Fundamentals of Computer Systems and Engineering. Fundamentals of computer systems and engineering for Master's students whose undergraduate background did not cover this material. Topics covered include: Digital logic, assembly programming, computer architecture, memory hierarchies and technologies, IO, hardware implementation in VHDL, operating systems, and networking. Taught at Duke Kunshan University in Kunshan, China. Corequisite: ECE 551DK. Instructor: Xin Li. 3 units.

551DK. Programming, Data Structures, and Algorithms in C++. Students learn to program in C and C++ with coverage of data structures (linked lists, binary trees, hash tables, graphs), Abstract Data Types (Stacks, Queues, Maps, Sets), and algorithms (sorting, graph search, minimal spanning tree). Efficiency of these structures and algorithms is compared via Big-O analysis. Brief coverage of concurrent (multi-threaded) programming. Emphasis is placed on defensive coding, and use of standard UNIX development tools in preparation for students' entry into real world software development jobs. Taught at Duke Kunshan University in Kunshan, China. Instructor: Ivan Mura. 3 units.

580K. Introduction to Machine Learning. Introduction to core concepts in machine learning and statistical pattern recognition, with a focus on discriminative and generative classifiers (nearest-neighbors, Bayes, logistic regression, linear discriminant, support vector machine, and relevance vector machine). Dimensionality reduction and feature selection. Classifier performance evaluation, bias-variance tradeoff, and cross-validation. Taught at Duke Kunshan University in Kunshan, China. Instructor: Xin Li. 3 units.

581K. Random Signals and Noise. Introduction to mathematical methods of describing and analyzing random signals and noise. Review of basic probability theory; joint, conditional, and marginal distributions; random processes. Time and ensemble averages, correlation, and power spectra. Optimum linear smoothing and predicting filters. Introduction to optimum signal detection, parameter estimation, and statistical signal processing. Taught at Duke Kunshan University in Kunshan, China. Instructor: Ming Li. 3 units.

586K. Vector Space Methods with Applications. Covers key concepts from advanced linear algebra that are used regularly in ECE/CS journal papers on signal processing, communications, circuit design, and machine learning (e.g., logic, topology, vector spaces, optimization). For each topic, key mathematical ideas/proofs will be presented and applied. The goal is to use application topics such as Markov chains, alternating projections, and pattern classification to illustrate important mathematical topics. Background in linear algebra, a high-level programming language, and probability is assumed. Taught at Duke Kunshan University in Kunshan, China. Instructor: Ming Li. 3 units.

590K. Advanced Topics in Electrical and Computer Engineering. Opportunity for study of advanced subjects related to programs within the electrical and computer engineering department tailored to fit the requirements of a small group. Taught at Duke Kunshan University in Kunshan, China. Instructor: Kishor Trivedi. 3 units.

650K. Systems Programming and Engineering. Focuses on a range of topics that are central to both the design of operating systems and the programming system-level software. Students will apply knowledge of basic concepts in operating systems, networking, and programming towards these two areas. Topics covered will include concurrency, process management, hypervisors, networking, security, databases, and file systems. Students will be expected to demonstrate their understanding in these areas through a series of programming assignments covering these topics. Taught at Duke Kunshan University in Kunshan, China. Prerequisite: ECE 550DK and ECE 551DK. Instructor: Ivan Mura. 3 units.

651K. Software Engineering. Teaches students about all steps of the software development lifecycle: requirements definition, design, development, testing, and maintenance. The course assumes students are skilled object-oriented programmers from prior courses, but will include a rapid introduction to Java. Students complete team-based semester-long software project which will progress through all phases of the software lifecycle. Taught at Duke Kunshan University in Kunshan, China. Prerequisite: ECE 551DK. Instructor: Ivan Mura. 3 units.

Mechanical Engineering and Materials Science

Professor Gall, *Chair*; Associate Professor of the Practice Kielb, *Associate Chair*; Associate Professor Chen and Professor Dolbow, *Directors of Graduate Studies*; Professors Bejan, Cocks, Curtarolo, Dolbow, Dowell, Gall, Hall, Huang, Marszalek, Needham, Shaughnessy, Tan, Virgin, Zauscher, and Zhong; Associate Professors Bliss, Blum, Chen, Cummings, Delaire, Franzoni, Howle, and Knight; Assistant Professors Hotz, Simmons, and Zavlanos; Assistant Research Professors Kopper and Thomas; Adjunct Assistant Professor Stepp; Professors Emeriti Pearsall, Hochmuth, and Garg; Associate Professor of the Practice Kielb

A master's degree and a PhD are available in this department.

The department offers programs of study and research leading to the MS and PhD in both mechanical engineering and materials science. The department's broad areas of concentration include nonlinear dynamics and control, unsteady aerodynamics and fluid mechanics including aeroelasticity (fluid/structure interaction), biomaterials and biomechanics, and thermal sciences and engineering. Additional areas of concentration include atomic force microscopy, biomaterials, electronic materials, material characteristics/properties and thin films.

The department emphasizes a highly research-oriented PhD program. Students in the PhD program who do not already have a master's degree are urged to meet the course and other general requirements of this degree and to obtain it during completion of their program. Programs of study are highly flexible to meet individual needs.

Current research areas include aeroelasticity; atomic force microscopy; bearing design and lubrication; biorheology; cell, membrane, and surface engineering; chaotic systems; computational fluid dynamics; computational materials science; convection; diffusion and kinetics on Si, GaAs, and other electronic materials; feed-back and feed-forward control systems; fluid dynamics of biological systems; heat transfer in heterogeneous media; magnetic bearings; mechanical properties of kidney stones; nano-tribology; nonlinear dynamics; oxide hetero-structures; robotics; shock-wave lithotripsy; sound propagation and absorbing materials; thermal design by entropy generation minimization; turbomachinery; ultrasound contrast enhancement; unsteady aerodynamics; and vibrations and acoustics of dynamic systems.

For additional information, visit https://mems.duke.edu.

Courses in Mechanical Engineering and Materials Science (ME)

510. Diffraction and Spectrometry of Materials. This course focuses on the fundamentals and applications of x-ray/neutron/electron scattering for the study of materials, with an emphasis on crystalline solids. The class will cover topics in diffraction for the study of the atomic structure of materials, as well as spectrometry to investigate microscopic dynamics and composition. The students should have a background in solid state physics/chemistry, quantum mechanics, materials science, and mathematics including Fourier transforms and complex numbers, convolution product. Open to graduate students; instructor consent required for undergraduate students to enroll. Instructor: Delaire. 3 units.

511. Computational Materials Science. This course will cover modern computational techniques for the prediction of materials properties, beginning from the scale of electrons and atoms and connecting to materials challenges in experiments today. Subjects covered will include Schroedinger's equation and density functional theory, molecular dynamics, and so-called multiscale approaches

to connect quantities computed at the nanoscale to macroscopic properties. The class will incorporate speci¿c examples as explicit computer exercises. The course is expected to provide an atomic-scale understanding of materials for both students with a primarily computational interest and those students whose research is primarily experimental. Open to graduate students; instructor consent required for undergraduate students to enroll. Instructor: Blum. 3 units.

512. Thermodynamics of Electronic Materials. Basic thermodynamic concepts applied to solid state materials with emphasis on technologically relevant electronic materials such as silicon and GaAs. Thermodynamic functions, phase diagrams, solubilities and thermal equilibrium concentrations of point defects; nonequilibrium processes and the kinetic phenomena of diffusion, precipitation, and growth. Instructor: Staff. 3 units.

513. Nanobiomechanics. The course consists of didactic lectures and many laboratory demonstrations and real experiments done by the students themselves. Topics include: Principles of single-molecule force spectroscopy (SMFS), SMFS experimental techniques, resolution and resolution limitations; Entropic and enthalpic elasticity of (bio)polymers; Structure and nanomechanics of DNA, polysaccharides, and proteins; Mechanisms of spontaneous folding, misfolding and refolding of proteins; Chaperones-assisted protein refolding; Principles of computer modeling of biopolymer mechanics; Development and characterization of novel, protein-based nanostructured, rationally designed biomaterials with unique mechanical properties. Open to graduate students; instructor consent required for undergraduate students to enroll. Instructor: Marszalek. 3 units.

514. Theoretical and Applied Polymer Science (GE, BB). An intermediate course in soft condensed matter physics dealing with the structure and properties of polymers and biopolymers. Introduction to polymer syntheses based on chemical reaction kinetics, polymer characterization. Emphasizes (bio)polymers on surfaces and interfaces in aqueous environments, interactions of (bio)polymer surfaces, including wetting and adhension phenomena. Instructor: Zauscher. 3 units. C-L: Biomedical Engineering 529

515. Electronic Materials. An advanced course in materials science and engineering dealing with materials important for solid-state electronics and the various semiconductors. Emphasis on thermodynamic concepts and on defects in these materials. Materials preparation and modification methods for technological defects in these materials. Prerequisite: Mechanical Engineering 221L. Instructor: Curtarolo. 3 units.

516. Thin-Film Photovoltaic Technology. This course will focus in on a promising class of solar cells based on thin-film absorbers, some of which are already commercialized (e.g., CdTe, CIGS), while others are on the cutting edge of new photovoltaics technology (e.g., perovskites). The course will employ a combination of lecture, directed reading and hands-on approaches. The hands-on component of the course will involve fabricating PV devices and employing contemporary characterization and modeling tools to evaluate device performance. Specific techniques and the intellectual framework are more generally applicable to other PV and electronic devices. Recommended prerequisite: ECE 230 or related familiarity with electronic properties of materials. Open to graduate students; instructor consent required for undergraduate students to enroll. Instructor: Mitzi. 3 units.

517. Electromagnetic Processes in Fluids. Electromagnetic processes and transport phenomena in fluids is overviewed. Topics to be discussed include: Maxwell's equations, statistical thermodynamic processes, origin of surface forces (i.e. Van der Waals), plasma in gases and electrolyte distribution, wave propagation near boundaries and in complex media, transport equations in continuum limit. Consent of instructor required. Instructor: Staff. 1 unit.

518. Biomedical Materials and Artificial Organs (GE, BB). 3 units. C-L: see Biomedical Engineering 525

519. Soft Wet Materials and Interfaces. The materials science and engineering of soft wet materials and interfaces. Emphasis on the relationships between composition, structure, properties and performance of macromolecules, self-assembling colloidal systems, linear polymers and hydrogels in aqueous and nonaqueous liquid media, including the role of water as an "organizing" solvent. Applications of these materials in biotechnology, medical technology, microelectronic technology, and nature's own designs of biological materials. Instructor: Needham. 3 units.

524. Introduction to the Finite Element Method. 3 units. C-L: see Civil and Environmental Engineering 530

525. Nonlinear Finite Element Analysis. 3 units. C-L: see Civil and Environmental Engineering 630

527. Buckling of Engineering Structures. 3 units. C-L: see Civil and Environmental Engineering 647

531. Engineering Thermodynamics. Axiomatic formulations of the first and second laws. General thermodynamic relationships and properties of real substances. Energy, availability, and second law analysis of energy conversion processes. Reaction and multiphase equilibrium. Power generation. Low temperature refrigeration and the third law of thermodynamics. Thermodynamic design. Instructor: Bejan. 3 units.

532. Convective Heat Transfer. Models and equations for fluid motion, the general energy equation, and transport properties. Exact, approximate, and boundary layer solutions for laminar flow heat transfer problems. Use of the principle of similarity and analogy in the solution of turbulent flow heat transfer. Two-phase flow, nucleation, boiling, and condensation heat and mass transfer. Instructor: Bejan. 3 units.

533. Fundamentals of Heat Conduction. Fourier heat conduction. Solution methods including separation of variables, transform calculus, complex variables. Green's function will be introduced to solve transient and steady-state heat conduction problems in rectangular, cylindrical, and spherical coordinates. Microscopic heat conduction mechanisms, thermophysical properties, Boltzmann transport equation. Prerequisite: Mathematics 111 or consent of instructor. Instructor: Bejan. 3 units.

534. Fundamentals of Thermal Radiation. Radiative properties of materials, radiation-materials interaction and radiative energy transfer. Emphasis on fundamental concepts including energy levels and electromagnetic waves as well as analytical methods for calculating radiative properties and radiation transfer in absorbing, emitting, and scattering media. Applications cover laser-material interactions in addition to traditional areas such as combustion and thermal insulation. Prerequisite: Mathematics 353 or consent of instructor. Instructor: Staff. 3 units.

535. Biomedical Microsystems. he objective of the course is to introduce students to the interdisciplinary field of biomedical microsystems with an emphasis on biomedical microelectromechanical systems (bioMEMS) and microtechnologies. Topics include

Scaling laws, Micropatterning of substrates and cells, Microfluidics, Molecular biology on a chip, Cell-based chips for biotechnology, BioMEMS for cell biology, Tissue microengineering, and Microfabricated implants and sensors. Open to graduate students; instructor consent required for undergraduate students to enroll. Instructor: Huang. 3 units.

536. Compressible Fluid Flow. Basic concepts of the flow of gases from the subsonic to the hypersonic regime. One-dimensional wave motion, the acoustic equations, and waves of finite amplitude. Effects of area change, friction, heat transfer, and shock on one-dimensional flow. Moving and oblique shock waves and Prandtl-Meyer expansion. Prerequisite: Mechanical Engineering 336L or equivalent. Instructor: Hotz. 3 units.

537. Mechanics of Viscous Fluids. Equations of motion for a viscous fluid, constitutive equations for momentum and energy transfer obtained from second-law considerations, general properties and exact solutions of the Navier-Stokes and Stokes (creeping-flow) equations, applications to problems of blood flow in large and small vessels. Prerequisite: Mechanical Engineering 336L or equivalent. Instructor: Staff. 3 units.

538. Physicochemical Hydrodynamics. An introduction to the fundamental principles of physicochemical hydrodynamics with an emphasis on the coupling between transport processes and interfacial phenomena. Topics include Brownian motion and molecular diffusion, electrokinetics and electrohydrodynamics, capillary and wetting. Through homework sets and a course project, the students will develop physical intuition and scaling tools to single out the dominant physicochemical process in a complex system. Prerequisite: Mechanical Engineering 336L or consent of instructor. Instructor: Chen. 3 units.

539. Interfacial Transport Phenomena for Energy Technologies. The main topics are transport phenomena taking place on interfaces in renewable/sustainable energy technology. These transport phenomena comprise of charge transport (ions, electrons), heat transfer, and mass transfer (e.g. diffusion), sometimes coupled with chemical reactions (e.g. catalytic, electrochemical, photochemical.). We will study these transport phenomena at interfaces, especially in the micro- and nano-scale and apply this knowledge to energy conversion and storage processes. These interfacial transport phenomena are essential for photovoltaic cells, fuel cells, batteries, solarthermal devices, thermoelectric devices, and many others. Open to graduate students; instructor consent required for undergraduate students to enroll. Recommended prerequisite: Mechanical Engineering 431 or equivalent. Instructor: Hotz. 3 units.

541. Intermediate Dynamics: Dynamics of Very High Dimensional Systems. Dynamics of very high dimensional systems. Linear and nonlinear dynamics of a string as a prototypical example. Equations of motion of a nonlinear beam with tension. Convergence of a modal series. Self-adjoint and non-self-adjoint systems. Orthogonality of modes. Nonlinear normal modes. Derivation of Lagrange's equations from Hamilton's Principle including the effects of constraints. Normal forms of kinetic and potential energy. Component modal analysis. Asymptotic modal analysis. Instructor: Dowell or Hall. 3 units. C-L: Civil and Environmental Engineering 625

542. Modern Control and Dynamic Systems. Dynamic modeling of complex linear and nonlinear physical systems involving the storage and transfer of matter and energy. Unified treatment of active and passive mechanical, electrical, and fluid systems. State-space formulation of physical systems. Time and frequency-domain representation. Controllability and observability concepts. System response using analytical and computational techniques. Lyapunov method for system stability. Modification of system characteristics using feedback control and compensation. Emphasis on application of techniques to physical systems. Instructor: Staff. 3 units.

543. Energy Flow and Wave Propagation in Elastic Solids. 3 units. C-L: see Civil and Environmental Engineering 626

544. Advanced Mechanical Vibrations. Advanced mechanical vibrations are studied primarily with emphasis on application of analytical and computational methods to machine design and vibration control problems. Equations of motion are developed using Lagrange's equations. A single degree-of-freedom system is used to determine free vibration characteristics and response to impulse, harmonic periodic excitations, and random. The study of two and three degree-of-freedom systems includes the determination of the eigenvalues and eigenvectors, and an in-depth study of modal analysis methods. The finite element method is used to conduct basic vibration analysis of systems with a large number of degrees of freedom. The student learns how to balance rotating machines, and how to design suspension systems, isolation systems, vibration sensors, and tuned vibration absorbers. Instructor: Kielb. 3 units.

545. Robot Control and Automation. Review of kinematics and dynamics of robotic devices; mechanical considerations in design of automated systems and processes, hydraulic and pneumatic control of components and circuits; stability analysis of robots involving nonlinearities; robotic sensors and interfacing; flexible manufacturing; man-machine interaction and safety consideration. Prerequisites: Mechanical Engineering 542 or equivalent and consent of instructor. Instructor: Staff. 3 units.

546. Intelligent Systems. An introductory course on learning and intelligent-systems techniques for the modeling and control of dynamical systems. Review of theoretical foundations in dynamical systems, and in static and dynamic optimization. Numerical methods and paradigms that exploit learning and optimization in order to deal with complexity, nonlinearity, and uncertainty. Investigation of theory and algorithms for neural networks, graphical models, and genetic algorithms. Interdisciplinary applications and demonstrations drawn from engineering and computer science, including but not limited to adaptive control, estimation, robot motion and sensor planning. Prerequisites: Mathematics 111 or 216. Consent of instructor required. Instructor: Staff. 3 units.

548. Multivariable Control. 3 units. C-L: see Civil and Environmental Engineering 648

555. Advanced Topics in Mechanical Engineering. Opportunity for study of advanced subjects related to programs within mechanical engineering tailored to fit the requirements of a small group. Approval of director of undergraduate or graduate studies required. Instructor: Staff. Variable credit.

571. Aerodynamics. Fundamentals of aerodynamics applied to wings and bodies in subsonic and supersonic flow. Basic principles of fluid mechanics analytical methods for aerodynamic analysis. Two-and three-dimensional wing theory, slender-body theory, lifting surface methods, vortex and wave drag. Brief introduction to vehicle design, performance and dynamics. Special topics such as unsteady aerodynamics, vortex wake behavior, and propeller and rotor aerodynamics. This course is open only to undergraduate seniors and graduate students. Prerequisites: Mechanical Engineering 336L or equivalent, and Mathematics 353 or equivalent. Instructor: Bliss. 3 units.

572. Engineering Acoustics. Fundamentals of acoustics including sound generation, propagation, reflection, absorption, and scattering. Emphasis on basic principles and analytical methods in the description of wave motion and the characterization of sound fields. Applications including topics from noise control, sound reproduction, architectural acoustics, and aerodynamic noise. Occasional classroom or laboratory demonstration. This course is open only to undergraduate seniors and graduate students. Prerequisites: Mathematics 353 or equivalent or consent of instructor. Instructor: Bliss. 3 units.

581. Introduction to Scientific Computing. Topics include: Discrete representation of floating-point numbers; integration of ODEs and systems of DEs; classification and numeric solution of PDEs; accuracy, consistency, and stability; integration and spectral representation of functions; introduction to finite difference, finite volume, and finite element methods; roots of equations; elements of linear algebra and conjugate gradient methods for sparse linear systems; programming methods; graphical user interfaces; arrays and collections; input-output and serialization; generics and lambda expressions; object oriented programming; 2D and 3D computer graphics; threading and parallelization; unit testing; third party numeric libraries. Open to graduate students; instructor consent required for undergraduate students to enroll. Instructor: Howle. 3 units.

591. Research Independent Study in Mechanical Engineering or Material Science. Research project mentored by an instructor with related interests and expertise. The project is expected to be graduate-level work. Instructor consent required. Instructor: Staff. 3 units.

592. Research Independent Study in Mechanical Engineering or Material Science. Research project mentored by an instructor with related interests and expertise. The project is expected to be graduate-level work. Instructor consent required. Instructor: Staff. 3 units.

593. Research Independent Study in Mechanical Engineering or Material Science. Research project mentored by an instructor with related interests and expertise. The project is expected to be graduate-level work. Instructor consent required. Instructor: Staff. 3 units.

594. Research Independent Study in Mechanical Engineering or Material Science. Research project mentored by an instructor with related interests and expertise. The project is expected to be graduate-level work. Instructor consent required. Instructor: Staff. 3 units.

626. Plates and Shells. 3 units. C-L: see Civil and Environmental Engineering 646

627. Linear System Theory. 3 units. C-L: see Civil and Environmental Engineering 627

631. Intermediate Fluid Mechanics. A survey of the principal concepts and equations of fluid mechanics, fluid statics, surface tension, the Eulerian and Lagrangian description, kinematics, Reynolds transport theorem, the differential and integral equations of motion, constitutive equations for a Newtonian fluid, the Navier-Stokes equations, and boundary conditions on velocity and stress at material interfaces. Instructor: Chen. 3 units.

632. Advanced Fluid Mechanics. Flow of a uniform incompressible viscous fluid. Exact solutions to the Navier-Stokes equation. Similarity methods. Irrotational flow theory and its applications. Elements of boundary layer theory. Prerequisite: Mechanical Engineering 631 or consent of instructor. Instructor: Chen. 3 units.

633. Lubrication. Derivation and application of the basic governing equations for lubrication; the Reynolds equation and energy equation for thin films. Analytical and computational solutions to the governing equations. Analysis and design of hydrostatic and hydrodynamic slider bearings and journal bearings. Introduction to the effects of fluid inertia and compressibility. Dynamic characteristics of a fluid film and effects of bearing design on dynamics of machinery. Prerequisites: Mathematics 353 and Mechanical Engineering 336L. Instructor: Knight. 3 units.

634. Turbulence 1. 3 units. C-L: see Civil and Environmental Engineering 688

639. Computational Fluid Mechanics and Heat Transfer. An exposition of numerical techniques commonly used for the solution of partial differential equations encountered in engineering physics. Finite-difference schemes (which are well-suited for fluid mechanics problems); notions of accuracy, conservation, consistency, stability, and convergence. Recent applications of weighted residuals methods (Galerkin), finite-element methods, and grid generation techniques. Through specific examples, the student is guided to construct and assess the performance of the numerical scheme selected for the particular type of transport equation (parabolic, elliptic, or hyperbolic). Instructor: Howle. 3 units.

643. Adaptive Structures: Dynamics and Control. Integration of structural dynamics, linear systems theory, signal processing, transduction device dynamics, and control theory for modeling and design of adaptive structures. Classical and modern control approaches applied to reverberant plants. Fundamentals of adaptive feedforward control and its integration with feedback control. Presentation of a methodical design approach to adaptive systems and structures with emphasis on the physics of the system. Numerous MATLAB examples provided with course material as well as classroom and laboratory demonstrations. Instructor: Staff. 3 units.

668. Cellular and Biosurface Engineering. A combination of fundamental concepts in materials science, colloids, and interfaces that form a basis for characterizing: the physical properties of biopolymers, microparticles, artificial membranes, biological membranes, and cells; and the interactions of these materials at biofluid interfaces. Definition of the subject as a coherent discipline and application of its fundamental concepts to biology, medicine, and biotechnology. Prerequisite: Mechanical Engineering 208 or consent of instructor. Instructor: Needham. 3 units.

671. Advanced Aerodynamics. Advanced topics in aerodynamics. Conformal transformation techniques. Three-dimensional wing theory, optimal span loading for planar and nonplanar wings. Ground effect and tunnel corrections. Propeller theory. Slender wing theory and slender body theory, transonic and supersonic area rules for minimization of wave drag. Numerical methods in aerodynamics including source panel and vortex lattice methods. Prerequisite: Mechanical Engineering 571. Instructor: Hall. 3 units.

672. Unsteady Aerodynamics. Analytical and numerical methods for computing the unsteady aerodynamic behavior of airfoils and wings. Small disturbance approximation to the full potential equation. Unsteady vortex dynamics. Kelvin impulse and apparent

mass concepts applied to unsteady flows. Two-dimensional unsteady thin airfoil theory. Time domain and frequency domain analyses of unsteady flows. Three-dimensional unsteady wing theory. Introduction to unsteady aerodynamic behavior of turbomachinery. Prerequisite: Mechanical Engineering 571. Instructor: Hall. 3 units.

674. Fundamentals of Shock Wave Lithotripsy. This course will cover fundamental physics and engineering topics in shock wave lithotripsy (SWL), a non-invasive medical treatment of kidney and upper urinary track stone disease. A historical review of the development of SWL will be provided. Shock wave generation, focusing, coupling, and propagation in biological tissues will be discussed, as well as state-of-the-art measurement techniques for characterization of lithotripter field and shock wave-stone-tissue interaction. Methodology and technologies to enhance therapeutic gain while reducing collateral tissue injury will be discussed, with laboratory projects to develop the basic concepts and essential skills for independent research. Prerequisite: Mechanical Engineering 336L, Mechanical Engineering 572, or BME 542. Instructor: Zhong. 3 units.

676. Advanced Acoustics. Analysis methods in acoustics including wave generation, propagation, reflection, absorption, and scattering; sound propagation in a porous material; coupled structure acoustic systems; acoustic singularities: monopoles, dipoles, quadrupoles; radiation from flat surfaces; classical radiation and scattering solutions for cylinders and spheres; Green's functions, Radiation conditions, Modal analysis; sound fields in rooms and enclosures: energy methods; dissipation in fluid media; introduction to nonlinear effects. This course is open only to graduate students with some prior background in acoustics and applied mathematics. Prerequisites: Mechanical Engineering 572 or equivalent. Instructor: Bliss. 3 units.

701. Capillarity & Wetting. Opportunity for study of advanced subjects related to programs within mechanical engineering tailored to fit the requirements of a small group. Approval of director of undergraduate or graduate studies required. Instructor: Chua. 3 units.

702. Constructal Thermal Design. Elements of thermal design, thermodynamic optimization. The constructal law projects. The generation and pursuit of flow configurations that perform better. Instructor: Bejan. 3 units.

711. Nanotechnology Materials Lab. This course provides an introduction to advanced methods for the characterization and fabrication of materials, nanostructures, and devices. Cleanroom methods to be covered include lithography, evaporation, and etching. Characterization methods include electron microscopy, atomic force microscopy, X-ray photoelectron spectroscopy, and optical spectroscopy. Students will receive an overview of the techniques in the Shared Materials Instrumentation Facility through lectures and demonstrations. In the lab section, each student will engage in a project that focuses on those capabilities that are needed for their research, and will receive training and certification on that equipment. 3 units. C-L: Electrical and Computer Engineering 721

717S. Biological Engineering Seminar Series (CBIMMS and CBTE). 1 unit. C-L: see Biomedical Engineering 711S

718S. Biological Engineering Seminar Series (CBIMMS and CBTE). 1 unit. C-L: see Biomedical Engineering 712S

738. Mechanics of Viscous Fluids. Instructor: Staff. 3 units.

741. Nonlinear Control Systems. Analytical, computational, and graphical techniques for solution of nonlinear systems; Krylov and Bogoliubov asymptotic method; describing function techniques for analysis and design; Liapounov functions and Lure's methods for stability analysis; Aizerman and Kalman conjectures; Popov, circle, and other frequency-domain stability criteria for analysis and synthesis. Prerequisite: Mechanical Engineering 542 or consent of instructor. Instructor: Staff. 3 units.

742. Nonlinear Mechanical Vibration. A comprehensive treatment of the role of nonlinearities in engineering dynamics and vibration. Analytical, numerical, and experimental techniques are developed within a geometrical framework. Prerequisite: Mechanical Engineering 541 or 544 or equivalent. Instructor: Virgin. 3 units.

758S. Curricular Practical Training. Curricular Practical Training. Student gains practical Mechanical Engineering and Materials Science experience by taking a job in industry and writing a report about this experience. Course requires prior consent from the student's advisor and from the Director of Graduate Studies and may be repeated with consent of the advisor and the Director of Graduate Studies. Instructor: Staff. Variable credit.

759. Special Readings in Mechanical Engineering. Individual readings in advanced study and research areas of mechanical engineering. Approval of director of graduate studies required. 1 to 3 units. Instructor: Staff. Variable credit.

775. Aeroelasticity. A study of the statics and dynamics of fluid/structural interaction. Topics covered include static aeroelasticity (divergence, control surface reversal), dynamic aeroelasticity (flutter, gust response), unsteady aerodynamics (subsonic, supersonic, and transonic flow), and a review of the recent literature including nonlinear effects such as chaotic oscillations. Prerequisite: Mathematics 230 and consent of instructor. Instructor: Dowell. 3 units.

789. Internship in Mechanical Engineering. Student gains practical mechanical engineering experience by taking a job in industry, and writing a report about this experience. Requires prior consent from the student's advisor and from the director of graduate studies. May be replaced with consent of the advisor and the director of graduate studies. Credit/no credit grading only. Instructor: Staff. Variable credit.

English

Professor Mitchell, *Chair*; Associate Professor Sussman, *Director of Graduate Studies*; Professors Aers, Armstrong, Beckwith, Ferraro, Khanna, Mackey, Mitchell, Moi, Pfau, Strandberg, Tennenhouse, Torgovnick, and Wald; Associate Professors Baran, Jaji, Psomiades, Stan, Sussman, and Vadde; Assistant Professors Black, D'Alessandro, McInnis, and Werlin; Professor of the Practice Donahue

A PhD is available in this department.

The department only admits students seeking a PhD (though see below on JD/MA). In addition to the dissertation, the PhD in English requires completion of a minimum of eleven courses, a reading proficiency in at least one foreign language (the specific language to be determined by the student's major areas of academic concentration), and a preliminary examination of three subfields (one major,

two minor) that consists of both a written and oral part by the end of the third year of study. Within six months of the preliminary exam, a dissertation chapter meeting is required with the thesis committee. A JD/MA degree is offered by the department in cooperation with the Duke Law School. JD/MA students must apply for admission to the Duke Law School, and must combine relevant coursework in English with full-time work toward a law degree.

Particular faculty interests currently cutting across the chronological and geographical categorizations of literature include the cultural work of memory; orientalism; mourning, history and reconciliation; literatures and discourses of the Atlantic; diasporic literatures; religion; sound studies; and science and technology. Students are encouraged to read broadly in English and American literatures (including four-nations British literature, English and America in the Black Atlantic, the Irish Atlantic and other Atlanticist literatures, Anglo-diasporic literatures, and postcolonial literatures). They are also encouraged to interrogate the constitution and writing of literary and cultural history, and to develop the specific range of linguistic, philosophical, and historical skills relevant to their chosen field and their chosen intervention therein.

For additional information, visit https://english.duke.edu/graduate.

Courses in English (ENGLISH)

505. Introduction to Old English. An introduction to the language of the Anglo-Saxon period (700-1100), with readings in representative prose and poetry. Not open to students who have taken 113A or the equivalent. Satisfies the Area I requirement for English majors. Instructor: Staff. 3 units. C-L: Medieval and Renaissance Studies 605

520S. Writing Poetry: Formal and Dramatic Approaches. A workshop comparing meter, stanza, and rhyme with free verse, to illuminate the freedom and form of all poetry. Narrative and conceptual content considered within the poem's emotive, musical dynamic. Group discussion of technique, personal aesthetic and creative process; revisions of poems. Instructor: Staff. 3 units.

522S. Narrative Writing. The writing of short stories, memoirs, tales, and other narrations. Readings from ancient and modern narrative. Close discussion of frequent submissions by class members. Instructor: Staff. 3 units.

530S. Special Topics in Middle English Literature: 1100 to 1500. Selected topics. Satisfies Area I requirement for English majors. Instructor: Staff. 3 units. C-L: Medieval and Renaissance Studies 690S-1

532S. Chaucer and His Contexts. The first two-thirds of his career, especially Troilus and Criseyde. Satisfies the Area I requirement for English majors. Instructor: Staff. 3 units. C-L: Medieval and Renaissance Studies 625S

536S. Shakespeare: Special Topics. Satisfies the Area I requirement for English majors. Instructor: Staff. 3 units. C-L: Medieval and Renaissance Studies 630S

537S. Shakespeare & Co.: English Renaissance Drama. Interrogates drama of Marlowe, Shakespeare, Jonson, and Middleton, and other playwrights from only the second time in world history when the genre conducts a culture's dominant intellectual currents. Umbrella questions: ethnicity, proto-feminism, sexual orientation, secularism, aesthetic-commercial rivalry, mercuriality, Shakespearean exceptionalism. In addition to edited play-texts we will also use major new electronic resources. Grade based equally on class discussion and a twenty-page essay. Instructor: Porter. Variable credit. C-L: Medieval and Renaissance Studies 637S

538S. Special Topics in Renaissance Prose and Poetry: 1500 to 1660. Selected topics. Satisfies the Area I requirement for English majors. Instructor: Staff. 3 units. C-L: Medieval and Renaissance Studies 632S

539S. Special Topics in Seventeenth-Century Literature. Topics vary by semester. Satisfies the Area I requirement for English majors. Instructor: Staff. 3 units.

540. Special Topics in Restoration and Eighteenth-Century Literature. Satisfies the Area II requirement for English majors. Instructor: Staff. 3 units.

540S. Special Topics in Restoration and Eighteenth-Century Literature (DS3). Seminar version of English 540. Instructor: Staff. 3 units.

545S. Romantic Literature: 1790 to 1830. Selected topics. Satisfies the Area II requirement for English majors. Instructor: Staff. 3 units.

546. Special Topics in Victorian Literature. Selected topics. Satisfies the Area II requirement for English majors. Instructor: Staff. 3 units.

546S. Special Topics in Victorian Literature. Satisfies the Area II requirement for English majors. Instructor: Staff. 3 units.

550S. British Literature since 1900. Selected topics. Satisfies the Area III requirement for English majors. Instructor: Staff. 3 units.

560. American Literature to 1820 (Selected Topics). Selected Topics. Satisfies the Area II requirement for English majors. Instructor: Staff. 3 units.

580S. Music in Literature and Philosophy. 3 units. C-L: see German 580S; also C-L: International Comparative Studies 527S

581S. Mimesis in Theory, Embodied Practice, and Literary Arts. 3 units. C-L: see French 507S; also C-L: Art History 509S, Literature 507S

582S. Wittgensteinian Perspectives on Literary Theory. 3 units. C-L: see Literature 681S; also C-L: Philosophy 681S

583. Theater in London: Text. 3 units. C-L: see Theater Studies 520A

584. Theater in London: Performance. 3 units. C-L: see Theater Studies 540A

590-1. Special Topics I. Subjects, areas or themes that cut across historical eras, several national literatures, or genres, medieval to early modern periods. Satisfies the Area I requirement for English majors. Instructor: Staff. 3 units.

590-2. Special Topics II. Subjects, areas or themes that cut across historical eras, several national literatures, or genres, eighteenth

and nineteenth centuries. Satisfies Area II requirement for English majors. Instructor: Staff. 3 units.

590-3. Special Topics III. Subjects, areas or themes that cut across historical eras, several national literatures, or genres,1860-Present. Satisfies Area III requirement for English majors. Instructor: Staff. 3 units.

590-4. Special Topics in Criticism. Satisfies the Criticism, Methodology, Theory (CTM) requirement for English majors. Instructor: Staff. 3 units.

590-5. Selected Topics in Feminist Studies. Selected Topics in Feminist Studies. Satisfies English Area or Criticism and Methodology requirements for the English major as determined by Director of Undergraduate Studies. Instructor: Staff. 3 units.

590S-1. Special Topics Seminar I. Subjects, areas or themes that cut across historical eras, several national literatures, or genres, medieval and early modern period. Satisfies Area I requirement for English majors. Instructor: Staff. 3 units.

590S-2. Special Topics Seminar II. Subjects, areas or themes that cut across historical eras, several national literatures, or genres. Satisfies Area II requirement for English majors. Topics course. Instructor: Staff. 3 units.

590S-3. Special Topics Seminar III. Subjects, areas or themes that cut across historical eras, several national literatures, or genres, 1860 to the present. Satisfies the Area III requirement for English majors. Instructor: Staff. 3 units.

590S-4. Special Topics Seminar in Criticism, Theory, or Methodology. Seminar Version of 288. Satisfies the Criticism, Theory, or Methodology (CTM) for English majors. Instructor: Staff. 3 units.

591. Special Readings - Independent Study. Independent study. Department consent required. Instructor: Staff. 3 units.

620S. Film-philosophers/Film-makers. 3 units. C-L: see Literature 620S; also C-L: Visual and Media Studies 622S, Theater Studies 620S, Documentary Studies 620S

691S. Black Sonic Culture—Analog to Digital. 3 units. C-L: see African & African American Studies 622S; also C-L: Literature 691S, Music 691S

02-G-B

710S. Saying and the Unsayable: Introduction to Lyric/Literary Theory. 3 units. C-L: see Romance Studies 710S; also C-L: Literature 710S, Religion 762S

730. Studies in Old English Literature. Intensive study of major Old English texts. Instructor: Aers or Beckwith. 3 units.

735. The History of Hip-Hop. 3 units. C-L: see African & African American Studies 735; also C-L: Music 735, Visual and Media Studies 735

740. Studies in Middle English Literature. Instructor: Aers or Beckwith. 3 units.

742. Studies in Chaucer. Instructor: Aers or Beckwith. 3 units.

750. Studies in Renaissance Literature. Instructor: Aers, Beckwith, Porter, Tennenhouse, or Werlin. 3 units.

752. Studies in Shakespeare. Instructor: Beckwith, Porter, Tennenhouse, or Werlin. 3 units.

754. Studies in Milton. Instructor: Aers or Werlin. 3 units.

760. Studies in Augustanism. Instructor: Staff. 3 units.

762. Studies in a Major Augustan Author. Instructor: Staff. 3 units.

767. How Blackness Thinks. 3 units. C-L: see Religion 767; also C-L: African & African American Studies 767, Christian Theology 774

770. Studies in Romanticism. Instructor: Mitchell or Pfau. 3 units.

780. Studies in Victorianism. Instructor: Armstrong or Psomiades. 3 units.

782. Studies in a Major Nineteenth-Century British Author. Instructor: Armstrong, Mitchell, Pfau, or Psomiades. 3 units.

810S. Early Modernism 1870-1914. Challenges involved in considering 1870-1914 a literary period. Historicizing the concepts of idealism, realism and modernism, whit special attention to the relationship between literature and painting. British literature in a comparative, European frame. Authors studied will vary from year to year, and may include Eliot, Ibsen, Wilde, Strindberg, Shaw, Hardy, Loti, Gide, Zola, Fontane, Rilke, Forster, Colette, Alain-Fournier, Proust, Woolf. Instructor: Moi, Moses, or Stan. 3 units. C-L: Literature 740S

820. Studies in Modern British Literature. Instructor: Moses, Stan, Torgovnick, or Vadde. 3 units.

822S. Writing is Thinking. This course aims to teach graduate students at any level, from first-year students to dissertation writers, how to write well and with enjoyment, and how to make writing a part of their daily life as creative intellectuals. We will cover questions of style, voice, and audience, and learn to read academic prose as writers. We will also focus on how to move from note-taking to writing, and develop an understanding of different academic genres. The course will be writing intensive. Consent of instructor is required. Instructor: Moi. 3 units. C-L: Literature 822S

825S. Outside the Nation State: The Global Novel. This course examines the recent emergence of novels in various parts of the globe that address a readership beyond their respective nations or regions of origins, sometimes even beyond the novelist's national language. To do so, we shall pursue a comparative investigation of the formal innovations allowing these works of fiction to move "outside" or "beyond" the modern nation states whose formation coincided with their own. We will bring such traditional theorists as Georg Lukàcs and Benedict Anderson to the task of asking how novels by Coetzee, Bolaño, Pamuk, Saviano, Whitehead and others attempt to produce alternative imagined communities. Consent of instructor is required. Instructor: Armstrong. 4 units. C-L: Romance Studies 825S

826S. Contemporary Genre Fiction: The Global Novel. 3 units. C-L: see Romance Studies 826S; also C-L: Literature 826S

827S. The Global Novel: Post, What?. 3 units. C-L: see Literature 827S; also C-L: Romance Studies 827S

830. Studies in American Literature before 1915. Instructor: Jaji or Wald. 3 units.

832. Studies in a Major American Author before 1915. Instructor: Jaji. 3 units.

838. Studies in Modern American Literature. Instructor: Ferraro, Jaji, Mackey, Moses, or Wald. 3 units.

840. Studies in a Modern Author (British or American). Instructor: Staff. 3 units.

850. Studies in Literary Criticism. Instructor: Graduate faculty. 3 units.

860S. Deleuze: Cinema and Philosophy. 3 units. C-L: see Literature 850S; also C-L: Visual and Media Studies 850S, Romance Studies 850S, Visual Arts 850S, Computational Media, Arts & Cultures 85, Documentary Studies 850S

890. Special Topics. Topics vary by semester. Department consent required. Instructor: Staff. 3 units.

890S. Special Topics Seminar. Instructor: Staff. 3 units.

890T. Tutorial in Special Topics. Tutorials by a faculty member for two or more students having a regular study session with a professor. Consent of instructor and Director of Graduate Studies required. Instructor: Staff. 3 units.

891. Special Readings. Special Readings. Variable credit.

900. African American Religion Through the Literary Imagination. 3 units. C-L: see Religion 900; also C-L: African & African American Studies 900

996. Practicum in Teaching College English. Provides graduates students in the English department with pedagogical training in the teaching of college-level composition and English department courses. Open only to English department graduate students in years 4 and above. Department consent required. Instructor: Staff. 3 units.

Environmental Policy, University Program in

Professor Steelman, *Dean of the Nicholas School of the Environment*; Professor Kelley, *Dean of the Sanford School of Public Policy*; Associate Professor Mullin, *Director of Graduate Studies*; Professors Kramer, Pattanayak, Pfaff, Pizer, Smith, Timmins, Vincent, Wiener, and Weinthal; Associate Professors Bennear, Bermeo, Conrad, Jeuland, Mullin, and Patino-Echeverri; Assistant Professor Sexton; Professors Emeriti Healy and McKean; Assistant Professor of the Practice Albright; Research Professor Murray

A PhD is available in this program.

The University Program in Environmental Policy is jointly administered by the Nicholas School of the Environment and the Sanford School of Public Policy. It is a multidisciplinary, research-focused five-year doctoral degree, intended to prepare candidates for positions in applied academic departments and professional schools, domestic and international public agencies and environmental organizations, research institutes, and policy consulting firms. Although the program is multidisciplinary, it is designed to ensure that students have strength in a particular social science discipline. Students designate their concentration when applying and currently may select either environmental economics or environmental political science. Coursework is offered through the Nicholas School, the Sanford School, the Department of Economics, and the Department of Political Science.

More information can be found at https://nicholas.duke.edu/academics/doctoral-programs/university-program-environmental-policy-upep.

Environmental Sciences

Professor Steelman, *Dean of the Nicholas School of the Environment*; Associate Professor Wernegreen, *Director of Graduate Studies*; Professors Albertson, Christensen, Clark, Di Giulio, Doyle, Gelfand, Hinton, Kasibhatla, Katul, Kramer, Mullin, Newell, Oren, Pimm, Porporato, Reynolds, Richardson, Richter, Salzmann, Smith, Urban, Vincent, Wiener, Wolpert, and Zhang; Associate Professors Bennear, Bernhardt, Ferguson, Meyer, Murray, Pattanayak, Pfaff, Poulsen, Stapleton, Timmons, Weinthal, Wernegreen, and Wright; Assistant Professors Heffeman, Pan, and Patino-Echeverri; Professors Emeriti Healy, Reckhow, and Terborgh; Professors of the Practice Clark, Gallagher, Maguire, and Von Windheim; Assistant Professors of the Practice Albright, Reid, Shapiro, and Swenson; Research Professor Murray; Associate Research Professor Qian; Assistant Research Professors Hoffman and Palmroth; Adjunct Professor Miranda; Adjunct Assistant Professor Way

A PhD is available in this program through The Graduate School.

Major and minor work for the environment graduate program is offered through the environmental sciences division of the Nicholas School of the Environment. The research emphasis of the environmental sciences and policy division is in the areas of ecosystem science and management, environmental chemistry and toxicology, aquatic and atmospheric sciences, and environmental social sciences.

College graduates who have a bachelor's degree in one of the natural or social sciences, forestry, engineering, business, or environmental science will be considered for admission to a degree program. Students will be restricted to the particular fields of specialization for which they are qualified academically. The Graduate School programs usually concentrate on some area of natural resource and environmental science/ecology, systems science, or economics/policy, while study in resource and environmental management is more commonly followed in one of the professional master's degree programs of the Nicholas School of the Environment. For more complete program descriptions and information on professional training in forestry or environmental studies, the Bulletin of Duke University: Nicholas School of the Environment should be consulted.

Nicholas School of the Environment faculty normally accept to the academic degree program only those students who wish to pursue a PhD. Applicants are strongly encouraged to contact the individual faculty member under whose supervision they are interested

in pursuing graduate study. Information about each faculty member's area of research interest can be found in the Nicholas School of the Environment bulletin and on the school's website at https://nicholas.duke.edu/. The degree is available for students enrolled in the joint law program, and the MS degree may be awarded as part of the doctoral program. Students generally are not admitted to the and MS tracks as stand alone programs in the Nicholas School with the exception of the Division of Earth and Ocean Sciences, which accepts students to a MS track. (See "Earth and Ocean Sciences" on page 132 for additional information.)

Courses in Environment (ENVIRON)

501. Environmental Toxicology. An introduction to the field of environmental toxicology. Study of environmental contaminants from a broad perspective encompassing biochemical, ecological, and toxicological principles and methodologies. Discussion of sources, environmental transport and transformation phenomena, accumulation in biota and ecosystems. Impacts at various levels of organization, particularly biochemical and physiological effects. Prerequisites: organic chemistry and an upper-level biology course, or consent of instructor. Instructor: Di Giulio/Meyer. 3 units.

501A. Environmental Toxicology. An introduction to the field of environmental toxicology. Study of environmental contaminants from a broad perspective encompassing biochemical, ecological, and toxicological principles and methodologies. Discussion of sources, environmental transport and transformation phenomena, accumulation in biota and ecosystems. Impacts at various levels of organization, particularly biochemical and physiological effects. Taught in Beaufort at Duke Marine Lab. Prerequisite: organic chemistry and an upper-level biology course, or consent of instructor. Instructor: Meyer, Di Giulio. 3 units.

501D. Environmental Toxicology. An introduction to the field of environmental toxicology. Study of environmental contaminants from a broad perspective encompassing biochemical, ecological, and toxicological principles and methodologies. Discussion of sources, environmental transport and transformation phenomena, accumulation in biota and ecosystems. Impacts at various levels of organization, particularly biochemical and physiological effects. Prerequisites: organic chemistry and an upper-level biology course, or consent of instructor. Instructor: Di Giulio/Meyer. 3 units.

503. Forest Ecosystems. Emphasis on the processes by which forests circulate, transform, and accumulate energy and materials through interactions of biologic organisms and the forest environment. Ecosystem productivity and cycling of carbon, water, and nutrients provide the basis for lecture and laboratory. Instructor: Oren. 3 units.

504A. Marine Protected Area Monitoring and Management. An interdisciplinary course that addresses concepts, issues, and approaches relevant to marine protected areas (MPAs) and their impacts on marine ecosystems and coastal people. Course will address key topics on MPA design, implementation, management, monitoring, and evaluation. Attention will be given to sensitive marine ecosystems (e.g. coral reefs) and resource-dependent fishing and tourism communities. Using real world case studies, students will apply introduced concepts and quantitative approaches to questions on MPA monitoring and evaluating their impacts. Students will engage with the course material primarily through group discussions, problem sets, and lectures. Taught in Beaufort at Duke Marine Lab. Instructor: Gill. 3 units.

505. Functional Ecology of Plants. This course is designed for graduate and undergraduate students with interest in plant functional ecology. We explore how (woody) plants function and respond to changing climate. We focus on plant functional traits (e.g., leaf properties, wood density, maximum height) and the main tradeoffs controlling plant form and function in various environments. Instructor: Palmroth, Domec. 3 units. C-L: Biology 505

505D. Functional Ecology of Plants. This course is designed for graduate and undergraduate students with interest in plant functional ecology. We explore how (woody) plants function and respond to changing climate. We focus on plant functional traits (e.g., leaf properties, wood density, maximum height) and the main tradeoffs controlling plant form and function in various environments. Instructor: Palmroth, Domec. 3 units. C-L: Biology 505D

507DS. The Amazon: Evolution of Its Climate, Landscape, Ecology, and Human Civilizations. 3 units. C-L: see Earth and Ocean Sciences 507DS

507S. The Amazon: Evolution of Its Climate, Landscape, Ecology, and Human Civilizations. 3 units. C-L: see Earth and Ocean Sciences 507S

510K. Environmental Change and Evolution of Ecosystems. The processes that control ecosystem production, the carbon cycle, and delivery of ecosystem services as well as the resilience of ecosystems exposed to environmental stress have been molded by millions of years of evolution under Global Change. Our developing understanding of earth system processes and current Global Change depends strongly on looking to the past and considering evolution of the climate system, plant and ecosystem processes, biological feedbacks, soils development, and all of these with respect to ecosystem (biosphere) carbon, water, and nutrient cycles. Taught at Duke Kunshan University. Instructor: Tenhunen. 3 units.

511K. China and US Comparative Environmental Law and Governance. This course will study China's environmental challenges and governance and compare them with those in the US. We will consider how environmental law may shape business, government, and culture, and the ways in which China and the US may learn from one another. Taught at Duke Kunshan University. Instructor: Guttman. 3 units.

512A. Deep-Sea Science and Environmental Management. Explores ecosystems in the deep sea, including fundamental aspects of geology, chemistry, and biodiversity; behavioral, physiological, and biochemical adaptations of organisms (primarily invertebrate, but may include microbial and vertebrate components) to deep-sea benthic and bentho-pelagic environments will be introduced. Students will gain an understanding of the ecosystem services of the deep sea; issues in deep-sea environmental management arising from exploitation of deep-sea resources will be discussed. Taught in Beaufort at Duke Marine Lab. Instructor: Van Dover. 3 units.

513. Groundwater and the Environment. 3 units. C-L: see Earth and Ocean Sciences 513

517. Tropical Ecology. Ecosystem, community, and population ecology of tropical plants and animals with application to conservation and sustainable development. Prerequisite: a course in general ecology. Instructor: Poulsen. 3 units. C-L: Biology 561

517D. Tropical Ecology. Ecosystem, community, and population ecology of tropical plants and animals with application to conservation and sustainable development. Prerequisite: a course in general ecology. Instructor: Poulsen. 3 units. C-L: Biology 561D

520. Resource & Environmental Economics I. Part 1 of a survey course in environmental and natural resource economics. Part 1 focuses on basic theory and methods of economic analysis of environmental problems including benefit-cost analysis, non-market valuation, and instrument choice. Prerequisite: Introductory course in microeconomics and one semester of calculus. Instructor: Bennear or Smith. 1.5 units. C-L: Economics 530, Public Policy 576, Energy 520

520D. Resource & Environmental Economics I. Part 1 of a survey course in environmental and natural resource economics. Part 1 focuses on basic theory and methods of economic analysis of environmental problems including benefit-cost analysis, non-market valuation, and instrument choice. Prerequisite: Introductory course in microeconomics and one semester of calculus. Instructor consent required. Instructor: Bennear or Smith. 1.5 units. C-L: Economics 530D, Public Policy 575D, Energy 520D

520L. Resource and Environmental Economics. The application of economic concepts to private- and public-sector decision making concerning natural and environmental resources. Intertemporal resource allocation, benefit-cost analysis, valuation of environmental goods and policy concepts. Prerequisite: introductory course in microeconomics. Instructor: Bennear or Smith. 3 units. C-L: Economics 530L, Public Policy 575L

521. Resource & Environmental Economics II. Part 2 of a survey course in environmental and natural resource economics. Part 2 focuses on basic theory and methods of economic analysis of natural resource problems including extraction of non-renewable resources over time, fisheries economics and forest economics. Prerequisite: Environment 520. Instructor: Bennear, Smith, or Vincent. Variable credit. C-L: Economics 531, Public Policy 584

521D. Resource & Environmental Economics II. Part 2 of a survey course in environmental and natural resource economics. Part 2 focuses on basic theory and methods of economic analysis of natural resource problems including extraction of non-renewable resources over time, fisheries economics and forest economics. Prerequisite: Environment 520. Instructor: Bennear, Smith, or Vincent. Variable credit. C-L: Economics 531D, Public Policy 584D

524. Water Quality Health. 3 units. C-L: see Earth and Ocean Sciences 524; also C-L: Global Health 534, Energy 524

528SA. Community-Based Marine Conservation in the Gulf of California. Experiential education course on community-based conservation. Students learn first-hand about the challenges (accomplishments, failures, and promises) involved in its design and practice in developing countries of high biological diversity. Learn about the unique natural and political history, and social characteristics of the places where conservation takes place. Students link local context to broader perspectives through key readings and class discussions. Taught in Beaufort at Duke Marine Lab. Travel to biodiversity hotspots in the Gulf of California required. Consent of instructor required. Instructor: Basurto. 3 units.

530. Remote Sensing in Coastal Environments. 3 units. C-L: see Earth and Ocean Sciences 530; also C-L: Civil and Environmental Engineering 574

531L. Economic Valuation of the Environment. Quantitative course with focus on economic valuation of changes in environmental quality. Covers theoretical foundations of major nonmarket valuation methods and, through a series of problem sets, provides opportunities to develop skills applying those methods. Also covers a range of regression methods commonly employed in valuation studies. Prerequisite: Environment 520 or equivalent and Environment 710 or equivalent. Instructor: Vincent. 3 units.

532. Evaluation of Public Expenditures. 3 units. C-L: see Public Policy 596; also C-L: Economics 521

532D. Evaluation of Public Expenditures. 3 units. C-L: see Public Policy 596D; also C-L: Economics 521D

533A. Marine Fisheries Policy. Principles, structure, and process of public policy-making for marine fisheries. Topics include local, regional, national, and international approaches to the management of marine fisheries. A social systems approach is used to analyze the biological, ecological, social, and economic aspects of the policy and management process. Taught in Beaufort at Duke Marine Lab. Instructor: Staff. 3 units.

535. Air Quality Management. Types, sources, effects of air pollutants. Regulatory framework emphasizing the Clean Air Act Amendments of 1990 and federal, state, local agency implementation. Application of risk assessment, technology, market incentives to air management. Scientific, policy aspects of acid deposition, global climate change, indoor air, mobile sources control. Dispersion modeling, exposure assessment. Instructor: Vandenberg, Zhang. 3 units.

536S. Food, Agriculture and the Environment: Law and Policy. This class examines agriculture and food production through some of the laws and policies that promote environmental protection and consumer welfare. Agriculture is the largest single land use in the U.S., occupying approximately 50% of the land mass. The industrial-agricultural model that has come to dominate food production has brought about env degradation in many communities. In many areas of the country, including NC, local food markets represent one of the most exciting opportunities for env stewardship, econ growth, and community building. However, these opportunities will not be realized without attention to the legal and policy structures that confront sustainable food production. Instructor: Nowlin. 2 units.

537. Environmental Health and Epidemiology. Introduction to environmental effects on human health, as well as ecological health. Focus on chronic effects of exposure to pollution on key health endpoints including cancer, neurological health, reproduction and development, cardiovascular and pulmonary health, the interaction between anthropogenic environmental changes and infectious diseases, and the relationship between human health and ecosystem health. Includes lectures from a variety of experts in this field from throughout the Triangle region. Course is designed to facilitate maximum student participation through discussion. For graduate and advanced undergraduate students. Instructor: Di Giulio. 3 units.

538. Global Environmental Health: Economics and Policy. 3 units. C-L: see Public Policy 582; also C-L: Global Health 538

539. Human Health and Ecological Risk Assessment. Topics central to both health and ecological risk assessment are explored. Basic concepts of hazard identification, dose-response relationships, exposure assessment, and risk characterization

and communication are discussed in the context of both human health and environmental assessment. The basis and rationale for using specific, as well as extrapolated, scientific information and expert judgment, and the strengths and weaknesses of alternative approaches, are evaluated. Applications emphasizing real cases are used to illustrate the interdisciplinary process and products of risk assessment, as well as the regulatory use of the information. Group projects emphasized. Instructors: Mihaich/McMasters. 3 units.

540. Chemical Fate of Organic Compounds. Equilibrium, kinetic, and analytical approaches applied to quantitative description of processes affecting the distribution and fate of anthropogenic and natural organic compounds in surface and ground waters, including chemical transfers between air, water, soils/sediments, and biota; and thermochemical and photochemical transformations. The relationships between organic compound structure and environmental behavior will be emphasized. Sampling, detection, identification, and quantification of organic compounds in the environment. Prerequisite: university-level general chemistry and organic chemistry within last four years. Instructor: Stapleton. 3 units. C-L: Civil and Environmental Engineering 563

540D. Chemical Fate of Organic Compounds. Equilibrium, kinetic, and analytical approaches applied to quantitative description of processes affecting the distribution and fate of anthropogenic and natural organic compounds in surface and ground waters, including chemical transfers between air, water, soils/sediments, and biota; and thermochemical and photochemical transformations. The relationships between organic compound structure and environmental behavior will be emphasized. Sampling, detection, identification, and quantification of organic compounds in the environment. Prerequisite: university-level general chemistry and organic chemistry within last four years. Instructor: Stapleton. 3 units. C-L: Civil and Environmental Engineering 563D

542L. Environmental Aquatic Chemistry. 3 units. C-L: see Civil and Environmental Engineering 561L

543S. Water Cooperation and Conflict. 3 units. C-L: see Public Policy 580S; also C-L: Global Health 533S, International Comparative Studies 580S

544S. Collective Action, Property Rights, and the Environment. 3 units. C-L: see Political Science 549S

548. Solid Waste Engineering. 3 units. C-L: see Civil and Environmental Engineering 672

549. California Water Crises: A Case Study Approach. Reviews history of California's water dependent economy, leading to a capture, storage system with conveyances extending thousands of miles to deliver water for agriculture, industry and homes. Examines recent political change coupled with chronic issues of a water-rich north, an expanding urban population and a water-poor but politically strong south. Emphasis includes climate change, seismic vulnerability, redirection of river flows, and large scale water reuse. Course will cover specific water crises in other states and nations, providing in depth coverage of aspects of the international crisis in quantity and quality of freshwater. Instructor: Hinton. 3 units.

550. Land Use Principles and Policy. The purpose of the course is to improve your understanding of how land is used, the key factors shaping those uses, the environmental, social and cultural impacts of different land uses, and how land use could be more sustainable. The course covers a wide range of land use issues and topics, from agriculture and forestry to zoning, property rights and natural disasters. Students will examine historical uses, current trends, and likely future uses of land. The main focus of the course will be on land use principles and practices in the United States, but we will also explore examples from other parts of the world. Instructor: Salvesen. 3 units. C-L: Public Policy 578

550D. Land Use Principles and Policy. The purpose of the course is to improve your understanding of how land is used, the key factors shaping those uses, the environmental, social and cultural impacts of different land uses, and how land use could be more sustainable. The course covers a wide range of land use issues and topics, from agriculture and forestry to zoning, property rights and natural disasters. Students will examine historical uses, current trends, and likely future uses of land. The main focus of the course will be on land use principles and practices in the United States, but we will also explore examples from other parts of the world. Instructor: Salvesen. 3 units. C-L: Public Policy 578D

551DA. International Conservation and Development. Interrelated issues of conservation and development. Topics include the evolution of the two concepts and of theories regarding the relationship between them, the role of science, values, ethics, politics and other issues in informing beliefs about them, and strategies for resolving conflicts between them. While attention will be given to all scales of interaction (i.e. local, regional, national, international), the focus will be on international issues and the `north-south' dimensions of the conservation and development dilemma. Examples from marine and coastal environments will be highlighted. Consent of instructor required. Taught in Beaufort at Duke Marine Lab. Instructor: Campbell. 3 units.

552. Climate and Society. 3 units. C-L: see Earth and Ocean Sciences 550

552D. Climate and Society. 3 units. C-L: see Earth and Ocean Sciences 550D

556. Environmental Conflict Resolution. Practical techniques and scholarly underpinnings of environmental conflict resolution, including interest-based negotiation, mediation, public disputes, science-intensive disputes, and negotiation analysis. In-class time will be spent conducting negotiation role plays of increasing complexity and then debriefing them. Outside of class, students will prepare for the role plays and read background material to aid in debriefing. Instructor: Addor. 3 units.

557. Social Science Surveys for Environmental Management. Social science research methods for collecting data for environmental management and policy analysis. Sampling, survey design, focus groups, pretesting, survey implementation, coding, and data analysis. Team projects emphasize development and practice of survey skills. Prerequisite: introductory applied statistics or equivalent. Instructor: Kramer. 3 units.

557D. Social Science Surveys for Environmental Management. Social science research methods for collecting data for environmental management and policy analysis. Sampling, survey design, focus groups, pretesting, survey implementation, coding, and data analysis. Team projects emphasize development and practice of survey skills. Prerequisite: introductory applied statistics or equivalent. Instructor: Kramer. 3 units.

558L. Remote Sensing for Environmental Analysis. Environmental analysis using satellite remote sensing. Theoretical and technical underpinnings of remote sensing (corrections/pre-processing, image enhancement, analysis) with practical applications (land

cover mapping, change detection e.g. deforestation mapping, forest health monitoring). Strong emphasis on hands-on processing and analysis. Will include variety of image types: multi-spectral, hyper-spectral, radar and others. Recommended prerequisite: familiarity with GIS. Instructor: Swenson. 4 units.

559. Fundamentals of Geographic Information Systems and Geospatial Analysis. Fundamental aspects of geographic information systems and satellite remote sensing for environmental applications. Covers concepts of geographic data development, cartography, image processing, and spatial analysis. Gateway into more advanced training in geospatial analysis curriculum. Consent of instructor required. Instructor: Halpin/ Harrell. 4 units.

561K. Chinese Environmental Policy. This course provides a venue for students to investigate the most recent environmental and energy policies in China. We will study the causes and consequences of environmental and energy problems. We will examine Chinese environmental and energy governance: institutions, laws and regulations for environmental protection, energy production and consumption. We will also explore the practices of Chinese government to address the emerging environmental and energy problems, with a special focus on climate change. Taught at Duke Kunshan University. Instructor: Zhang. 3 units.

563. Cost-Benefit Analysis for Health and Environmental Policy. 3 units. C-L: see Global Health 531; also C-L: Public Policy 607

564. Biogeochemistry. 3 units. C-L: see Biology 564

564D. Biogeochemistry. 3 units. C-L: see Biology 564D

565S. Stormwater Science: Pollution, Pavement, and Precipitation. 3 units. C-L: see Biology 563S

566. Environmental Analytical Chemistry. 3 units. C-L: see Civil and Environmental Engineering 565

568S. Integrated Assessment Modeling—Examining Strategies for Meeting Energy and Environmental Goals. 3 units. C-L: see Earth and Ocean Sciences 568S

569. Should I Eat Fish? Economics, Ecology and Health. Examines role that individual consumer can play in promoting marine conservation. Course considers array of issues that confront seafood consumers and tradeoffs that only an informed consumer can assess. In context of evaluating seafood students will learn to evaluate tradeoffs systematically, assess how different policy options affect incentives for users and polluters. This process allows students to place consumer initiatives in context of other approaches to marine conservation. Interdisciplinary approach but economic themes will inform course. Course intended for Master of Environmental Management students, but open to advanced undergraduates with permission. This course is intended for MEM students and is based on a Marine Conservation Leadership Certificate capstone course offered previously to undergraduates. Advanced undergraduates permitted pending space availability. Instructor: Smith. 3 units.

570. Isotopes in Earth and Environmental Sciences. 3 units. C-L: see Earth and Ocean Sciences 571; also C-L: Civil and Environmental Engineering 551

570LA-2. Marine Ecology of the Pacific Coast of California. 2 units. C-L: see Biology 570LA-2

571A. Sojourn in Singapore: Urban Tropical Ecology. The mix of human ecology, tropical diversity, disturbed habitats and invasive species in Singapore. How Singapore maintains and enhances the quality of life of its citizens while radically modifying its environment. Research on politics, management or biology. Travel to Singapore required. Taught in Beaufort at Duke Marine Lab. Consent of instructor required. Instructor: Rittschof and Schultz. 3 units. C-L: Biology 571A

572. Economic Evaluation of Sustainable Development. 3 units. C-L: see Public Policy 574

573. Coastal and Marine Pollution. Sources, fate, and effects of organic, inorganic, and particulate pollutants in the marine environment. Topics include oil spills, coastal eutrophication, marine debris, harmful algae, sewage contamination, dredging, and emerging contaminants. Methods for measuring pollution in the marine environment and consequences for human and ecological health will be discussed. Case studies of impacted marine environments will be highlighted. Short local field trips possible. Recommended prerequisite: introductory chemistry and biology, or consent of instructor. Instructor: Ferguson. 3 units.

573A. Coastal and Marine Pollution. Sources, fate, and effects of organic, inorganic, and particulate pollutants in the marine environment. Topics include oil spills, coastal eutrophication, marine debris, harmful algae, sewage contamination, dredging, and emerging contaminants. Methods for measuring pollution in the marine environment and consequences for human and ecological health will be discussed. Case studies of impacted marine environments will be highlighted. Short local field trips possible. Taught in Beaufort at Duke Marine Lab. Recommended prerequisite: introductory chemistry and biology, or consent of instructor. Instructor: Ferguson. 3 units.

575L. Biodiversity Science and Application. 3 units. C-L: see Biology 565L

575S. Biodiversity Science and Application. 3 units. C-L: see Biology 565S

577. Environmental Politics. Environmental policy formation and implementation in comparative perspective. Topics include interest groups, environmental movements and parties, public opinion, political systems and institutions. Case students selected from the United States and other advanced industrialized countries and the developing world. Spring. Instructor: Albright or Mullin. 3 units. C-L: Public Policy 577, International Comparative Studies 577

579LA. Biological Oceanography. Physical, chemical, and biological processes of the oceans, emphasizing special adaptations for life in the sea and factors controlling distribution and abundance of organisms. Four units (spring); six units (summer). Taught in Beaufort at Duke Marine Lab. Prerequisite: introductory biology. Instructor: Johnson. Variable credit. C-L: Biology 579LA, Earth and Ocean Sciences 579LA

579S. Collective Action, Environment, and Development. 3 units. C-L: see Public Policy 579S

581. Global Environmental Health Problems: Principles and Case Studies. Many environmental problems occur both

locally & globally. Having insights and experience from different parts of the world is important for students to gain problem-oriented training. This course will cover fundamental principles on physical & chemical processes related to major environmental problems. These principles will then be integrated to discussions of case studies addressing a specific set of problems. The case studies will involve the participation of invited guest instructors who are experts on specific topics/cases. Depending on preference of guest instructors, they can introduce a case study via online lecturing/chatting or providing a pre-made video. Online course. Instructor consent required. Instructor: Zhang. 3 units. C-L: Global Health 581

581D. Global Environmental Health Problems: Principles and Case Studies. Many environmental problems occur both locally & globally. Having insights and experience from different parts of the world is important for students to gain problem-oriented training. This course will cover fundamental principles on physical & chemical processes related to major environmental problems. These principles will then be integrated to discussions of case studies addressing a specific set of problems. The case studies will involve the participation of invited guest instructors who are experts on specific topics/cases. Depending on preference of guest instructors, they can introduce a case study via online lecturing/chatting or providing a pre-made video. Online course. Instructor consent required. Instructor: Zhang. 3 units. C-L: Global Health 581D

581K. Global Environmental Health Problems: Principles and Case Studies. Many environmental problems occur both locally & globally. Having insights and experience from different parts of the world is important for students to gain problem-oriented training. This course will cover fundamental principles on physical & chemical processes related to major environmental problems. These principles will then be integrated to discussions of case studies addressing a specific set of problems. The case studies will involve the participation of invited guest instructors who are experts on specific topics/cases. Depending on preference of guest instructors, they can introduce a case study via online lecturing/chatting or providing a pre-made video. Online course. Open to Duke Kunshan students only. Instructor consent required. Instructor: Zhang. 3 units. C-L: Global Health 581K

583S. Energy and U.S. National Security. 3 units. C-L: see Public Policy 583S; also C-L: Political Science 663S

583SK. Energy and National Security. 3 units. C-L: see Public Policy 583SK; also C-L: Political Science 663SK

585. Fisheries Biogeography and Ecology. Current status of the distribution and abundance of fisheries globally and current topics in fisheries ecology, explored through lecture and discussion of primary literature. Participation in leading discussions and mini literature review. Basic knowledge of ecology and oceanography. Instructor consent required. Instructor: Dunn. 3 units.

585A. Fisheries Biogeography and Ecology. Current status of the distribution and abundance of fisheries globally and current topics in fisheries ecology, explored through lecture and discussion of primary literature. Participation in leading discussions and mini literature review. Basic knowledge of ecology and oceanography. Intended for master and doctoral students. Taught in Beaufort at Duke Marine Lab. Instructor: Staff. 3 units.

590. Special Topics. Content to be determined each semester. May be repeated. Instructor: Staff. Variable credit.

590A. Duke-Administered Study Away: Special Topics. Content to be determined each semester. May be repeated. Taught in Beaufort at Duke Marine Lab. Instructor: Staff. Variable credit.

590D. Special Topics. Content to be determined each semester. May be repeated. Instructor: Staff. Variable credit.

590K. Special Topics in Environmental Sciences and Policy. Content varies each semester. Offered only at Duke Kunshan University. Instructor: Staff. 3 units.

590L. Special Topics. Content to be determined each semester. May be repeated. Instructor: Staff. Variable credit.

590LA. Duke-Administered Study Away: Special Topics. Content to be determined each semester. May be repeated. Taught in Beaufort at Duke Marine Lab. Instructor: Staff. 4 units.

590S. Special Topics. Seminar version of 590. Instructor: Staff. Variable credit.

590SA. Seminar in Ocean Sciences. Biological, chemical, physical, and geological aspects of the ocean and their relation to environmental issues. Consent of instructor required. Taught in Beaufort at Duke Marine Lab. Instructor: Staff. Variable credit.

593. Independent Studies and Projects. Directed readings or research at the graduate level to meet the needs of individual students. Consent of instructor required. Units to be arranged. Instructor: Staff. Variable credit.

593K. Independent Studies and Projects. For iMEP students or Duke students studying abroad at Duke Kunshan University. Directed readings or research at the graduate level to meet the needs of individual students. Units to be arranged. Instructor consent required. Instructor: Zhang, Ji, Furst, Li, Ward. Variable credit.

600K. Key Areas in International Environmental Policy. An overview of the key areas in international environmental policy. This course's seven modules cover international environmental economics, international environmental policy and politics, international environmental negotiations, policy debates and simulations. The principal goal of the course is to preview the application of social sciences (economics, public policy, and political science) to the environment, and to facilitate the translation of core curricular concepts into a variety of real-word applications. Students will engage in self-directed research and learning on international environmental policy. Taught at Duke Kunshan University. Instructor: Fürst. 3 units.

601K. Building an NGO Toolkit: From Design to Monitoring. Non-governmental organizations (NGOs) that address conservation issues in China face large, complex, and urgent problems. To be successful, these NGOs must be equipped with the skills to be efficient, effective, and transparent when planning, implementing, and monitoring their conservation initiatives. In this hands-on course, students will become familiar with decision-support tools that allow organizations to systematically address strategic planning, project design, project budgeting, implementation, monitoring, evaluation, communication, and donor transparency. Students will apply these tools to real-world conservation problems. Taught at Duke Kunshan University. Instructor: Losos. 3 units.

602K. Natural Resources and Protected Area Management. Toolkit for practical natural resources management and understanding the challenges involved in protected area management. Wildlife monitoring, environmental change tracking, socio-economic surveys and stakeholders engagement. Combines lectures for essential survey methods and experiential education through a seven-day field course. Students will design their own group project to carry out in the local context. Taught in Kunshan, China, at Duke Kunshan University. Instructor: Li. 3 units.

603. Air Quality: Management. Management systems are discussed, including varied approaches used to address criteria air pollutants, air toxics, mobile sources and acid deposition. Course prepares students to understand systems approach to apply science and technical information to inform policy decisions affecting air quality; understand and be conversant in varied approaches to manage air quality to meet policy objectives; be familiar with major common air pollutants and air quality management approaches applied to each and why approaches vary. Instructor: Vandenberg. 1.5 units.

604. Air Quality: Human Exposure and Health Effects. Looks at how individuals and populations are exposed to air pollution and what adverse health effects the exposure will cause. Covers exposure analysis methods, toxicological and epidemiological studies that examine health effects of air pollution exposure. Students will be prepared to understand concept and major methodologies of analysis for air pollution; how toxicology is used to determine adverse effects of air pollution exposure and underlying biological mechanisms; collect evidence on air pollution health effects in supporting health risk assessment. Prerequisites: general biology, statistics. Instructor: Zhang. 1.5 units. C-L: Global Health 634

610. Ecotoxicology. Overview of ecological and toxicological effects of chemicals on structure and function of ecosystems, primarily at population, community and ecosystem levels of biological organization. Topics include environmental fate and transport of contaminants, biomonitoring, biomarkers/bioindicators, evolution of resistance to pollution, and extrapolating from molecular interactions to ecosystems. Incorporates critical discussion of in-depth case studies to highlight application of ecotoxicological concepts to real-world scenarios. For graduate and advanced undergraduate students. Instructor: Raftery. 3 units.

615A. Aquaculture and the Environment. The major environmental, social and economic drivers of increasing global aquaculture, with a focus on marine systems. Quantitative evaluation and comparison of the range of species for aquaculture, locations where operations occur, operational aspects including environmental impacts and management considerations. Investigation of alternative approaches and potential future areas for aquaculture expansion as well as social, economic and technical barriers to implementation. Taught in Beaufort at Duke Marine Lab. Instructor: Johnson. 3 units.

621. Water Resources, Finance and Planning. Introductory course to water in the built environment, with basic treatment of hydrology, treatment, regulation, and planning of water resources. Course will serve as a survey course for non-water specialists, and a bridge course from hydrology to policy, management, planning, and finance, or vice versa for policy students interested in bridging to hydrology. Emphasis will be on applications of basic techniques common in management contexts. Instructor: Doyle. 3 units.

623L. Ecological Diversity and Climate Change. Evaluates the science of biodiversity and climate change, including changes happening now, in the past, and what we can expect in the future. Topics include forest diebacks, intensifying drought, increased wildfire, insect and pathogen outbreaks, and poleward migrations of land and marine populations. Analytical tools used to quantify change include elements of basic distribution theory, data manipulation in R, and examples of simulation methods. Each lab implements one or more models, including regression, GLMs, and species distribution modeling. Prerequisites: calculus, statistics. Instructor: Clark. 3 units.

624. Agriculture and Sustainability: Feeding the Growing Human Population Today for the Future. Introduces agroecology through basic scientific knowledge of plant physiology and growth for crop production, crop diversity and breeding, and comparison of agricultural practices (industrial, subsistence, organic, sustainable). Covers resources needed for whole-plant growth, biomass output for human use including bioenergy, and impacts on ecosystems. Examines environmental sustainability through assessment of drawbacks and benefits of agricultural practices for human food and biofuel production. Applications include management plan for sustainable agroecosystems and forecast of crop agricultural practices in need of a future altered environment. Prerequisites: introductory Biology or Ecology. Instructor: Reid. 3 units.

626. River Processes. Course focuses on river processes and how rivers change and how to analyze rivers. Course is a mixture of hydrology, geomorphology, and ecology. Focus is on quantitative analysis of processes using simple modeling approaches. Problems will be drawn from policy and river management applications such as river restoration, channel design, dam management, and floodplain regulation. Instructor: Doyle. 3 units.

627. Molecular Ecology. Explore use of molecular tools to investigate ecological processes within natural populations and communities from terrestrial to marine. Emphasis on fundamental principles and predictions from ecological and evolutionary theory, as well as historical approaches and precedents. In addition to exploring very basic ecological questions, course discusses interpretation of molecular datasets to evaluate applied ecological problems with societal implications (e.g., conservation, antibiotic resistance, genetically modified crops, adaptation to climate change). Open to graduate students, and upper-level undergraduates with backgrounds in ecology and/or molecular biology. Instructor: Wernegreen. 3 units. C-L: Science & Society 627, Biology 627

630. Transportation and Energy. Examination of transportation-related energy use and its impact on the environment. Learn how technology, infrastructure, and policy, as well as personal and cultural preferences, interact to meet demands for personal mobility and freight movement. Cutting across these themes will be consideration of strategies to reduce transportation energy use and its environmental impacts, with an introduction to information resources and tools for evaluating both. Provides opportunities to hone problem solving and analytical skills, and challenges students to think critically and creatively about the trade-offs among complex transportation options. Instructor: Johnson. 3 units. C-L: Energy 630

630D. Transportation and Energy. Examination of transportation-related energy use and its impact on the environment. Learn how technology, infrastructure, and policy, as well as personal and cultural preferences, interact to meet demands for personal mobility and freight movement. Cutting across these themes will be consideration of strategies to reduce transportation energy use and its

environmental impacts, with an introduction to information resources and tools for evaluating both. Provides opportunities to hone problem solving and analytical skills, and challenges students to think critically and creatively about the trade-offs among complex transportation options. Instructor: Johnson. 3 units. C-L: Energy 630D

631. Energy Technology and Impact on the Environment. Efficiencies and environmental impacts of both new and established energy sources and conversion methods. Consideration of alternative energy technologies, including electricity generation by fossil fuels, nuclear, solar, wind and water; space heating and cooling by traditional methods and by solar; and transportation energy in automobiles, mass transit and freight. Environmental consequences of energy choices on local, national and global scales, including toxic emissions, greenhouse gases and resource depletion. Prerequisite: Environment 231 or Environment 711. Instructor consent required. Instructor: Johnson. 3 units. C-L: Energy 631

631D. Energy Technology and Impact on the Environment. Efficiencies and environmental impacts of both new and established energy sources and conversion methods. Consideration of alternative energy technologies, including electricity generation by fossil fuels, nuclear, solar, wind and water; space heating and cooling by traditional methods and by solar; and transportation energy in automobiles, mass transit and freight. Environmental consequences of energy choices on local, national and global scales, including toxic emissions, greenhouse gases and resource depletion. Prerequisite: Environment 231 or Environment 711. Instructor consent required. Instructor: Johnson. 3 units. C-L: Energy 631D

632. Environmental Education and Interpretation. Course will provide students with foundational knowledge and practical communication skills drawn from five schools of environmental education (EE): natural resource interpretation, science education, European approaches to EE, placed-based learning, and nature connectedness. Through readings, program observations, practicums, and instructor- and peer-based evaluations, students learn to evaluate their audience, develop measurable goals for communication, and refine their presentation skills. Students will also be able to adapt presentations and programs based on the five school of EE addressed in class. Students successfully completing course will become NAI Certified Interpretive Guides. Instructor: Cagle. 3 units.

633. Critical Readings in Environmental Epidemiology. Basic introduction to epidemiological methods, skills to understand and critique, and emerging issues in environmental epidemiology reported in relevant journals. Students will gain knowledge of study designs and analytical methods used in applied epidemiology, practice designing translational and environmental epidemiological studies, and understand the role of epidemiology in Risk Assessment. Course will include lectures, readings, class discussion, oral presentation and written assignments. Instructor: Pan. 3 units. C-L: Global Health 635

634. Introduction to Ecosystem Services and Methods for Quantification. An introduction to ecosystem services, which is increasingly recognized as a useful concept for decision-making, and provide an overview of the suite of methods that are used to quantify them. The course will also provide an overview of a suite of skills/courses needed for ecosystem services assessment and show how they contribute to quantifying ecosystem services. These skills include Structured Decision Making, Ecological Modeling, Bayesian Belief Networks, Multi-Criteria Decision Analysis, Monetary Valuation (non-market valuation methods), & Structural Equation Modeling. Prerequisites: ecology, microeconomics, Environment 520/521 or equivalent. Instructor: Olander. 1 unit.

635. Energy Economics and Policy. Economics of markets and policies for various energy supply sources, energy demand and efficiency, their interactions with each other, and with the economy and environment. Will explore rationales for why markets for energy and related technologies have been subject to extensive government intervention. Course will analyze effects of policy responses, including energy price regulation, the interface of energy, environmental, and technology policy, and policy motivated by energy security concerns. Prerequisite: Introductory Microeconomics (Economics 101 or equivalent) and college calculus. Instructor: Staff. 1.5 units. C-L: Energy 635

635D. Energy Economics and Policy. Economics of markets and policies for various energy supply sources, energy demand and efficiency, their interactions with each other, and with the economy and environment. Will explore rationales for why markets for energy and related technologies have been subject to extensive government intervention. Course will analyze effects of policy responses, including energy price regulation, the interface of energy, environmental, and technology policy, and policy motivated by energy security concerns. Prerequisite: Introductory Microeconomics (Economics 101 or equivalent) and college calculus. Instructor: Staff. 1.5 units. C-L: Energy 635D

637K. Population and Environmental Dynamics Influencing Health. 3 units. C-L: see Global Health 637K

637S. Population and Environmental Dynamics Influencing Health. 3 units. C-L: see Global Health 637S

638. Environmental Life Cycle Analysis & Decision. Provides theoretical foundations of environmental life cycle assessment tools and methods used for products and global supply chains. Introduces various life cycle inventory and life cycle assessment tools used by the community of scientists and industry. Instructor consent required. Instructor: Golden. 3 units. C-L: Energy 638

640. Climate Change Economics and Policy. This course explores the economic characteristics of the climate change problem, assesses national and international policy design and implementation issues, and surveys the economic tools necessary to evaluate climate change policies. Discussion-oriented requiring high degree of student participation. Course objectives are increased comprehension of economic aspects of climate change and ability to apply tools of economic analysis to climate policy and the responses of firms and households to it. Course designed for graduate and advanced undergraduate students. Instructor: Pizer. 3 units. C-L: Public Policy 585

640K. Climate Change Economics and Policy. Explores the economic characteristics of the climate change problem, assesses national and international policy design and current implementation issues, and surveys the economic tools necessary to evaluate climate change policies. Prerequisite: Public Policy 810 and 812, or equivalent, or consent of the instructor. Instructor: Pizer. 3 units. C-L: Public Policy 585K

642. Air Pollution: From Sources to Health Effects. Both urban outdoor air pollution and household indoor air pollution contribute significantly to global burden of disease. Course covers fundamentals about how major air pollutants are generated and transported in the atmosphere and how these pollutants affect human health. Relevant exposure assessment, toxicology and

epidemiology case studies are discussed. Prerequisites: general chemistry; introductory-level statistics. Instructor: Zhang. 3 units. C-L: Global Health 630

646. Urban Ecology. Addresses how to understand urban areas as ecological and socio-ecological systems and the distinction between the study of ecology in and of cities. Examines both through theoretical lens of socio-ecological systems, in which humans and their actions are a component of, rather than disturbance imposed on, ecological systems. Applies theoretical and methodological tools to global, regional, and local urban issues. Prerequisites: One ecology course and one environmental social sciences course. Instructor: Heffernan. 3 units.

646D. Urban Ecology. Addresses how to understand urban areas as ecological and socio-ecological systems and the distinction between the study of ecology in and of cities. Examines both through theoretical lens of socio-ecological systems, in which humans and their actions are a component of, rather than disturbance imposed on, ecological systems. Applies theoretical and methodological tools to global, regional, and local urban issues. Prerequisites: One ecology course and one environmental social sciences course. Instructor: Heffernan. 3 units.

650S. Advanced Topics in the Conservation of Biodiversity. Current topics in conservation and biodiversity. Intended for graduate students; advanced undergraduate students admitted with permission of instructor. Prerequisite: introductory conservation biology or permission of instructor. Instructor: Pimm. 2 units.

658. Applied Qualitative Research Methods. Broadly covers qualitative and mixed methods research design, analysis, and interpretation. Students gather a limited amount of their own data and produce a pilot research project throughout the semester. Students learn to use NVivo10, a qualitative research software program. Instructor: C. Clark. 3 units.

665. Bayesian Inference for Environmental Models. 3 units. C-L: see Biology 665

666. Aquatic Geochemistry. 3 units. C-L: see Civil and Environmental Engineering 666

667. Chemical Transformation of Environmental Contaminants. 3 units. C-L: see Civil and Environmental Engineering 667

678. Population Ecology for a Changing Planet. Overview of the expanding field of population ecology, including the use of new bioinformatic tools to study topics such as the impacts of climate change on population dynamics, population growth and regulation, adaptive evolution, and emerging diseases. Lecture and discussion of case studies will evaluate current knowledge and productive research directions, highlighting analysis of observational and experimental data sets. Prerequisites: introductory statistics and calculus. Instructor: J. Clark. 3 units. C-L: Biology 678

680. Economics of Forest Resources. Core economic theory of forest management and application of theory to selected forestry policy issues. Course focuses on management of forests for timber production as well as for non-timber values. Concepts explored include policy challenges such as biodiversity conservation, deforestation, community forest management, and payments for ecosystem services. Two groups of economic tools will be used: non-market valuation methods and program evaluation techniques. Prerequisites: college-level calculus, microeconomics and statistics, as well as Excel proficiency. Instructor: Vincent. 1.5 units.

680D. Economics of Forest Resources. Core economic theory of forest management and application of theory to selected forestry policy issues. Course focuses on management of forests for timber production as well as for non-timber values. Concepts explored include policy challenges such as biodiversity conservation, deforestation, community forest management, and payments for ecosystem services. Two groups of economic tools will be used: non-market valuation methods and program evaluation techniques. Prerequisites: college-level calculus, microeconomics and statistics, as well as Excel proficiency. Instructor: Vincent. 1.5 units.

684. Politics of the Urbanized Environment. Examines the politics of environmental management in urbanized areas. Students will gain understanding of political, economic and social constraints on local government decision-making; pathways by which local policy decisions shape environmental outcomes; tools to improve environmental outcomes and conditions for using the tools. Students will gain competencies in identifying opportunities for improved environmental outcomes, evaluating feasibility of environmental management strategies, and developing and communicating them appropriately. Course material will emphasize US cities with some attention to non-US urbanized environments. Course assumes familiarity with US government. Instructor: Mullin. 3 units.

700. Integrated Case Studies. A group of two to four students may plan and conduct integrated research projects on a special topic, not normally covered by courses or seminars. A request to establish such a project should be addressed to the case studies director with an outline of the objectives and methods of study and a plan for presentation of the results to the school. Each participant's adviser will designate the units to be earned (up to six units) and evaluate and grade the work. Instructor: Staff. Variable credit.

701. Forest Measurements. Course is designed to provide field and analytical measurement skills expected of professionals working in forest ecosystem management. Additional emphasis on habitat assessment, forest vegetation, and wildlife identification. Extensive field work required. Instructor: Cagle. 3 units.

702. Ecology Seminar. 1 unit. C-L: see Biology 711S; also C-L: Evolutionary Anthropology 743

703. Conservation Biology: Theory and Practice. An overview of biological diversity, its patterns, and the current extinction crisis. Historical and theoretical foundations of conservation, from human values and law to criteria and frameworks for setting conservation priorities; island biogeography theory, landscape ecology, and socioeconomic considerations in reserve design; management of endangered species in the wild and in captivity; managing protected areas for long term viability of populations; the role of the landscape matrix around protected areas; and techniques for conserving biological diversity in semiwild productive ecosystems like forests. Three field trips. Prerequisite: one ecology course or consent of instructor. Instructor: Pimm. 3 units.

704LA. Biological Oceanography. 4 units. C-L: see Biology 704LA; also C-L: Earth and Ocean Sciences 704LA

705A. Social Impact Analysis. This course covers the theoretical, methodological and applied aspects of social impact analysis. Students will think sociologically about environmental issues and the social impacts they create. The course reviews key US policies and guidelines that require and inform social impact analysis. Students will understand and critique Key methods and approaches used in social impact analysis to generate inclusive decisions that protect the environment and the health of the human communities that

share its abundance and meaning. The course will compare and critique a range of national and international social impact examples, including the ethical issues associated with the non-human world. Taught in Beaufort at Duke Marine Lab. Instructor: Murray. 3 units.

705L. Ecological Management of Forest Systems (Silviculture). The aim of the course is to equip future resource managers and environmental consultants with knowledge allowing them to propose lower impact practices to individuals and organizations who need to balance wood production with maintenance of environmental quality. Underlying principles of growth, from seed to mature trees, and stand dynamics are explored. Various alternative methods of manipulating growth, stand structure and development, ranging from little to large perturbations of forest systems, are presented and assessed in terms of their effect on resource quality. Includes laboratory. Instructor: Palmroth. 3 units.

706. Wildlife Surveys. With a focus on birds, reptiles, amphibians, and mammals, this course introduces students to a wide variety of wildlife survey methods and skills through both classroom lectures and hands-on experience in the field. Design, practical application, and post-survey data analyses for conducting wildlife surveys for research as well as for management. Limitations and advantages of various field monitoring techniques; learn to identify many common birds, herps, and mammals of season for this area. Significant time spent in the field. Instructor: Swenson or Staff. 3 units.

707. Geospatial Analysis for the Human Environmental Condition. Application course focusing on spatial analysis and image processing applications to support spatial analysis of the human environment. Map representation of human and population characteristics, spatial analysis of movements and accessibility to resources, impacts of humans on the environment and impacts of environmental conditions on humans. Requires a fundamental knowledge of geospatial analysis theory and analysis tools (ENVIRON 559 or equivalent). Consent of instructor is required. Instructor: Swenson. 3 units.

708. Silviculture Prescription. Professional foresters meet management objectives through stand manipulation by using appropriate methods. Silviculture prescription is an operational plan that describes the goals, the silvicultural manipulations needed to achieve these goals, and the development of the stands over the projected period. Facing diverse management objectives and stand conditions, success in this planning process depends on understanding the underlying principles of tree growth and stand dynamics, but also relies on the intuitive knowledge that aids in assessing stand conditions and future development. Class is designed to provide the practical experience needed for developing the intuitive knowledge. Instructor: Palmroth. 2 units.

709. Conservation Biology and Policy. Introduction to the key concepts of ecology and policy relevant to conservation issues at the population to ecosystems level. Focus on the origin and maintenance of biodiversity and conservation applications from both the biology and policy perspectives (for example, endangered species, captive breeding, reserve design, habitat fragmentation, ecosystem restoration/rehabilitation). Open to undergraduates only under Biology 270. Recommended prerequisite: introductory biology; also suggested: a policy and/or introductory ecology course. Instructors: Nowacek. 3 units.

709A. Conservation Biology and Policy. Introduction to the key concepts of ecology and policy relevant to conservation issues at the population to ecosystems level. Focus on the origin and maintenance of biodiversity and conservation applications from both the biology and policy perspectives (for example, endangered species, captive breeding, reserve design, habitat fragmentation, ecosystem restoration/rehabilitation). Open to undergraduates only under Biology 270A. Taught in Beaufort at Duke Marine Lab. Prerequisite: introductory biology; suggested: a policy and/or introductory ecology course. Instructors: Nowacek. 3 units.

710. Applied Data Analysis for Environmental Sciences. Graphical and exploratory data analysis; modeling, estimation, and hypothesis testing; analysis of variance; random effect models; regression and scatterplot smoothing; generalized linear models; resampling and randomization methods. Concepts and tools involved in data analysis. Special emphasis on examples drawn from the social and environmental sciences. Students to be involved in applied work through statistical computing using software, STATA or R. Instructor: Albright or Poulsen. 3 units.

711. Energy and Environment. Overview of the challenges confronting humanity as a consequence of our reliance on energy. Challenges include dwindling supplies, rising demand and environmental degradation. Realistic responses require an understanding of the complexity of the energy system, including energy resources, uses, and impacts, in the context of social, political and economic imperatives. Lectures will be augmented by presentations from guest speakers from industry, government and non-profit organizations. Instructor: Pratson. 3 units. C-L: Energy 711

712A. Hydrocarbons: Production to Policy Seminar. Field study of hydrocarbons production in and around Houston, Texas, with first-hand perspective of oil and gas from industry experts. Includes a field trip with a required fee for the trip. Instructor: Pratson. 1 unit.

713A. Clean Energy Field Trip. Field study of the clean energy industry around the San Francisco Bay area, California, with first-hand perspective from renewable energy experts. Includes a field trip with a required fee for the trip. Instructor: Pratson. 1 unit. C-L: Energy 713A

714. Landscape Ecology. Landscape ecology is concerned with spatial heterogeneity (pattern) on landscapes-what generates pattern, its characteristic scaling in space and time, and why it matters for populations, communities and ecosystem processes. As essentially all agencies that manage land now profess an aim to manage functional, resilient and sustainable landscapes, this course provides the foundational knowledge to support these applications in conservation planning and ecosystem management. The course consists of lectures, small-group exercises and discussions with an emphasis on understanding key concepts and applying these to real-world applications mgmt scenarios. Prerequisite: ecology; statistics preferred. Instructor: Urban. 3 units.

714D. Landscape Ecology. Landscape ecology is concerned with spatial heterogeneity (pattern) on landscapes-what generates pattern, its characteristic scaling in space and time, and why it matters for populations, communities and ecosystem processes. As essentially all agencies that manage land now profess an aim to manage functional, resilient and sustainable landscapes, this course provides the foundational knowledge to support these applications in conservation planning and ecosystem management. The course consists of lectures, small-group exercises and discussions with an emphasis on understanding key concepts and applying these to real-world applications mgmt scenarios. Prerequisite: ecology; statistics preferred. Instructor: Urban. 3 units.

715L. Understanding Energy Models and Modeling. Course aims to nurture basic modeling literacy by focusing on widely-used class of "bottom-up," optimization-based, energy models commonly used for economic, environmental, and technology assessments. Students will gain practical experience searching for relevant modeling data, constructing scenarios, and running an energy model. Will gain a working knowledge of model mechanics and experience asking the type of questions needed to evaluate quality of modeling results. Instructor: T. Johnson. 3 units. C-L: Energy 715L

716K. Modeling for Energy Systems. Introduction to the use of computer models and the methods of optimization and simulation for students interested in the analysis of energy systems; emphasis in the formulation of optimization problems and simulation models, and in the identification of the available methods to solve them. Students should also be familiar with capital-sigma (¿) notation for compactly representing summation of similar terms, and know the basics of Excel. Taught in China at Duke Kunshan University. Recommended prerequisite: college-level calculus (including partial derivatives of functions of several variables), probability theory, and basic linear algebra (how to write—and solve—systems of linear equations in matrix form). Instructor: Patiño-Echeverri. 3 units.

716L. Modeling for Energy Systems. Introduction to computer programming and operations research in energy systems analysis with emphasis on formulation of optimization problems and simulation models. Applications and case studies dealing with energy systems problems, their externalities, and government policies that affect them. Data analysis, spreadsheet modeling, VBA programming in Excel; linear programming (lp), post-optimality and sensitivity analysis, multi-period lp, stochastic lp, network models for minimum path, maximum flow and optimal planning problems; probabilistic analysis Monte Carlo simulation, including generation of independent and correlated random variables, and goodness of fit tests. Instructor: Patiño-Echeverri. 3 units. C-L: Energy 716L

717. Markets for Electric Power. Examines basic concepts and tools in economics and engineering necessary to understand the operation of power markets. Includes physical systems; industry structure and economic models to understand the supply side; operational reliability; long-term reliability; and integration of renewables. Instructor: Patiño-Echeverri. 3 units.

718K. Environmental Sciences. This course introduces students to the core concepts and topics of environmental sciences. It will give an in-depth overview of main themes in the field of environmental studies: global environmental challenges, human population trends, global atmospheric changes, air, land and water resources and pollution, the ocean and fisheries, key ecosystems (forests, grasslands, wetlands, freshwater and marine environment), biodiversity and conservation, non-renewable and renewable energy, agriculture and sustainable production. Quantitative and qualitative research methods will be introduced with case studies. Taught at Duke Kunshan University. Instructor: Li. 3 units.

719. Aquaculture. The major environmental, social and economic drivers of increasing global aquaculture, with a focus on marine systems. Quantitative evaluation and comparison of the range of species for aquaculture, locations where operations occur, operational aspects including environmental impacts and management considerations. Investigation of alternative approaches and potential future areas for aquaculture expansion as well as social, economic and technical barriers to implementation. Instructor: Johnson. 3 units.

719A. Aquaculture and the Environment. The major environmental, social and economic drivers of increasing global aquaculture, with a focus on marine systems. Quantitative evaluation and comparison of the range of species for aquaculture, locations where operations occur, operational aspects including environmental impacts and management considerations. Investigation of alternative approaches and potential future areas for aquaculture expansion as well as social, economic and technical barriers to implementation. Taught in Beaufort at Duke Marine Lab. Instructor: Johnson. 3 units.

720S. Land Conservation in Practice. Provides an overview of the applied skills and techniques currently used to conserve land in the land trust movement. covers a variety of topics from setting priorities for conservation, completing land transactions, working with private landowners, fundraising, land monitoring and stewardship, evaluating conservation success, etc. Course leverages the experience of guest speakers from regional land trust and conservation organizations to provide working examples of how land conservation is done. Instructor: Swenson. 1 unit.

721. Soil Resources. Emphasis on soil resources as central components of terrestrial ecosystems, as rooting environments for plants, and as porous media for water. Soil physics and chemistry provide the basis for the special problems examined through the course. Laboratory emphasizes field and lab skills, interpretive and analytical. Instructor: Richter. 3 units.

722. Hydrologic and Environmental Data Analysis. 3 units. C-L: see Earth and Ocean Sciences 722; also C-L: Civil and Environmental Engineering 761

724. Landscape Analysis & Management. This course presents a task-oriented perspective on landscape ecology, by introducing the fundamental tasks of landscape analysis and management. These tasks include habitat classification and species distribution modeling; sampling designs for landscapes; inventory and monitoring; site prioritization; change detection and forecasting landscape change; inferences on landscape data (an introduction to the analysis of multivariate and spatial data); and integrated assessment. The course consists of lectures and computer labs. Prerequisites: Environment 714 and Environment 710 or equivalent, or consent of instructor. Instructor: Urban. 4 units.

724L. Landscape Analysis & Management. This course presents a task-oriented perspective on landscape ecology, by introducing the fundamental tasks of landscape analysis and management. These tasks include habitat classification and species distribution modeling; sampling designs for landscapes; inventory and monitoring; site prioritization; change detection and forecasting landscape change; inferences on landscape data (an introduction to the analysis of multivariate and spatial data); and integrated assessment. The course consists of lectures and computer labs. Prerequisites: Environment 714 and Environment 710 or equivalent, or consent of instructor. Instructor: Urban. 4 units.

725S. Protected Areas, Tourism, and Development. Investigates issues of establishing and managing national parks, biosphere reserves, and other protected areas in situations where local populations compete for the same resources. Tourism is considered as a possible source of negative impacts on the protected area and as a source of local economic development. Includes consideration of tourism policy, resource protection strategies, microenterprise development, sustainable agriculture, and forestry. Instructor: Staff. Variable credit.

727DS. Forests in the Public Interest Seminar. Discussion and analysis of current forestry issues of concern to the public—United States and abroad. Students propose discussion topics by identifying forest-related news stories reported in leading print or online sources during the current calendar year. Topics discussed in two parts. Students assess through class discussion the information reported in the news stories and generate questions for additional analysis. Teams then investigate the questions and make an oral presentation of their findings at the next class session; they also provide a list of sources they consulted. Particular themes highlighted in different years. May be taken up to three times for credit. Required for MF degree. Instructor: Vincent. 1.5 units.

727S. Forests in the Public Interest Seminar. Discussion and analysis of current forestry issues of concern to the public—United States and abroad. Students propose discussion topics by identifying forest-related news stories reported in leading print or online sources during the current calendar year. Topics discussed in two parts. Students assess through class discussion the information reported in the news stories and generate questions for additional analysis. Teams then investigate the questions and make an oral presentation of their findings at the next class session; they also provide a list of sources they consulted. Particular themes highlighted in different years. May be taken up to three times for credit. Required for MF degree. Instructor: Vincent. 1.5 units.

728. Fire Ecology and Management Seminar. A wide range of wildland and forest fire seminars are organized for students to interact with leaders in the wide variety of environmental fields that work with fire issues: ecological science of fires, prescribed, fire, fire behavior, fire on federal and state public lands, fire economics, fire and restoration, and fire in history and in the future. Instructor: Richter. 1 unit.

729A. Oceans in Human and Environmental Health. Focus on the concept of "One Health" that the health of the environment and the people who live in it are linked. The basis (from a biological perspective) of threats facing the marine environment and interactions between environmental and human health and their role in global health disparities. For example, in discussing fisheries and aquaculture, the course will cover environmental impacts of these extractive industries and their importance in human and societal well-being. This course will embrace immersive field experiences in North Carolina that will contextualize classroom learning and develop connections with practitioners and residents. Taught in Beaufort at Duke Marine Lab. Instructor: Hunt. 3 units.

729DA. Oceans in Human and Environmental Health. Focus on the concept of "One Health" that the health of the environment and the people who live in it are linked. The basis (from a biological perspective) of threats facing the marine environment and interactions between environmental and human health and their role in global health disparities. For example, in discussing fisheries and aquaculture, the course will cover environmental impacts of these extractive industries and their importance in human and societal well-being. This course will embrace immersive field experiences in North Carolina that will contextualize classroom learning and develop connections with practitioners and residents. Taught in Beaufort at Duke Marine Lab. Instructor: Hunt. 3 units.

731. Dendrology. This course aims to familiarize students with the secret lives of trees. We begin by learning to identify over 130 woody plants of the Piedmont. To do this, we will also grapple with dichotomous keys and plant systematics to help us identify plants anywhere in the world. We also address topics like the chemical communication of trees, the relationships among wildlife and trees, and the value of trees. Most of this course will be outside. Instructor consent required. Instructor: Cagle. 2 units.

733. Risk Regulation in the United States, Europe, and Beyond. Advanced, integrated analysis of the law, science and economics of societies' efforts to assess and manage risks of harm to human health, safety and the environment. Course examines the regulation of a wide array of risks, such as those from medical care and drugs, food, automobiles, drinking water, air pollution, energy, global climate change, and terrorism. The course explores the treatment of several basic issues confronting any regulatory system: risk assessment, risk management (including the debate over "precaution" versus benefit-cost analysis), risk evaluations by experts vs. the public, and risk-risk tradeoffs. Instructors: Wiener and Bennear. 2 units.

734L. Watershed Hydrology. Introduction to the hydrologic cycle with emphasis on the influence of land use, vegetation, soil types, climate, and land forms on water quantity and quality and methods for control. Development of water balance models. Analysis of precipitation patterns, rainfall and runoff, and nonpoint source impacts. Statistical handling and preparation of hydrologic data, simulation and prediction models, introduction to groundwater flow, laboratory and field sampling methods. Instructor: Katul. 4 units.

735. Drones in Marine Biology, Ecology, and Conservation. Includes a full overview of past and emerging applications for ecology and biology of marine species and coastal habitats with in-depth discussion on future of drone applications in coastal biological and ecological research. Comprehensive exploration of current drone technologies, including detection of target species, payloads, aeronautical concepts, rules and regulations, mission planning, aircraft design, maintenance, data collection, management and analysis. Components tailored to student interests: Active participation in megafaunal or environmental research and data analysis. Building, operating and maintaining aircraft, programming for manual and autonomous flight. Instructor: Johnston. 3 units.

735A. Drones in Marine Biology, Ecology, and Conservation. Lab-based version of Environment 735LA. Taught in Beaufort at Duke Marine Lab. Instructor: Johnston. 3 units.

735LA. Drones in Marine Biology, Ecology, and Conservation. Includes a full overview of past and emerging applications for ecology and biology of marine species and coastal habitats with in-depth discussion on future of drone applications in coastal biological and ecological research. Comprehensive exploration of current drone technologies, including detection of target species, payloads, aeronautical concepts, rules and regulations, mission planning, aircraft design, maintenance, data collection, management and analysis. Lab components tailored to student interests: Active participation in megafaunal or environmental research and data analysis. Building, operating and maintaining aircraft, programming for manual and autonomous flight. Taught in Beaufort at Duke Marine Lab. Instructor: Johnston. 4 units.

736K. Planetary Health and Environmental Epidemiology. Study the human health impacts of accelerating environmental change through interdisciplinary approaches including environmental science, political science, public health and social science; engage in diverse materials from many types of examples of planetary health research, from nutrition and mental health, to infectious and non-communicable diseases. A special emphasis will be placed on environmental epidemiology. Taught in China at Duke Kunshan University. Recommended prerequisite: one quantitative methodology class (statistics, biostatistics, epidemiology, or econometrics). Instructor: Ji. 3 units.

738. US Water Governance. This course examines the governance systems that manage freshwater resources in the United States. American water policy is densely institutionalized, constrained by historical systems of rights and long-established patterns of water usage. It is also organizationally complex, with authority fragmented among myriad agencies and authorities at all jurisdictional levels. Our task will be first to understand current governing structures as a consequence of historical, functional, and political forces, and second to analyze contemporary efforts to promote collaboration, adaptive management, and market solutions within the framework of existing governance systems. Instructor: Mullin. 1.5 units.

738D. US Water Governance. This course examines the governance systems that manage freshwater resources in the United States. American water policy is densely institutionalized, constrained by historical systems of rights and long-established patterns of water usage. It is also organizationally complex, with authority fragmented among myriad agencies and authorities at all jurisdictional levels. Our task will be first to understand current governing structures as a consequence of historical, functional, and political forces, and second to analyze contemporary efforts to promote collaboration, adaptive management, and market solutions within the framework of existing governance systems. Instructor: Mullin. 1.5 units.

739. Atmospheric Chemistry: From Air Pollution to Climate Change. A broad overview of the science of oxidant chemistry in the atmosphere. Basic physical and chemical concepts relevant to the understanding of atmospheric chemistry; several contemporary topics discussed from a process-level perspective. Topics include atmospheric structure and chemical composition; atomic structure and chemical bonds; chemical thermodynamics and kinetics; atmospheric radiation and photochemistry, tropospheric and stratospheric ozone chemistry; aqueous-phase atmospheric chemistry; atmospheric aerosols; and air quality modeling. Prerequisites: one college-level course each in chemistry and calculus. Instructor: Kasibhatla. 3 units. C-L: Civil and Environmental Engineering 665

740. Water Resources Planning and Management. This half-credit course is intended to give students a first exposure to ideas of planning and management of organizations related to water resources. The course will develop a very basic framework for strategic planning for environmental organizations with specific applications to water resources. It will provide some tools for forecasting future water conditions, as well as emerging tools for forecasting uncertain water conditions. Finally, it will expose students to approaches in water management, particularly adaptive management and scenario forecasting. Instructor: Doyle. 1.5 units.

741. Water Resources Finance. This half-credit course is intended to provide students with applications of project finance to water assets, particularly municipal water/wastewater systems and irrigation infrastructure, financed primarily through municipal bonds. The primary concepts will be forecasting demand, revenue-generation, pricing effects, debt financing, and emerging alternative finance. Instructor: Doyle. 1.5 units.

742. Forestry and Conservation Finance. This course focuses on the growing practice of utilizing private capital to help fund the costs of a variety of environmental projects, including examples from conservation and mitigation banking, as well as fisheries. We consider potential future trends in the role of private capital as a tool to help solve environmental problems, drawing in part from the broader experience of development finance. Students should emerge with a basic grasp of primary finance instruments as well as specific considerations underlying conservation finance deals and projects. Examples include more mature cases such as forestry and to a lesser extent mitigation banking in the US, to emerging areas such as tropical fisheries. Instructor: Doyle. 1.5 units.

744. Ecology and Conservation of Streams and Rivers. Overview of ecological processes in flowing waters and application to conservation and management of these ecosystems. Lecture and discussion formats to integrate basic principles governing physical, chemical, and biological structure of streams and rivers with anthropogenic drivers of change and policy and management tools. Laboratories will provide hands-on experience in collection and analysis of physical, chemical, and biological data. Field and literature projects will enable students to focus on either basic or applied analysis techniques. Prerequisite: general ecology recommended. Instructor: Heffernan. 3 units.

745A. Climate Change in the Marine Environment. Exploration of climate change science focusing on marine ecosystems and inhabitants —specifically ocean acidification, warming and sea level rise. Factors causing climate change, and how those vary spatially, focusing on sensitive polar ecosys and mar mammal populations. Critical examination of climate change modeling using EdGCM (research-grade Global Climate Model), focusing on how scientists use models, observations/theory to predict climate, and assumptions/uncertainty implicit in modeling. Discussion of potential human impacts, including consequences of sea level rise and potential increases in disease due to climate change. Taught in Beaufort at Duke Marine Lab. Grad students responsible for research paper. Instructor: Johnston. 3 units.

750. Genomics of Microbial Diversity. Graduate seminar explores the use of genomic approaches to illuminate microbial diversity and to clarify mechanisms generating variation within and among microbial lineages and communities. Course is targeted to Ph.D. students in the areas of genomics, genetics, environmental sciences, ecology, and/or computational biology. Discussions will focus on case studies from the primary literature, followed by computer labs allowing hands-on use of current programs. Instructor: Wernegreen. 3 units. C-L: Science & Society 750

752. Sustainability and Renewable Resource Economics. Economic theories of sustainability, contrasted with other scientific views. Focus on renewable resource economics, modeling, and management. Prerequisite: Environment 520. Instructor: Smith. 3 units. C-L: Economics 752

753LA. Sensory Physiology and Behavior of Marine Animals. Sensory physiological principles with emphasis on visual and chemical cues. Laboratories will use behavior to measure physiological processes. Only open to undergraduates under Biology 373LA. Taught in Beaufort at Duke Marine Lab. Prerequisite: introductory biology and chemistry. Instructor: Rittschof. 4 units.

754. Species Distribution Modeling and Habitat Classification. This is a tools course that covers the most popular statistical methods for modeling species distributions. The techniques include generalized linear models, generalized additive models, tree-based models (random forests), and maximum entropy methods. The course also attends model evaluation methods, mapping models in a GIS, and ensembling techniques. Prerequisite: Environment 710 or equivalent course or consent of the instructor. Instructor: Urban. 4 units.

754A. Research Design for Environmental Social Sciences. Examination of the concept of research (philosophy, epistemology, practice) along with methods used widely in the social sciences. Focus is on qualitative methods, and related research ethics, objectives, design, data collection, analysis, and presentation. Consideration of the relevance and utility of qualitative research methods for understanding human uses, values, interactions, and beliefs about the environment. Taught in Beaufort at Duke Marine Lab. Online course. Instructor: Campbell. 3 units.

755. Community-Based Environmental Management. Goal of the course is to provide students with fundamental theory and methods that will allow them to identify some of the potential problems and pitfalls associated with community-based environmental management (CBEM) initiatives, both domestically and internationally, along with tools necessary to create and manage their own projects. To accomplish this, course will combine readings and discussion of academic literature with presentations of specific CBEM case studies, guest speakers, and interactions with local CBEM projects. Instructor: Shapiro. 3 units.

755D. Community-Based Environmental Management. Goal of the course is to provide students with fundamental theory and methods that will allow them to identify some of the potential problems and pitfalls associated with community-based environmental management (CBEM) initiatives, both domestically and internationally, along with tools necessary to create and manage their own projects. To accomplish this, course will combine readings and discussion of academic literature with presentations of specific CBEM case studies, guest speakers, and interactions with local CBEM projects. Instructor: Shapiro. 3 units.

756. Spatio-Temporal Environmental Models. Spatio-temporal models are now being widely used for inference on environmental data. This course will consist of weekly topics with readings of new literature and application of models and software to data sets. We will specifically focus on spBayes in R. Students will each volunteer to lead one week, track down and distribute a data set, set up a model and provide a short demo on computation. Instructor: J. Clark. 2 units.

756A. Spatio-Temporal Environmental Models. Spatio-temporal models are now being widely used for inference on environmental data. This course will consist of weekly topics with readings of new literature and application of models and software to data sets. We will specifically focus on spBayes in R. Students will each volunteer to lead one week, track down and distribute a data set, set up a model and provide a short demo on computation. Taught in Beaufort at Duke Marine Lab. Online course. Instructor: Clark. 2 units.

757. Current Issues in Protected Area Management. Principles of management of protected areas. Topics vary and include wilderness, national park, or international protected areas. Focus on legal and historical frameworks, ecological and social issues, and development and practical application of terrestrial protected area management techniques. Lecture and class discussion of topics. Required 1-day field trip to NC wilderness area. Undergraduates may enroll by permission of instructor. Prerequisite: introductory ecology. Instructor: Swenson. 3 units.

759K. Environmental GIS. Core concepts and latest application of geographic information system in environment area; an in-depth overview of the key data types (raster and vector files) in this area, data collection and entry, data management, data analysis and output using ArcGIS; introduction of application of GIS in real world problem solving, such as species habitat mapping and conservation planning. Students will be exposed to Google Earth, QGIS and other open source GIS tools. Taught in China at Duke Kunshan University. Instructor: Li. 3 units.

760A. Western Field Trip. One-week trip to observe land management and utilization practices in the western United States. Exposure to ecological, economic, and policy issues, as well as watershed, wildlife, and land use questions. May be repeated for credit. Consent of instructor required. Instructor: Staff. 1 unit.

761. Geospatial Analysis for Conservation Management. Application course focusing on spatial analysis and image processing applications to support conservation management. Habitat mapping, spatial analysis of animal movements, habitat modeling, and the optimization of nature reserve selection. Requires a fundamental knowledge of geospatial analysis theory and analysis tools. Consent of instructor required. Prerequisite: Environment 559. Instructor: Fay. 4 units.

762. Environmental Mega-Trends. Course investigates major, over-arching trends in environmental science, policy, thought, and practice and likely trajectories for the coming 25 years. Goal is to understand these trends and assess how changes in the environment might impact - and be impacted by - society, from the scale of individual decisions to global economies. Individual topics driven by emerging issues that are of most pressing interest but also that may not have immediately obvious connections to contemporary environmental discussions. Instructor: Doyle. 1.5 units.

763. Forest Management Traveling Seminar. Covers current topics in the broad field of forest management. Taught as a set of coordinated field trips with expert contacts in sites in the Carolina piedmont, coastal plain, and mountains. Topics of past seminars include fiber utilization, best management practices, forest regeneration, the chip mill issue, forest-pest management, and forest preservation management. May be repeated for credit. Instructor: Richter. 1 unit.

764. Applied Differential Equations in Environmental Sciences. General calculus and analytic geometry review; numerical differentiation and integration; analytic and exact methods for first and second order ordinary differential equations (ODE); introduction to higher order linear ODE, numerical integration of ODEs and systems of ODEs; extension of Euler's method to partial differential equations (PDE) with special emphasis on parabolic PDE. Example applications include population forecasting, soil-plant-atmosphere water flow models, ground water and heat flow in soils, and diffusion of gases from leaves into the atmosphere. Prerequisite: Mathematics 21 or equivalent or consent of instructor. Instructor: Katul. 3 units.

765. Geospatial Analysis for Coastal and Marine Management. Application course focusing on spatial analysis and image processing applications to support coastal and marine management. Covers benthic habitat mapping, spatial analysis of marine animal movements, habitat modeling, optimization of marine protected areas. Requires fundamental knowledge of geospatial analysis theory and analysis tools. Consent of instructor required. Prerequisite: Environment 559. Instructor: Halpin. 4 units.

766A. Ecology of Southern Appalachian Forests. Field trips to various forest ecosystems in the southern Appalachian Mountains. Species identification, major forest types, field sampling, and history of effects of human activities. Instructor: Richter. 1 unit.

766DA. Ecology of Southern Appalachian Forests. Field trips to various forest ecosystems in the southern Appalachian Mountains. Species identification, major forest types, field sampling, and history of effects of human activities. Instructor: Richter. 1 unit.

767. Entrepreneurial Experience. Teaches marketing, finance and business planning within the context of forming a start-up. Core concepts include: establishing a value proposition; identifying an opportunity; intellectual property and technology management; marketing & financing a start-up; and exiting a company. The course has a technology focus, but many of the concepts apply to any start-up activity. Students will form teams to go through all the steps required to form a business, stopping short of executing legal agreements to do so. The experience is an ideal springboard for students who want to start a company or be part of an early-stage company in the future. Instructor: von Windheim. 3 units.

767D. Entrepreneurial Experience. Teaches marketing, finance and business planning within the context of forming a start-up. Core concepts include: establishing a value proposition; identifying an opportunity; intellectual property and technology management; marketing & financing a start-up; and exiting a company. The course has a technology focus, but many of the concepts apply to any start-up activity. Students will form teams to go through all the steps required to form a business, stopping short of executing legal agreements to do so. The experience is an ideal springboard for students who want to start a company or be part of an early-stage company in the future. Instructor: von Windheim. 3 units.

768. GIS for Water Quantity and Quality Assessment. Spatial analysis and image processing applications to support water resources management: water quality, flooding, and water supply primarily at watershed scale. Topics include water resources data modeling, terrain modeling and processing, river and watershed network analysis, and geospatial modeling of hydrologic processes. Knowledge of geospatial analysis theory and analysis tools. Instructor: Kumar. 3 units.

769. Hydrologic Modeling for Water Quantity and Quality Assessment. Hydrologic modeling concerns itself with understanding and prediction of different components of the hydrologic cycle by solving abstract representations of respective hydrologic processes. Students acquire an in-depth understanding of how and where hydrologic models can be used, and will be prepared to address water quantity and quality problems using computer models. Course will discuss in detail the assumptions, limitations and uncertainty associated with different modeling strategies. Course addresses both surface and ground water processes. Models discussed in course include TopModel, Stanford Watershed Model, HEC-HMS, SWAT, HSPF, RUSLE, SPARROW, PIHM, etc. Instructor: Kumar. 3 units. C-L: Civil and Environmental Engineering 687

770A. Physical Oceanography. Fundamental physical principles of ocean circulation. Physical properties of seawater; forces acting on the ocean such as heat, pressure gradients, wind stress, rotation, and friction; and conservation equations for heat, mass and momentum. Applications include geostrophic balances, thermal wind, coastally trapped waves, El Nino/ENSO, and tidal circulation. Taught in Beaufort at Duke Marine Lab. Prerequisite: prior course work in calculus and physics or permission of instructor. Instructor: Hench. 3 units.

771L. GIS Field Skills. Covers integration of GPS and GIS technology for field data collection. Data is set up in ArcGIS in lab, exported to GPS units, field data to be collected, and imported back to GIS system. ArcGIS Personal Geodatabase is the fundamental data structure. Course covers data accuracy and precision and how to use base stations to correct data differentially for highest possible accuracy. Will discuss how to determine what GPS unit is necessary for project accuracy needs. Prerequisite: Environment 559. Instructor: Harrell. 2 units.

773A. Marine Ecology. 4 units. C-L: see Biology 773A

773L. Marine Ecology. 4 units. C-L: see Biology 773L

773LA. Marine Ecology. 4 units. C-L: see Biology 773LA

774. One Health: From Philosophy to Practice. 3 units. C-L: see Global Health 771

775. Ocean and Coastal Law and Policy. Explores law, policies and attitudes that affect US ocean and coastal resources. Using case studies and other materials, examines use, management and protection of coasts and oceans. Government and private sector approaches to ocean and coastal resources such as, wetlands, estuaries, beaches, reefs, fisheries, endangered species and special areas. Instructor consent required. Instructor: Roady. 3 units.

776. Marine Mammals. Ecology, social organization, behavior, acoustic communication, and management issues. Focused on marine mammals in the southeastern United States (for example, bottlenose dolphin, right whale, West Indian manatee). The biology of cetaceans, pinnipeds, sirenians, and sea otters. Detailed consideration given to the adaptations that allow these mammals to live in the sea. Evaluation of the scientific, ethical, and aesthetic factors influencing societal attitudes toward these animals and of their conservation management in light of domestic legislation and international treaties. Instructor: Read. 3 units.

776A. Marine Mammals. Ecology, social organization, behavior, acoustic communication, and management issues. Focused on marine mammals in the southeastern United States (for example, bottlenose dolphin, right whale, West Indian manatee). Only open to undergraduates under Biology 376A. Taught in Beaufort at Duke Marine Lab. Prerequisite: introductory biology. Instructor: Read. 3 units.

776L. Marine Mammals. Laboratory version of Environment 776. Laboratory exercises consider social organization and acoustic communication in the local bottlenose dolphin population. Recommended prerequisite: introductory biology. Instructor: Read. 4 units.

776LA. Marine Mammals. Laboratory version of Environment 776LA. Laboratory exercises consider social organization and acoustic communication in the local bottlenose dolphin population. Taught in Beaufort at Duke Marine Lab. Prerequisite: introductory biology. Instructor: Read. 4 units.

777A. Biology and Conservation of Sea Turtles. Essential biology of sea turtles (evolution, anatomy, physiology, behavior, life history, population dynamics) and their conservation needs, emphasizing their role in marine ecosystem structure and function. Will integrate basic ecological concepts with related topics including conservation and management of endangered species, contributions of

technology to management of migratory marine species, role of research in national and international law and policy, and veterinary aspects of conservation. Taught in Beaufort at Duke Marine Lab. Field trip to Puerto Rico is required. Instructor permission is required. Prerequisite: introductory biology. Instructor: Godfrey or staff. 3 units.

777L. Biology and Conservation of Sea Turtles. Biology including the anatomy, physiology, behavior, life histories, and population dynamics of sea turtles linked to conservation issues and management. Focus on threatened and endangered sea turtle species, with special attention to science and policy issues in United States waters. Includes field experience with the animals and with their habitat requirements. Sea turtle assessment and recovery efforts, fishery-turtle interactions, population modeling and state/national/international management efforts. Only to undergraduates as Biology 375L. Recommended prerequisite: introductory biology. Instructor: Godfrey or staff. 4 units.

777LA. Biology and Conservation of Sea Turtles. Biology including the anatomy, physiology, behavior, life histories, and population dynamics of sea turtles linked to conservation issues and management. Focus on threatened and endangered sea turtle species, with special attention to science and policy issues in United States waters. Includes field experience with the animals and with their habitat requirements. Sea turtle assessment and recovery efforts, fishery-turtle interactions, population modeling and state/national/international management efforts. Only open to undergraduates under Biology 375LA. Taught in Beaufort at Duke Marine Lab. Prerequisite: introductory biology. Instructor: Godfrey or staff. 4 units.

778L. Comparative Physiology of Marine Animals. 4 units. C-L: see Biology 778L

778LA. Comparative Physiology of Marine Animals. 4 units. C-L: see Biology 778LA

780. Environmental Exposure Analysis. Course will explore different routes by which people are exposed to contaminants through daily behaviors including exposure factors, inhalation exposure, dietary exposure, water exposures, statistical methods. Various experimental techniques used to measure exposure will be introduced, reviewed and discussed; will also explore statistical approaches used to evaluate variables contributing to exposure. Students will gain thorough understanding of how to develop an effective exposure assessment experiment and how to use various mathematical models to quantify this exposure. Prerequisites: ENVIRON 710 statistics; college level general chemistry, or consent of instructor. Instructor: Zhang and Stapleton. 3 units.

781K. Narrating Nature: Documentaries For Environmental Studies. Evaluate and illustrate how film documentary media can help communicate, critique, and educate the public about the complex environmental and social issues of our times. Taught in China at Duke Kunshan University. Instructor: Rojas-Sotelo. 3 units.

782. Marketing for Environmental Professionals. Focus of course is foundations of entrepreneurial activity within the context of environmental sciences and policy. Course concentrates on new enterprises based on substantial technology innovations with potential for high growth and funding by venture capitalists. Format is readings, lectures and case discussion with practical exposure to all basic operational tools required to start up and operate a company. Instructor: von Windheim. 3 units.

784LA. Sound in the Sea: Introduction to Marine Bioacoustics. Fundamentals marine bioacoustics with focus on current literature and conservation issues. Topics include: intro acoustics; acoustic analysis methods and quantitative tools; production/recording of sound; ocean noise; propagation theory; active/passive acoustics; hearing, sound production and communication in marine organisms, potential impacts of anthropogenic noise; and regulation of marine sound. Lab focus on methodologies for generating, recording and analyzing marine sounds. Grad students responsible for additional acoustic analyses and results prep for student projects plus preparation additional lit review/critique. Taught in Beaufort at Duke Marine Lab. Prerequisite: AP or introductory biology or consent; Physics 41L or 161L (or equivalent) or consent. Instructor: Nowacek. 4 units. C-L: Biology 784LA, Electrical and Computer Engineering 784LA

786. Marine Policy. Formal study of policy and policy-making concerning the coastal marine environment. History of specific marine-related organizations, legislation, and issues and their effects on local, regional, national, and international arenas. Topics explored through use of theoretical and methodological perspectives, including political science, sociology, and economics. Instructor: Murray. 3 units.

786A. Marine Policy (A). Formal study of policy and policy-making concerning the coastal marine environment. History of specific marine-related organizations, legislation, and issues and their effects on local, regional, national, and international arenas. Topics explored through use of theoretical and methodological perspectives, including political science, sociology, and economics. Consent of instructor required. Taught in Beaufort at Duke Marine Lab. Instructor: Murray. 3 units. C-L: Public Policy 849A, Political Science 707A

787A. Analysis of Ocean Ecosystems. The history, utility, and heuristic value of the ecosystem; ocean systems in the context of Odum's ecosystem concept; structure and function of the earth's major ecosystems. Open to undergraduates only under Biology 272A. Taught in Beaufort at Duke Marine Lab. Prerequisite: one year of biology, one year of chemistry, or consent of instructor. Instructor: Johnson. 3 units.

788LA. Biodiversity of Marine Invertebrates. An introduction to the biodiversity represented by major marine invertebrate groups, with emphasis on the diversity of body forms and behaviors and on anatomical structures and functions. Field trips primarily by boat allow students to explore invertebrates characteristic of a variety of coastal habitats in North Carolina, including mud flats, sandy beaches, salt marshes, oyster reefs, piers and docks, and the water column. Live invertebrates maintained in the laboratory serve as models for detailed study of form and function. Taught in Beaufort at Duke Marine Lab. Instructor: Van Dover, Silliman. 4 units. C-L: Biology 777LA

790. Special Topics. Content to be determined each semester. May be repeated. Instructor: Staff. Variable credit.

790A. Duke-Administered Study Away: Special Topics. Content to be determined each session. Instructor: Staff. Variable credit.

790D. Special Topics. Content to be determined each semester. May be repeated. Instructor: Staff. Variable credit.

790L. Special Topics. Content to be determined each semester. May be repeated. Instructor: Staff. Variable credit.

790SA. Duke-Administered Study Away: Special Topics. Content to be determined each session. Instructor: Staff. Variable credit.

791. Independent Studies and Projects. Directed readings or research at the graduate level to meet the needs of individual students. Consent of instructor required. Units to be arranged. Instructor: Staff. Variable credit.

792. Wetlands of Coastal North Carolina. This field based course explores the ecology and management of coastal wetlands North Carolina. Wetlands included in the course include Pocosin bogs, bottomland hardwoods, cedar swamps, freshwater marshes and coastal saltmarshes. Field measurements are taken for water quality, soils and vegetation. Analysis includes the effects of sea level as well as urban coastal development, farming and forestry rise on coastal wetland communities. Students are required to be enrolled in or have taken a wetland or aquatic ecology course. Instructor consent required. Instructor: Richardson. 1 unit.

795. Community-Based Environmental Management Practicum. Course is designed for students who wish to learn theory, skills and tools necessary for working with communities to manage their own environment. Course includes in-class lectures, discussions of readings, guest speakers and an in-depth client project with a local community-based environmental organization. Topics will include: community organizing; assessing and capturing resources; participatory planning and evaluation; participatory monitoring; outreach and social marketing; and political action for environmental change. Second of two required courses for the Community-Based Environmental Management certificate (NSOE only). Prerequisite: Environment 755. Instructor: Shapiro. 3 units.

796. Financial Foundations for Environmental Managers. An introductory finance course designed to cover a broad range of finance topics with the goal of creating a requisite level of financial comprehension. Closely related to the field of Economics, Finance entails the study and practice of asset pricing, money flows and the financial markets. From an applied perspective, it provides the means to understand pricing and the valuation of future cash flows, and in its many disciplines it comprises a critical underpinning of both professional and personal management. Financial decision-making fields of practice such as accounting, budgeting, and investing are cornerstones of modern society and have tremendous environmental implications. Instructor: Bachman. 3 units.

798. Communicating Outside the Box: Effective Science Communications and Research Translation Skills. Course primarily aimed at late-stage doctoral students who wish to translate their own research to audiences outside of the academy. Students will develop skills to effectively communicate science and research to non-academic audiences using a variety of methods and will develop and implement a research translation/communication strategy for their own research. Specific topics include underlying theories and frameworks, science and advocacy, environmental justice/community-based research, science and K-12 education, expert testimony, communicating with media, and communicating with policy makers. Prerequisite: consent of instructor. Instructor: C. Clark. 2 units.

799S. Topics in Ecological Genomics. This graduate seminar explores how genomic approaches are impacting research in ecology and environmental biology. The course is targeted to PhD or research-active masters students interested in genomics, genetics, ecology, ecotoxicology, conservation genetics, environmental sciences, and/or computational biology. Discussions will focus on case studies from primary literature, and computer labs will allow hands-on use of current programs. May be repeated. Wernegreen. 1 unit. C-L: Science & Society 799S

800. Professional Communications for MEM and MF Students. Skills-building in professional communication, emphasizing visual communication and speaking. Oral presentations, written document design, graphic display of information, presentation software, and giving and receiving constructive feedback on projects in these areas. Open only to MEM and MF students. Instructor: Vidra. 1 unit.

801. Topics in Experiential Learning for Environmental Management. Field trips, short courses, guest lectures series and other learning experiences that bring students into practice of environmental management and bring environmental managers to students. Example of topics include sustainable energy and sustainable forest practices. Main mode of instruction: face-to-face participation by students in learning experiences designed by environmental managers; some sections will also include background reading and student project work. Grading: pass/fail, with attendance at all class sessions and completion of any projects required to pass. MEM/MF students may count up to a total of 3 credits toward 48 credits required for the degree. Registration limited to Nicholas School MEM/MF students; undergraduates and PhD students may participate on a non-credit basis if space is available. Fall and Spring. Instructor: Staff. Variable credit.

802. Program Management for Environmental Professionals. Overview of principles of program management, with application to diverse environmental professions. Lectures, case studies and discussion focus on topics including leadership, organizational structures, managing complex systems, adaptive management, risk and uncertainty, and advocacy within an organization. MEM and MF students only. Instructors: Staff. 3 units.

805K. Environmental Economics. An overview of environmental economics by introducing analytical methods and tools to analyze environmental problems and identify policy solutions; including 1) a microeconomic foundation of environmental economics, with a focus on market efficiency and market failures; 2) environmental policy decision tools, such as benefit-cost analysis and cost-effectiveness criterion; 3) environmental regulation, with topics covering command-and-control regulation, market-based approaches, and behavioral interventions. Instructor: Zhang. 3 units.

806. Duke Forest Practicum. Designed to focus on practical skills required of land managers in a variety of settings, including conservation organizations, government, and industrial and non-industrial forestland ownerships. The management plan of the Duke Forest will serve as a guide and example for specific resource and administrative considerations. Classroom and field settings provide hands-on experience with range of topics, including elements of a forest management plan, certification and best management practices, timber sales planning and administration, conservation easements, wildlife management, and recreation management. Open only to MEM and MF students. Instructor: Palmroth. Variable credit.

806K. Environmental Economics II. This course provides for continued development and practice of skills learned in Statistics and Program Evaluation and Environmental Economics. Students develop conceptual and professional skills related to environmental

policy evaluation. The goal is to stimulate critical thinking about today's environmental problems and the public policies designed to improve them by implementing the theories and principles acquired in class. Prerequisites: Public Policy 870K and Environment 805K or instructor consent. Taught at Duke Kunshan University. Instructor: Kim. 3 units.

808. Aquatic and Wetland Field Skills. Introduces students to basic techniques of data collection and application of field indicators in wetlands. In the course students will monitor wetland hydrology, soils and plant communities for research purposes and for jurisdictional determination of wetland boundaries using U.S. Army Corps of Engineers protocols. Instructor: Flanagan. 3 units.

809. Wetland Restoration Ecology. Restoration of wetlands requires understanding of wetland hydrology, biogeochemical processes, decomposition, community habitat requirements and soil processes. Factors are discussed in an ecosystem context along with current restoration techniques. Course utilizes newly constructed wetlands in Duke Forest to explore wetland restoration principles. Students teamed together to develop restoration plan for a restored wetland. Final report and oral presentation required. Instructor: Richardson. 3 units.

810. Topics in Environmental and Ecological Statistics. Project-based course on environmental and ecological statistics for PhD/MS students. Students work on specific data analysis projects associated with current research. Class consists of modules based on specific topics. Students required to complete introduction module and one additional module. Presentation and discussion of projects after introduction module required. Objective of class to provide statistical guidance in students' thesis research work. Instructor: Staff. 3 units.

811. Business and Environment. Theoretical grounding on Sustainable Systems (SS) thinking and overview of national and international frameworks that have led to development and use of sustainable systems modeling, life cycle analysis and policy decision models. Topics include socio-metabolic consumption, sustainability as a field of inquiry, systems thinking, industrial ecology, earth systems engineering, complexity and resiliency. Explore current drivers and implications of sustainable systems with specific focus on nexus of industry and environmental systems including examining cumulative impacts and benefits resulting from shifting supply chains, green engineering, technological designs and consumer behavior. Instructor: Gallagher. 3 units. C-L: Energy 811

811D. Business and Environment. Theoretical grounding on Sustainable Systems (SS) thinking and overview of national and international frameworks that have led to development and use of sustainable systems modeling, life cycle analysis and policy decision models. Topics include socio-metabolic consumption, sustainability as a field of inquiry, systems thinking, industrial ecology, earth systems engineering, complexity and resiliency. Explore current drivers and implications of sustainable systems with specific focus on nexus of industry and environmental systems including examining cumulative impacts and benefits resulting from shifting supply chains, green engineering, technological designs and consumer behavior. Instructor consent required. Instructor: Gallagher. 3 units. C-L: Energy 811D

812. Wetlands Ecology and Management. The study of bogs, fens, marshes, and swamps. Emphasis on processes within the ecosystem: biogeochemical cycling, decomposition, hydrology, and primary productivity. Ecosystem structure, the response of these systems to perturbations, and management strategies are discussed. A research project is required. Prerequisites: one course in ecology and chemistry. Instructor: Richardson. 3 units.

813. Advanced Environmental Toxicology. Discussion of current issues. Topics vary but may include chemical carcinogenesis in aquatic animals; biomarkers for exposure and sublethal stress in plants and animals; Discussion of current issues. Topics vary but may include chemical carcinogenesis in aquatic animals; biomarkers for exposure and sublethal stress in plants and animals; techniques for ecological hazard assessments; and means of determining population, community, and ecosystem level effects. Lectures and discussions led by instructor, guest speakers, and students. Prerequisite: Environment 501. Instructor: Di Giulio. 3 units.

814. Integrated Case Studies in Toxicology. 1 unit. C-L: see Pharmacology and Cancer Biology 814

815. Focused Topics in Toxicology. A contemporary advanced toxicology research area covered with readings from the current primary literature. An integrative review of the topic prepared as a collaborative effort. Consent of instructor required. Prerequisites: Pharmacology 533 and 847S. Instructor: Levin. 1 unit. C-L: Pharmacology and Cancer Biology 815

816. International Climate Change Negotiations Practicum. Climate change promises to impact almost every aspect of life on earth across the globe. It is an issue that, because of the diffuse nature of its causes and solutions, will require a global solution. Since the Rio Earth Summit in 1992, the United Nations Framework Convention on Climate Change (UNFCCC) has been the primary forum for the negotiation of international agreements concerning climate change. Students will learn about primary issues involved in negotiation of international climate change agreements under UNFCCC and train them to take part as a stakeholder with the intention of developing students' analytical thinking through experiential learning at international level. Instructor: Shapiro. 3 units.

819. Mechanisms in Environmental Toxicology. Provides an in-depth examination of key molecular and biochemical mechanisms by which organisms defend themselves against environmental pollutants. Cellular mechanisms by which chemicals produce toxicity when the defense systems are overwhelmed will be addressed. Includes examinations of "state of the art" approaches for experimentally elucidating these phenomena. Course format will be that of a graduate seminar, with lectures given and discussions led by the instructors, guest speakers, and course participants. Prerequisites: one course in biochemistry and one course in toxicology. Instructors: DiGiulio. 3 units.

820S. Conservation Ethics. Students will delve into the tension between science and advocacy through the lens of environmental ethics. Students will gain a strong foundation in principles of environmental ethics, drawing from the rich literature on this topic from the fields of philosophy and ethics, environmental communications and education, and conservation ecology. Seminar-style course requires students to actively lead and participate in weekly discussions, write a series of essays and collaboratively design and initiate a semester project. Ultimately, the course is about reflecting on not just the academic literature and individual scenarios but seriously considering the role our own values play in our work. Instructor: Vidra. 3 units.

821. Advanced Readings in Soil Science. An advanced discussion course based on readings that concern current critical topics in the soil sciences. Readings are selected from both basic and applied aspects of the field. Instructor: Richter. 1 unit.

822A. Coastal Watershed and Policy. Examine hydrology of coastal watersheds and how watersheds modifications impact estuaries and near shore coastal ecosystems. Hydrologic functioning of natural unaltered watersheds is contrasted with changes caused by man's modification of those systems. Include discussion of efforts to remedy impacts through installation of Best Management Practices and wetlands restoration. Emphasis on gaining understanding of what the impacts of hydrologic change are on biology of coastal waters as watershed development alters the physics, chemistry, and geology of coastal waters. Includes field trips to watersheds in coastal North Carolina. Taught in Beaufort at Duke Marine Lab. Instructor: Hunt. 3 units.

823. Ecological Resilience and Ecosystem Management. Course provides an introduction to concepts of ecological resilience and its application to the management of ecological systems, and is intended for both PhD and MEM students. The course does not require formal mathematical training, but students are expected to engage the models used in this field. Course consists of lectures, discussion, and a group research project. Lectures will address fundamental theory, case studies, and empirical approaches used to understand the resilience of basic ideas, observations, and approaches to understanding the ecology of flowing water systems. Instructor: Heffernan. 3 units.

824A. Marine Conservation Biology. Introduction to marine conservation in a small island context with an exploration of how traditional and modern methods play out in practice. Most of the course will be taught in Palau, where students will meet traditional chiefs, fishers, state governors, NGO practitioners, scientists and politicians to hear their perspectives on marine conservation. The course will focus on the theory and practice of marine conservation, as exemplified by case studies in traditional management, marine protected areas, conservation of protected species and ecotourism. Taught in Beaufort at Duke Marine Lab. Trip to Palau required. Permission required. Instructor: Read. 3 units.

825LA. Marine Molecular Microbiology. Covers a broad overview of the ecological and biogeochemical role that microbes play in marine environments. Lab exercises focus on applying molecular techniques to the study of microbial ecology. Taught in Beaufort at Duke Marine Lab. Instructor: Hunt. 4 units.

826. Global Environmental Politics. Course examines how states and non-states actors cooperate to resolved global environmental problems. Central focus is on the creation of international environmental regimes, their implementation, and effectiveness. Case studies include climate change, ozone depletion, water sharing and dams, fisheries, biodiversity, forestries, oil pollution, sustainable development, environmental security, and trade and the environment. Instructor: Weinthal. 3 units.

827. Principles of Management. Provides introduction to business terminology and practices for environmental professionals. Introduce students to foundational concepts and language associated with the different functional areas of the firm and to some of the processes and tools available to organizational managers to enhance organizational effectiveness. Areas covered include finance and accounting, management and leadership, and organizations and strategy. Permission of instructor required. Instructor: Emery. 3 units.

829. Natural Resource Economics. Addresses questions about natural resource scarcity using modern capital theory and optimal control theory to derive core results. Two objectives: provide students with a solid foundation in theory of natural resource economics, emphasizing tools and theoretical breadth to enhance research and teaching. Second objective to highlight contemporary themes in theoretical and empirical resource economics. Designed for PhD students in economics, finance, agriculture and resource economics, or public policy (with economics concentration). Prerequisite: one year PhD-level microeconomic theory and econometrics; review of differential equations recommended. Consent of instructor required. Instructor: Smith. 3 units. C-L: Economics 753

829D. Natural Resource Economics. Addresses questions about natural resource scarcity using modern capital theory and optimal control theory to derive core results. Two objectives: provide students with a solid foundation in theory of natural resource economics, emphasizing tools and theoretical breadth to enhance research and teaching. Second objective to highlight contemporary themes in theoretical and empirical resource economics. Designed for PhD students in economics, finance, agriculture and resource economics, or public policy (with economics concentration). Prerequisite: one year PhD-level microeconomic theory and econometrics; review of differential equations recommended. Consent of instructor required. Instructor: Smith. 3 units. C-L: Economics 753D

830. Building Energy on Campus: Evaluating Efficiency and Conservation Measures at Duke. Buildings use more than 40% of the energy consumed in the US, and are a natural target of energy efficiency and conservation measures. Building owners and facility managers, as well as the policy community, are therefore interested in identifying means of reducing energy consumption in the current building stock and taking advantage of the embodied energy already sunk into its construction. Using the campus as a laboratory, course examines energy use in existing Duke buildings. Students will learn about the relationship between building design and energy use, and gain hands-on experience conducting energy audits and evaluating energy saving measures in campus facilities. Instructor: Johnson. 3 units. C-L: Energy 830

831. Sustainable Business Strategy. Businesses are increasingly applying strategic management tools to incorporate consideration of sustainability into decision-making and operations. While some businesses incorporate sustainable practices because of ethical convictions, most businesses are motivated to do so to address pressures from stakeholders such as regulators, shareholders, customers and neighbors and to exploit knowledge and experience for long term competitive advantage. Students will learn how businesses develop and implement strategies to promote sustainability by examining roles and responsibilities of sustainable strategic managers and applying tools of strategic business management to problems of sustainability. Permission of instructor required. Instructor: Gallagher. 3 units.

831D. Sustainable Business Strategy. Businesses are increasingly applying strategic management tools to incorporate consideration of sustainability into decision-making and operations. While some businesses incorporate sustainable practices because of ethical convictions, most businesses are motivated to do so to address pressures from stakeholders such as regulators, shareholders, customers and neighbors and to exploit knowledge and experience for long term competitive advantage. Students will learn how businesses develop and implement strategies to promote sustainability by examining roles and responsibilities of sustainable strategic managers and applying tools of strategic business management to problems of sustainability. Permission of instructor required. Instructor: Gallagher. 3 units.

832. Environmental Decision Analysis. Quantitative methods for analyzing environmental problems involving uncertainty and multiple, conflicting objectives. Topics include subjective probability, utility, value of information, multi-attribute methods. Students will apply these tools to an environmental policy decision in a group project. Prerequisite: introductory applied statistics or equivalent. Instructor: Albright. 3 units.

834S. Environmental Social Science Research Workshop. Seminar format designed to give graduate students in environmental social sciences a venue to present research proposals and preliminary work. Emphasis is on application of social science research methods. Includes presentations by faculty and students. Intended for doctoral students in environmental social sciences. Students wishing to earn more than one credit will prepare an additional separate paper on topic with approval of instructor. Permission of instructor required. Instructor: Kramer or Smith. Variable credit.

835. Environmental Law. Examination of rapidly growing body of law concerned with interrelationships between human activities and the larger environment. Focus on rationales for environmental protection; risk assessment and priorities. Instructor: Wiener. 3 units. C-L: Energy 835

835K. Environmental Law. Emphasizing the practical use and application of legal concepts within the context of pollution control and resource management; exploring the role of law, regulation and governance in protecting, managing and restoring the environment and natural resources. Taught in China at Duke Kunshan University. Instructor: Furst. 3 units.

836. Seabird Survival and Dispersal Analysis. Client-inspired class held at the Dry Tortugas National Park (near Key West). The principal field activity will be catching, ringing and measuring sooty terns as part of a National Park Service effort. The graduate version of this course has close similarities to the undergraduate class. Both classes will travel together and be expected to catch, ring and process the same numbers of birds. The graduate version differs in the written expectations. These vary somewhat, but have included very extensive documents that eventually comprised the student's master's project and considerable post-trip involvement with the professor and Park Service personnel—such projects are encouraged but not guaranteed. Instructor consent required. Prerequisite: Environment 703. Instructor: Pimm. 2 units.

838. Environmental Modeling: A Bayesian Perspective. Introduction to Bayesian hierarchical and Bayesian networks models and their applications in water quality modeling and assessment. Offered in Spring. Instructor: Reckhow. 2 units.

840. Ecology and Conservation of Gabon. Field course to study environmental problems, challenges and aspirations of Gabon, W. Africa. Goal is to expose students to Gabon's natural ecosystems and its development challenges and to think critically about development trade-offs. Study of coastal ecosystems & interior tropical forests including drivers of environmental degradation & destruction: subsistence agriculture, large-scale logging, industrial agriculture, mining & hunting/poaching. Field research & evaluation of environmental policy options, examining role of human and industrial impacts on the environment. Prerequisite: graduate course in Tropical Ecology or Conservation Biology/Management. Course may be repeated. Instructor consent required. Priority to students with French language skills. Instructor: Poulson. 1 unit.

841. Ecological Perspectives: Evolution to Ecosystems. 4 units. C-L: see University Program in Ecology 701; also C-L: Biology 841, Evolutionary Anthropology 741

842. Ecological Perspectives: Individuals to Communities. 4 units. C-L: see University Program in Ecology 702; also C-L: Biology 842, Evolutionary Anthropology 742

847S. Seminar in Toxicology. 1 unit. C-L: see Pharmacology and Cancer Biology 847S

848S. Seminar in Toxicology. A weekly research seminar throughout the year is required of participants in the Toxicology Program. Students, faculty, and invited speakers present their findings. Instructor: Levin. 1 unit. C-L: Pharmacology and Cancer Biology 848S

849A. Doctoral Student Seminar and Professional Development. Addresses topics of relevance to the professional development of PhD students in the Marine Science Conservation program. Topics addressed include: the nature of inter-disciplinary research, critical reading, grant writing, communicating results to the public, mentoring students, and preparing manuscripts for academic journals. Taught in Beaufort at Duke Marine Lab. Instructor: Campbell. 2 units.

850. Program Evaluations of Environmental Policies. Designed to give students foundation in methods and applications of quantitative program evaluation in environmental policy. Program evaluation seek to identify casual effect of program/regulation/policy on some outcome of interest using statistical methods. Students will learn major empirical methods in program evaluation and apply them to current environmental policies. Instructor: Bennear. 3 units.

851S. Environment and Development Economics. Readings course surveys range of important natural resource and environmental issues in developing countries. Emphasizes use of economic principles to understand these issues and to formulate effective policy responses to them. Course has theoretical content, but deals with theory more qualitatively than mathematically. Provides an opportunity for learning how economic theory taught in other courses can be applied to natural resource and environmental issues in developing countries. Course objective: familiarize students with key portions of literature on environment and development economics and foster students' abilities to read this literature critically and after graduation. Instructors: Vincent or Pattanayak. 1.5 units. C-L: Public Policy 827S

852. Spatial Analysis for Ecologists. Descriptive and inferential statistics for spatial data as encountered in community and landscape ecology. Course covers spatial point patterns (e.g., clustering in plant communities), geostatistical samples (e.g., species-environment relationships inferred from spatially distributed samples), and lattices (e.g., maps, networks). Emphasis on hands-on applications with ecological data sets. Students may analyze their own datasets as a term project. Prerequisites: Introductory statistics, basic ecology, or consent of instructor. Taught in alternate, odd-numbered years, spring semester. Instructor: Urban. 3 units.

853. Advanced Topics in Landscape Ecology. Small groups of students working together to complete a project in landscape analysis integrating remote sensing, geographic information systems, spatial analysis, and simulation modeling. Expectation is that each student will have experience in at least one of these areas. Consent of instructor required. Offered on demand. Instructors: Halpin and Urban. Variable credit.

854. GIS Analysis for Conservation Management. This course explores applications of geographic and spatial analysis to conservation management issues such as habitat analysis, biodiversity protection assessments, and nature reserve design. The primary goals of the course are: (1) to critically assess the theoretical underpinnings of conservation analysis techniques; and (2) to develop a high level of proficiency in the application of geographic and spatial analysis techniques for conservation management problems. Prior experience with GIS systems and consent of instructor required. Instructors: Halpin and Urban. 3 units.

856. Environmental Fluid Mechanics. Introduction to turbulent fluid flow and Navier Stokes equations; basic concepts in statistical fluid mechanics; development of prognostic equations for turbulent fluxes, variances, and turbulent kinetic energy; Monin and Obukhov similarity theory for stratified turbulent boundary layer flows; applications to CO2, water vapor, and heat fluxes from uniform and nonuniform surfaces; the local structure of turbulence and Kolmogorov's theory; turbulent energy transfer and energy cascade between scales; turbulence measurements in the natural environment. Prerequisite: Civil Engineering 301L, Mathematics 230, or equivalent. Instructor: Katul. 3 units.

858. Multivariate Analysis for Ecologists. All of nature is multivariate, and this course embraces this richness. Two general approaches include classification (creating discrete groups) and ordination (emphasizing continuous trends in data). Ecological applications include habitat classification and species distribution modeling, clustering (i.e., community classification), and ordination-based approaches to integrated assessment. Prerequisites: Introductory statistics, basic ecology, or consent of instructor. Taught alternate (even-numbered) years, spring semester. Instructor: Urban. 3 units.

859. Advanced Geospatial Analysis. Provide training in more advanced skills such as: GIS database programming, modeling applications, spatial decision support systems and Internet map server technologies. The course requires a fundamental knowledge of geospatial analysis theory, analysis tools, and applications. Consent of instructor required. Prerequisite: Environment 559 and Environment 761, 765, or 789. Instructor: Fay. 3 units.

859A. Advanced Geospatial Analysis. Provide training in more advanced skills such as: GIS database programming, modeling applications, spatial decision support systems and Internet map server technologies. The course requires a fundamental knowledge of geospatial analysis theory, analysis tools, and applications. Taught in Beaufort at Duke Marine Lab. Recommended prerequisite: Environment 559 and Environment 761, 765, or 789. Instructor consent required. Instructor: Fay. 3 units.

859D. Advanced Geospatial Analysis. Provide training in more advanced skills such as: GIS database programming, modeling applications, spatial decision support systems and Internet map server technologies. The course requires a fundamental knowledge of geospatial analysis theory, analysis tools, and applications. Consent of instructor required. Prerequisite: Environment 559 and Environment 761, 765, or 789. Instructor: Fay. 3 units.

859DA. Advanced Geospatial Analysis. Provide training in more advanced skills such as: GIS database programming, modeling applications, spatial decision support systems and Internet map server technologies. The course requires a fundamental knowledge of geospatial analysis theory, analysis tools, and applications. Taught in Beaufort at Duke Marine Lab. Recommended prerequisite: Environment 559 and Environment 761, 765, or 789. Instructor consent required. Instructor: Fay. 3 units.

860SA. Political Ecology. Seminar to examine concept of political ecology as means of conceptualizing conservation and development conflicts and solutions. Intended to engage students with political ecology to strengthen usefulness, enrich possibilities, and improve participants ongoing research, collaborations and critical inquiries. Enrollment limited to graduate students. Taught in Beaufort at Duke Marine Lab. Instructor: Campbell. 3 units.

865SA. College Teaching and Course Design. Designed for graduate students seeking to teach an independent course at Duke and beyond; topics include models of course design, syllabus construction, critical thinking, college student development, clarifying learning objectives, variety in assignments, and classroom assessment techniques. Taught in Beaufort at Duke Marine Lab. Instructor: Murray. 2 units.

868. Natural Resources Law. 2 units. C-L: see Law 368

869. Environmental Law Clinic. Under Law faculty supervision, students work on interdisciplinary teams to solve nonprofit clients' legal and policy problems. Students gain hands-on, skills-based professional experience. Clinic follows Law School's academic calendar. Minimum 100 client work hours plus weekly seminar; mandatory, all-day intensive, typically 2nd Friday of semester; no dropping after 1st class. Nicholas School students may enroll starting in their second semester. Suggested corequisite: Environment 835. More information is available at: https://law.duke.edu/envlawpolicy/. Instructor: Longest, Nowlin. 4 units.

869D. Environmental Law Clinic. Under Law faculty supervision, students work on interdisciplinary teams to solve nonprofit clients' legal and policy problems. Students gain hands-on, skills-based professional experience. Clinic follows Law School's academic calendar. Minimum 100 client work hours plus weekly seminar; mandatory, all-day intensive, typically 2nd Friday of semester; no dropping after 1st class. Nicholas School students may enroll starting in their second semester. Suggested corequisite: Environment 835. More information is available at: https://law.duke.edu/envlawpolicy/. Instructor: Longest, Nowlin. 4 units.

870. Fire Ecology and Management. Principles underlying field of fire ecology and skillful application of fire to meet land management objectives are explored through guest lectures, training sessions, readings and assignments. Specific topics range from history of fire in America, to role of fire in landscape change, to relationship of fire to climate change. Prescribed burning and use of fire in the contemporary landscape are important topics in the class. Instructor: Richter. 1 unit.

871. Fish As Models For Disease Research. Fish serve as models for disease research in genetic regulation of development, aging, cancer and high throughput screening of drugs and toxins. Due to their importance in human nutrition, fish are a central part of resource assessment following oil spills. To better appreciate fish as models and sentinels, this course will include coverage at all levels of biological organization and will acquaint the student with current methods, approaches and analyses. Instructor: Hinton. 4 units.

872L. Environmental Data Analytics. Environmental data analytics introduces fundamental data skills needed to conduct research. We explore a variety of techniques and technologies for obtaining, re-formatting, managing, and visualizing diverse data

sets with an emphasis on developing reproducible workflows and sharing both methods and results. We will use actual environmental data (hydrologic, demographic, energy, etc.) in class exercises, but students will have the opportunity to involve their own data sets. Instructor: Salk. 3 units.

872L-1. Environmental Data Analytics. Environmental data analytics introduces fundamental data skills needed to conduct research. We explore a variety of techniques and technologies for obtaining, re-formatting, managing, and visualizing diverse data sets with an emphasis on developing reproducible workflows and sharing both methods and results. We will use actual environmental data (hydrologic, demographic, energy, etc.) in class exercises, but students will have the opportunity to involve their own data sets. Instructor: Salk. 3 units.

876A. Data and Time Series Analysis in Marine Sciences. Analysis of environmental time-series and other data sets. Topics include discrete sampling issues, data rejection and interpolation, coordinate rotations and principal axes, curve fits, regression, error and propagation of uncertainty, bootstrapping, filtering, spectral analysis, harmonic analysis, EOFs, wavelets. Lectures, workshops and homework assignments will apply these methods to environmental data sets. Each student will complete a final project, applying methods covered in class to data sets they choose, as part of or related to their research. Taught in Beaufort at Duke Marine Lab. Consent of instructor required. Instructor: Hench. 4 units.

878A. Current Topics in Marine Biology. PhD-level reading seminar to review current literature in marine biology focusing on basic ecological principles. Course will satisfy the "Current Topics" requirement in the Marine Biology track of the Marine Science and Conservation PhD degree. Students will rotate presenting primary literature on current week's topic. Although based on current primary literature, relevant classic articles will be included. Discussion will place articles in the broader context of evolution, ecology and biogeochemistry. Taught in Beaufort at Duke Marine Lab. Instructor: Hunt, staff. 2 units.

882. Religion and Media. Examines leading theoretical contributions to the study of religious media broadly understood¿from tracts to lithographs to television. Technology, mediation, network theory, ritual, and the public sphere receive careful attention. Attention focuses on leading cultural theory applied to the study of media as religious practice. Instructor: Morgan. 3 units.

886. Current Topics in Marine Conservation. Discussion of a topic of interest chosen by students with guidance from instructors. Topic is discussed from a social and natural science perspective. Open only to PhD students. Instructor: Staff. 2 units.

886A. Current Topics in Marine Conservation. Discussion of a topic of interest chosen by students with guidance from instructors. Topic is discussed from a social and natural science perspective. Open only to PhD students. Taught in Beaufort at Duke Marine Lab. Instructor: Staff. 2 units.

887A. Theory and Methods for Policy Analysis of the Commons. Survey course of main theories and methods used by scholars to understand how collective action problems and different institutional arrangements affect how common-pool resources and public goods are governed. Students are asked to design a project that incorporates some of the concepts and methodological approaches learned in class. Taught in Beaufort at Duke Marine Lab. Instructor: Basurto. 3 units.

891. Topics in Environmental Regulation. In-depth analysis of current issues in environmental regulation. Topics vary. Course may be repeated. Instructor: Bennear. 1.5 units. C-L: Energy 891

893. MEM/MF Internship Practical Training. Students gain practical environmental management or forestry experience/ training by participating in a project-based internship. Open only to Master of Environmental Management and Master of Forestry students. Instructor consent required. Instructor: Gallagher. 1 unit.

894. Writing, Publishing and Reviewing Scientific Papers. Grad students in ecology, biology, forestry & related disciplines who desire skills in the language of science and how info is disseminated. To learn to write clearly & concisely for effective communication for publication; to express scientific ideas & results and persuade others by the merits of scientific writing in peer-review & eventual publication; to find relevant articles in citation databases, to understand the publication system from the point of view of author/editor/ reviewer; what impact factors represent; how to write a convincing letter accompanying your submission & the stages of review; and develop the students' abilities to read/write/present & critique scientific literature. Instructor: Domec. 1 unit.

895. Master of Environmental Management/Forestry Internship/Project. Students gain practical environmental management or forestry experience by participating in a project-based internship. Focus areas in the Stanback Program include energy, conservation, advocacy, policy, research, or other environmental management and/or forestry practical opportunities. Open only to Master of Environmental Management or Master of Forestry students. Instructor: Gallagher. 1 unit.

896. Professional Communications. This is the first of two half credit courses in professional communications. To be taken in the first fall of enrollment in the MEM or MF degree, this course focuses on skills-building in professional communication, emphasizing visual communication and speaking. Oral presentations, written document design, graphic display of information, presentation software, and giving and receiving constructive feedback on projects in these areas. Open only to MEM and MF students. Instructor: Cagle. 0.5 units.

897. Writing a Master's Project. This is the second of two half credit courses in professional communications. To be taken in the second fall of enrollment in the MEM or MF degree, this course addresses different aspects of writing a master's project. Course will include a mixture of lecture and in-class workshopping of written materials. Course covers writing introductions, background sections, methods, writing results, discussion, conclusions, executive summaries and developing a professional website. Open only to MEM and MF students. Instructor: Cagle. 0.5 units.

898. Program Area Seminar. Required symposium in each program area. Students present master's project research. Pass/fail grading only. Instructor: Staff. 1 unit.

898A. Topic: Program Area Seminar - Duke University Marine Lab. Required symposium in each program area. Students present master's project research. Pass/fail grading only. Taught in Beaufort at Duke Marine Lab. Instructor: Staff. 1 unit.

898K. Master's Project International Master in Environmental Policy II. Designed to help students develop a master's

project (MP). Guide students in conceptualizing an idea, identifying key environmental policy question, writing a prospectus, finding an advisor, finding a client, designing an analytical approach, data collection, and a producing a draft of their project. Taught at Duke Kunshan University. Instructor: Ji. 3 units.

899. Master's Project. An applied study of a forestry or environmental management problem or a theoretical research effort. A seminar presentation of the objectives, methodology, and preliminary findings is required. A written (or other medium) report at the conclusion of the project is also required. Undertaken with the guidance of the student's adviser. Consent of instructor required. Pass/fail grading only. Instructor: Staff. Variable credit.

899K. Master's Project II. Follows after Environment 898K, in which students conceived of, designed, and completed the initial steps of their master's project (MP). Students will complete their MP and present project findings. Students will review and revise project content in peer-to-peer and instructor-to-student settings, critically evaluate their methods and data, search for new ways to leverage their findings, and tighten their resulting analysis. Required course for iMEP students. Taught at Duke Kunshan University. Instructor: Ewing. 3 units.

905. DEL: Environmental Communication for Behavior Change. Course provides environmental professionals with a practical introduction to the strategies, methods, and tools of environmental communication that effectively lead to changes in behavior. Emphasis on practical, field-based tools. Executive Education short course. Consent of instructor required. Instructor: Day. 1 unit.

906. DEL: Social Media for Environmental Communication. This six-week distance learning course is offered by Duke Environmental Leadership. Students will become competent in the basic features and functions of popular social media tools. Students will understand the advantages and limitations of these tools and be able to choose the most appropriate ones for their programs. Students will become comfortable communicating through various social media tools and be able to incorporate these tools into a larger communication plan. Executive Education short course. Online course. Instructor: Thaler, Besch, Nevius. 1 unit.

907. DEL: Writing for Environmental Professionals. Writing in environmental fields encompasses many genres, from policy memos to manuals, blog posts to interpretive signs. This course will allow you to refine and reflect on your writing process. For some, the course may serve as a tune-up; for others, a significant remodeling. Through six modules, on-line discussion, and a series of writing assignments, we will examine the move important aspects of any piece of professional writing: organization, use of evidence, clarity and cohesion, and incorporating feedback during the revision process. The goal is for your writing to become more powerful as a result of this work. Open to Duke Environmental Leadership Master of Environmental Management students only. Executive Education short course. Online course. Instructor: Cagle and Besch. 1 unit.

909. Survey of Environmental Leadership at Duke and Beyond. Students invite Duke faculty to share their perspectives on environmental leadership with a series of web conferences. Students will read a range of scholarly work from these faculty, as well as key readings in the environmental leadership literature. Grade will be based on participation in class meetings, online discussions, and a short summary paper. Consent of instructor is required. Online course. Instructor: Vidra. 1 unit.

924. DEL: Agriculture and Sustainability. Introduces agroecology through basic scientific knowledge of plant physiology and growth for crop production, crop diversity and breeding, and comparison of agricultural practices (industrial, subsistence, organic, sustainable). Covers resources needed for whole-plant growth, biomass output for human use including bioenergy, and impacts on ecosystems. Examines environmental sustainability through assessment of drawbacks and benefits of agricultural practices for human food and biofuel production. Applications include management plan for sustainable agroecosystems and forecast of crop agricultural practices in need of a future altered environment. Prerequisites: Intro Biology or Ecology. Instructor consent required. Instructor: Reid. 3 units.

931. One Health: Introduction to the One Health Approach. 2 units. C-L: see Global Health 731

932. One Health: Introduction to Environmental Health. 3 units. C-L: see Global Health 732

935. DEL: Social Science Research Methods & Design. Provides students with introduction to theory and practice of social science research methods and design. Intended for students who wish to learn both qualitative and quantitative research methods or who wish to combine natural and social science questions and methods into their research. Through lecture, discussion of readings and case studies, and review of research proposals of their peers, students will become proficient at not only social science theory, but at producing a sound and well-designed research proposal. Instructor consent required. Instructor: Shapiro. 3 units.

938. One Health: Introduction to Entomology, Zoonotic Diseases, and Food Safety. 3 units. C-L: see Global Health 735

939. One Health: Public Health Laboratory Techniques. 1 unit. C-L: see Global Health 739

955. DEL: Community-Based Environmental Management. Course combines analysis of potential problems and pitfalls involved in community-based environmental management with discussion of the tools necessary to create and manage these projects. Focus is on discussion of academic literature with presentations of specific case studies and analysis of a community program in students' proximity. Open to Duke Environmental Leadership Master of Environmental Management students only. Department consent required for all other students. Online course. Instructor: Shapiro. 3 units.

956. DEL: Restoration Science, Policy and Leadership in South Florida. One of the largest restoration efforts in the US, both in terms of area and funding, is the Everglades Restoration Project. This project provides a framework for us to explore how restoration science, policy and leadership come together to create innovative solutions, for some issues, and quagmires for others. This field course involves meeting with leaders in the restoration community and participating in restoration efforts. We will develop a framework for restoration science and policy. We will develop a comprehensive picture of the larger Everglades Restoration Project and make connections between lessons learned in Florida and in other areas. Open to Duke Environmental Leadership Master of Environmental Management students only. Department consent required for all other students. Instructor: Vidra. 1 unit.

958. DEL: Applied Qualitative Research Methods. Broadly covers qualitative and mixed methods research design, analysis, and interpretation. Students gather a limited amount of their own data and produce a pilot research project throughout the semester.

Students learn to use NVivo10, a qualitative research software program. Instructor consent required. Instructor: Clark, Charlotte. 3 units.

959. DEL: Intro to ArcGIS Pro Exercises. Learn the essential concepts you need to jump-start your productivity with ArcGIS Pro. This course introduces the ribbon-style interface, project-based organization, key capabilities, and ArcGIS Pro terminology. Instructor: Harrell. Variable credit.

960. Duke Environmental Leadership: Orientation Course: Making a Difference in the World. One-week course to introduce the curriculum of the Duke Environmental Leadership (DEL) program. Provides framework for program studies. Focus on real-world environmental challenges and timely case studies. Field studies in Durham and at Duke University Marine Lab, Beaufort, NC. Open to Duke Environmental Leadership Master of Environmental Management students only. Instructor: Vidra. 1 unit.

961. Duke Environmental Leadership: Ecosystem Science and Management. This course will explore the challenges of managing ecosystems by focusing on both structure (i.e. species, populations, communities) and function (i.e. ecosystem services), grounded in the best available science. We will examine how humans have transformed landscapes and evaluate management strategies for both terrestrial and marine systems. Students will gain the scientific grounding and the practical skills necessary to evaluate the use of science in mgmt efforts through a semester-long case study project, mini-presentations, and writing assignments. Discussions will focus on current controversies in conservation science. Open to DEL-MEM students only. Online course. Instructor: Vidra. 3 units.

962. Duke Environmental Leadership: Economics of Environmental Management. An economic perspective on the management of env. resources. Conceptual topics emphasized include env. externalities, market failure, public goods, sustainability, and benefit-cost analysis. Applications illustrate the role of price signals in energy choices, managing renewable resource use over time, use of marketable pollution permits to encourage voluntary reductions in air and water pollution, and the political economy of env. policy formulation. Case studies examine carbon trading and taxes to address climate change, and economic incentives and values for biodiversity conservation. Open to Duke Environmental Leadership Master of Environmental Management students only. Department consent required for all other students. Online course. Instructor: Holmes. 3 units.

963. DEL: Program Management for Environmental Professionals. In the private and public sectors, as well as not-for-profit organizations, managerial effectiveness is central to environmental leadership. This course will focus on the development of management skills including decision-making, motivation, working in teams, organizational cultures, organizational design, learning organizations and change management. Open to Duke Environmental Leadership Master of Environmental Management students only. Department consent required for all other students. Online course. Instructor: Shapiro. 3 units.

964. Duke Environmental Leadership: Environmental Law and Policy. Environmental policies have evolved from strict reliance on command and control systems to experimentation with alternative approaches. In this course students study this evolution by first examining the history and context of U.S. policy development processes and institutions. Command approaches to air and water pollution and waste management are considered along with alternative approaches, such as market-based programs, public-private partnerships and voluntarism. Policies for managing land, natural resources, species protection and addressing transnational and global environmental problems are examined. Policy implementation and devolution of responsibilities to state and local governments and the private sector is stressed. Open to Duke Environmental Leadership Master of Environmental Management students only. Department consent required for all other students. Online course. Instructor: Gallagher. 3 units.

965. DEL: Environmental Leadership Module. One of the driving themes of the DEL-MEM Program is leadership. We believe that leadership is cultivated by each individual and requires time and effort; it is a process. Participation in the DEL-MEM program will put students one step closer in their leadership pursuit by providing opportunities to assess and enhance leadership skills, building confidence in critical and creative thinking, communication, collaboration and conflict resolution. This course is designed to orient students towards these goals. More specifically, to provide a framework and point of reference for students' leadership development. During the three-day session, we will explore leadership in a variety ways, including individual meetings with prominent leaders in the field, discussions, and case study project. Students will also experience Washington, D.C. through a tour of the Capitol, meetings with Congressional members and staff, and time on the Mall. Open to Duke Environmental Leadership Master of Environmental Management students only. Instructor: Gallagher. 1 unit.

966. DEL: Professional Writing Course. This course teaches skills and strategies to make the writing process less intimidating and written work more clear and powerful. Comprised of online writing modules that provide examples of excellent nonfiction writing with the goal of identifying what makes the writing successful. Students develop and sharpen their own writing skills through incorporating feedback from a series of drafts. Student writing is reviewed in various forums-including writing workshops, peer reviews, and teacher conferences-to provide detailed feedback, allowing students to rethink and revise their writing. Open to Duke Environmental Leadership Master of Environmental Management students only. Department consent required for all other students. Online course. Instructor: Cagle. 1 unit.

972. DEL: Making Environmental Decisions. In environmental management, things don't always turn out as expected. You must address multiple goals, even when those goals themselves conflict. You must respond to diverse stakeholders, with varying worldviews. The tools of decision analysis help you to - going beyond unaided intuition - organize and analyze difficult environmental management decisions. This course covers quantitative methods for analyzing environmental problems involving uncertainty and multiple, conflicting objectives. Topics include subjective probability, utility, value of information, and multiattribute methods. Students will apply these tools to an environmental policy decision in a group or individual project. Open to Duke Environmental Leadership Master of Environmental Management students only. Online course. Instructor: Albright. 3 units.

973. DEL: Business Strategy for Environmental Sustainability. Businesses are increasingly applying strategic management tools to incorporate considerations of sustainability into decision-making and operations. Course focuses on the development and implementation of strategies to promote environmental sustainability. Students examine roles and responsibilities of sustainable strategic managers and learn how to apply the tools of strategic management: external analysis, forecasting and stakeholder management to problems of sustainability. Business case studies are used. Open to Duke Environmental Leadership Master of

Environmental Management students only. Department consent required for all other students. Online course. Instructor: Gallagher. 3 units.

974. DEL: Seeing the Big Picture: Lessons from Watershed Management in California. This course is an exploration of the interdisciplinary and often controversial nature of watershed management in California using examples from arguably the most manipulated and well-studied watershed in the US. These problems and their solutions are relevant to all watersheds. Topics include: host factors governing fish and wildlife responses and effects; fate, transport, and biogeochemistry of agricultural chemicals; exotic species introduction; economics considerations governing water allocations storage; transport, and conservation; and conflict resolution efforts between competing interest groups. Open to Duke Environmental Leadership Master of Environmental Management students only. Department consent required for all other students. Online course. Instructor: Hinton. 3 units.

975. DEL: Community Based Environmental Management in Mexico. Class offers students a focused introduction to the general history of rural common property governance and resource politics and management in Mexico and to the specific history and current context of community environmental management in Oaxaca. Requires participation in week long field trip (spring break) to Oaxaca (additional costs involved). Open to Duke Environmental Leadership Master of Environmental Management students only. Department consent required for all other students. Instructor: Shapiro. 2 units.

976. DEL: Restoration Ecology: Practice and Principles. Class explores the fundamental principles of ecological restoration, environmental history, and social context. Faculty and students will use the restoration process as a framework and will focus on how the science informs the practice and vice versa. Requires participation in week long field trip over spring break to Hawaii. Open to Duke Environmental Leadership Master of Environmental Management students only. Department consent required for all other students. Instructor: Vidra. 2 units.

977. DEL: Classic Environmental Literature. Classic environmental literature shapes contemporary discourse about environmental issues. These texts also reveal our relationships with nature and offer new approaches to living with our environment. In this class, we will consider six classic works: Walden, A Sand County Almanac, Silent Spring, Limits to Growth, Small is Beautiful, and Our Common Future. Using close reading, discussion, and written reflection, we will analyze both the social and environmental context, as well as the enduring impact, of each work. Open to Duke Environmental Leadership Master of Environmental Management students only. Department consent required for all other students. Online course. Instructor: Cagle. 2 units.

978. DEL: Energy and Environment Today. This course will provide students with a broad overview of why and how we use energy, the complex system that has evolved for furnishing energy, the challenges that our energy use has spawned, specifically with respect to the environment, and possible paths to a sustainable energy future. The course is designed to give students a framework for thinking about why energy-related events are happening, what that means for future energy uses and societal well-being, and how we might change the system moving forward. Instructor consent required. Online course. Instructor: Pratson. 1 unit.

979. DEL: The Science of Climate Change. This course will provide students with a broad, policy-relevant overview of contemporary scientific understanding of climate change. The recently released IPCC Fourth Assessment Report (IPCC AR4) titled 'Climate Change 2007' will provide the framework for discussion of various aspects of climate change, including the fundamental physical science basis, potential impacts and vulnerability, and mitigation of climate change. Open to Duke Environmental Leadership Master of Environmental Management students only. Department consent required for all other students. Online course. Instructor: Kasibhatla. 1 unit.

980. DEL: California Water Management Field Trip. California has long been the poster child for conflict over water management and appropriation. Much of that conflict has focused on the diversion of water from the Sierra Nevada and the Great Central Valley. In this 5-day field course we will provide an overview of the hydrology and history of water development of the Central Valley, and focus on three case studies: Hetch Hetchy, the Californian Aquaduct, and the re-watering of the San Joaquin River. Open to Duke Environmental Leadership Master of Environmental Management students only. Department consent required for all other students. Instructor: Christensen and Hinton. 1 unit.

982. DEL: Sustainable Development in Chile. In this 5-day field and online course we will provide an overview of international sustainable development in Chile, while focusing on environmental management at the government level, sustainable forestry, fisheries, and wineries, and eco-tourism. Open to Duke Environmental Leadership Master of Environmental Management students only. Department consent required for all other students. Instructor: Gallagher. 2 units.

983. DEL: Green Development. This course will cover green building, smart cities, and related cleantech innovations. Students will explore these topics through the lenses of business strategy, corporate sustainability drivers, challenges and risks, global megatrends, investor perspectives, entrepreneurship, measures of success, and implementation tools. Teaching methods will include case studies, practice-oriented assignments, readings from industry and thought leaders, structured group discussions, and skill building such as professional memo writing. Open to Duke Environmental Leadership Master of Environmental Management students only. Department consent required for all other students. Instructor: Wedding. 3 units.

985. DEL: Energy, Environment and the Law. Examines legal framework governing energy production and consumption in US, environmental issues associated with the nation's energy sectors, and policy approaches for balancing energy needs with environmental protection. Three main sections: state utility regulation; energy resources for electricity generation; petroleum. Open to Duke Environmental Leadership Master of Environmental Management students only. Department consent required for all other students. Online course. Instructor: Monast. 3 units.

986. DEL: Environmental Ethics and Advocacy. Are you an environmentalist? Do we have a moral obligation to protect the planet? Can we imagine solutions to the environmental crises that are powerfully possible? In this course, we will step back from the details of ecology and conservation, energy and economics to consider the big picture of the environmental movement and our role within it. To inspire our thinking, we will draw on a collected set of essays that address climate change, specifically, and other readings to broaden our thinking about what it means to be an environmentalist. We will also examine the recent history of the environmental

movement and the criticisms that have come from within and outside that movement. By examining the ethical frameworks of the contemporary environmental movement, students will gain a more nuanced perspective of the role and challenges of advocacy. Open to Duke Environmental Leadership Master of Environmental Management students only. Department consent required for all other students. Online course. Instructor: Vidra. 2 units.

987. DEL: Contemporary Environmental Issues. This course examines a broad range of contemporary environmental issues, including climate change impacts, endangered species conservation, and environmental health. This examination draws from the most-cited and recent peer-reviewed literature, current academic texts, and essays from popular literature. During the course, you will practice weighing evidence, synthesizing research, and articulating your perspective through written reflection and discussion. Discussions will also give you the opportunity to moderate conversations on hot-button issues. Open to Duke Environmental Leadership Master of Environmental Management students only. Department consent required for all other students. Online course. Instructor: Cagle. 2 units.

990. DEL: Special Topics. Content to be determined each semester. May be repeated. Open to Duke Environmental Leadership Master of Environmental Management students only. Department consent required for all other students. Instructor: Staff. Variable credit.

995. DEL: Leadership Seminar. Leadership is both a way of doing things and a way of being in the world. Now, more than ever, leaders need to work collaboratively if we are to solve our greatest collective challenges. To do so effectively, those who aspire to lead must develop a deep sense of both internal and external awareness. Course focus areas: Developing a Toolkit, Defining a Leadership Journey, Ongoing Discussion of Leadership Challenges and Coaching through the use of various tools to identify personal characteristics and capacity for leadership. Instructor: Vidra and Kingery. 1 unit.

996. DEL MEM Capstone. Students will propose a Capstone Pathway and provide a detailed explanation why this choice meets their master's project goals. A final leadership capstone project, which will integrate all DEL leadership sessions, particularly the DC leadership seminar, capstone courses, and interviews; project not limited to an academic paper. An interview protocol will be developed to ensure thoughtful conversations around issues of leadership that the student is interested in. The Capstone must be a rigorous experience, integrating coursework, outreach, and reflection. Instructor: Vidra. Variable credit.

997. Duke Environmental Leadership: Independent Studies and Projects. Directed readings or research at the graduate level to meet the needs of individual students. Open to Duke Environmental Leadership-Master of Environmental Management students only. Instructor consent required. Instructor: Staff. Variable credit.

998. Program Area Seminar DEL MEM. This program seminar is required for all Duke Environmental Leadership (DEL) MEM students. The seminar will assist students in all phases of the master's project (MP) process, from developing research questions to presenting results. Instructor consent required. Instructor: Vidra. 1 unit.

999. Duke Environmental Leadership: Master's Project. An applied study of a forestry or environmental management problem or an original research effort. A seminar presentation of the objectives, methodology, and preliminary findings is required. A written (or other medium) report at the conclusion of the project is also required. Undertaken with the guidance of the student's adviser. Open to Duke Environmental Leadership Master of Environmental Management students only. Department consent required for all other students. Instructor: Staff. 4 units.

01-G-A

557D. Social Science Surveys for Environmental Management. Social science research methods for collecting data for environmental management and policy analysis. Sampling, survey design, focus groups, pretesting, survey implementation, coding, and data analysis. Team projects emphasize development and practice of survey skills. Prerequisite: introductory applied statistics or equivalent. Instructor: Kramer. 3 units.

01-G-K

510K. Environmental Change and Evolution of Ecosystems. The processes that control ecosystem production, the carbon cycle, and delivery of ecosystem services as well as the resilience of ecosystems exposed to environmental stress have been molded by millions of years of evolution under Global Change. Our developing understanding of earth system processes and current Global Change depends strongly on looking to the past and considering evolution of the climate system, plant and ecosystem processes, biological feedbacks, soils development, and all of these with respect to ecosystem (biosphere) carbon, water, and nutrient cycles. Taught at Duke Kunshan University. Instructor: Tenhunen. 3 units.

511K. China and US Comparative Environmental Law and Governance. This course will study China's environmental challenges and governance and compare them with those in the US. We will consider how environmental law may shape business, government, and culture, and the ways in which China and the US may learn from one another. Taught at Duke Kunshan University. Instructor: Guttman. 3 units.

561K. Chinese Environmental Policy. This course provides a venue for students to investigate the most recent environmental and energy policies in China. We will study the causes and consequences of environmental and energy problems. We will examine Chinese environmental and energy governance: institutions, laws and regulations for environmental protection, energy production and consumption. We will also explore the practices of Chinese government to address the emerging environmental and energy problems, with a special focus on climate change. Taught at Duke Kunshan University. Instructor: Zhang. 3 units.

581K. Global Environmental Health Problems: Principles and Case Studies. Many environmental problems occur both locally & globally. Having insights and experience from different parts of the world is important for students to gain problem-oriented training. This course will cover fundamental principles on physical & chemical processes related to major environmental problems. These principles will then be integrated to discussions of case studies addressing a specific set of problems. The case studies will involve the participation of invited guest instructors who are experts on specific topics/cases. Depending on preference of guest instructors, they

can introduce a case study via online lecturing/chatting or providing a pre-made video. Online course. Open to Duke Kunshan students only. Instructor consent required. Instructor: Zhang. 3 units. C-L: Global Health 581K

583SK. Energy and National Security. 3 units. C-L: see Public Policy 583SK; also C-L: Political Science 663SK

590K. Special Topics in Environmental Sciences and Policy. Content varies each semester. Offered only at Duke Kunshan University. Instructor: Staff. 3 units.

593K. Independent Studies and Projects. For iMEP students or Duke students studying abroad at Duke Kunshan University. Directed readings or research at the graduate level to meet the needs of individual students. Units to be arranged. Instructor consent required. Instructor: Zhang, Ji, Furst, Li, Ward. Variable credit.

600K. Key Areas in International Environmental Policy. An overview of the key areas in international environmental policy. This course's seven modules cover international environmental economics, international environmental policy and politics, international environmental negotiations, policy debates and simulations. The principal goal of the course is to preview the application of social sciences (economics, public policy, and political science) to the environment, and to facilitate the translation of core curricular concepts into a variety of real-word applications. Students will engage in self-directed research and learning on international environmental policy. Taught at Duke Kunshan University. Instructor: Fürst. 3 units.

601K. Building an NGO Toolkit: From Design to Monitoring. Non-governmental organizations (NGOs) that address conservation issues in China face large, complex, and urgent problems. To be successful, these NGOs must be equipped with the skills to be efficient, effective, and transparent when planning, implementing, and monitoring their conservation initiatives. In this hands-on course, students will become familiar with decision-support tools that allow organizations to systematically address strategic planning, project design, project budgeting, implementation, monitoring, evaluation, communication, and donor transparency. Students will apply these tools to real-world conservation problems. Taught at Duke Kunshan University. Instructor: Losos. 3 units.

602K. Natural Resources and Protected Area Management. Toolkit for practical natural resources management and understanding the challenges involved in protected area management. Wildlife monitoring, environmental change tracking, socio-economic surveys and stakeholders engagement. Combines lectures for essential survey methods and experiential education through a seven-day field course. Students will design their own group project to carry out in the local context. Taught in Kunshan, China, at Duke Kunshan University. Instructor: Li. 3 units.

637K. Population and Environmental Dynamics Influencing Health. 3 units. C-L: see Global Health 637K

640K. Climate Change Economics and Policy. Explores the economic characteristics of the climate change problem, assesses national and international policy design and current implementation issues, and surveys the economic tools necessary to evaluate climate change policies. Prerequisite: Public Policy 810 and 812, or equivalent, or consent of the instructor. Instructor: Pizer. 3 units. C-L: Public Policy 585K

716K. Modeling for Energy Systems. Introduction to the use of computer models and the methods of optimization and simulation for students interested in the analysis of energy systems; emphasis in the formulation of optimization problems and simulation models, and in the identification of the available methods to solve them. Students should also be familiar with capital-sigma (¿) notation for compactly representing summation of similar terms, and know the basics of Excel. Taught in China at Duke Kunshan University. Recommended prerequisite: college-level calculus (including partial derivatives of functions of several variables), probability theory, and basic linear algebra (how to write—and solve—systems of linear equations in matrix form). Instructor: Patiño-Echeverri. 3 units.

718K. Environmental Sciences. This course introduces students to the core concepts and topics of environmental sciences. It will give an in-depth overview of main themes in the field of environmental studies: global environmental challenges, human population trends, global atmospheric changes, air, land and water resources and pollution, the ocean and fisheries, key ecosystems (forests, grasslands, wetlands, freshwater and marine environment), biodiversity and conservation, non-renewable and renewable energy, agriculture and sustainable production. Quantitative and qualitative research methods will be introduced with case studies. Taught at Duke Kunshan University. Instructor: Li. 3 units.

736K. Planetary Health and Environmental Epidemiology. Study the human health impacts of accelerating environmental change through interdisciplinary approaches including environmental science, political science, public health and social science; engage in diverse materials from many types of examples of planetary health research, from nutrition and mental health, to infectious and non-communicable diseases. A special emphasis will be placed on environmental epidemiology. Taught in China at Duke Kunshan University. Recommended prerequisite: one quantitative methodology class (statistics, biostatistics, epidemiology, or econometrics). Instructor: Ji. 3 units.

759K. Environmental GIS. Core concepts and latest application of geographic information system in environment area; an in-depth overview of the key data types (raster and vector files) in this area, data collection and entry, data management, data analysis and output using ArcGIS; introduction of application of GIS in real world problem solving, such as species habitat mapping and conservation planning. Students will be exposed to Google Earth, QGIS and other open source GIS tools. Taught in China at Duke Kunshan University. Instructor: Li. 3 units.

781K. Narrating Nature: Documentaries For Environmental Studies. Evaluate and illustrate how film documentary media can help communicate, critique, and educate the public about the complex environmental and social issues of our times. Taught in China at Duke Kunshan University. Instructor: Rojas-Sotelo. 3 units.

803K. Environmental Policy Process. This course provides an introduction to and overview of the environmental policy process. The first part of the course introduces the environmental policy process with case studies from different countries exemplifying regional differences. The second part of the course introduces various aspects and challenges in the design and formation of environmental policies. The third part of the course focuses on implementation and tools to evaluate the impact of environmental policies. The fourth part of the course discusses the formation of international environmental policies and their impact on national priorities. Taught at Duke Kunshan University. Instructor: Furst. 3 units.

805K. Environmental Economics. An overview of environmental economics by introducing analytical methods and tools to analyze environmental problems and identify policy solutions; including 1) a microeconomic foundation of environmental economics, with a focus on market efficiency and market failures; 2) environmental policy decision tools, such as benefit-cost analysis and cost-effectiveness criterion; 3) environmental regulation, with topics covering command-and-control regulation, market-based approaches, and behavioral interventions. Instructor: Zhang. 3 units.

806K. Environmental Economics II. This course provides for continued development and practice of skills learned in Statistics and Program Evaluation and Environmental Economics. Students develop conceptual and professional skills related to environmental policy evaluation. The goal is to stimulate critical thinking about today's environmental problems and the public policies designed to improve them by implementing the theories and principles acquired in class. Prerequisites: Public Policy 870K and Environment 805K or instructor consent. Taught at Duke Kunshan University. Instructor: Kim. 3 units.

835K. Environmental Law. Emphasizing the practical use and application of legal concepts within the context of pollution control and resource management; exploring the role of law, regulation and governance in protecting, managing and restoring the environment and natural resources. Taught in China at Duke Kunshan University. Instructor: Furst. 3 units.

898K. Master's Project International Master in Environmental Policy II. Designed to help students develop a master's project (MP). Guide students in conceptualizing an idea, identifying key environmental policy question, writing a prospectus, finding an advisor, finding a client, designing an analytical approach, data collection, and a producing a draft of their project. Taught at Duke Kunshan University. Instructor: Ji. 3 units.

899K. Master's Project II. Follows after Environment 898K, in which students conceived of, designed, and completed the initial steps of their master's project (MP). Students will complete their MP and present project findings. Students will review and revise project content in peer-to-peer and instructor-to-student settings, critically evaluate their methods and data, search for new ways to leverage their findings, and tighten their resulting analysis. Required course for iMEP students. Taught at Duke Kunshan University. Instructor: Ewing. 3 units.

Evolutionary Anthropology

Professor Alberts, *Chair*; Professor Nunn, *Director of Graduate Studies*; Professors Alberts, Churchill, Drea, Hare, Kay, Nunn, Roth, Schmitt, Tomasello, Wray, and Yoder; Associate Professors of the Practice Digby and Williams; Associate Professors Boyer, Ponzer, and Tung; Assistant Professor Goldberg; Assistant Research Professor Valenta; Professors Emeriti Cartmill, Glander, and Pusey; Research Professor Emerita Wall; Senior Lecturing Fellows Doyle and Zeininger

A PhD is available in this program.

Admission to the PhD Program in Evolutionary Anthropology is not contingent on any particular course of study at the undergraduate level. The goal of the graduate program is to provide students with a broad-based background in organismal biology with a focus on primate and human evolution. Courses of study are tailored to meet individual needs, but all students will be expected to take courses in four of six core areas: evolutionary theory, behavior and ecology, paleontology, morphology and physiology, research design and statistics; and genetics and genomics.

For general information, visit https://evolutionaryanthropology.duke.edu/. To learn about research opportunities visit the websites of the faculty.

Courses in Evolutionary Anthropology (EVANTH)

510SL. Molecular Anthropology in Practice. Hands-on introduction to research in molecular anthropology and primate genomics. Engagement in collaborative research on the use and interpretation of molecular data to understand primate evolution. Topics include: molecular and analytical tools for generating and interpreting genomic data; methods for identifying the signature of natural selection; basic computational and statistical methods for data analysis; research culture and collaboration in the natural sciences; scientific writing and revision. Prerequisite: Biology 202L or Evolutionary Anthropology 310 or Evolutionary Anthropology 514. Instructor: Tung. 3 units.

520S. Reconstructing the Past: The Paleobiology and Paleoecology of Primates. Interpretation of the paleobiology of extinct primates relies on indirect evidence linking morphology to particular attributes of a species' ecological niche—be it diet, mode of locomotion, body size, sensory ecology, social systems, etc. Reconstructions require understanding the functional attributes of the anatomical systems of living primates followed by an inference by analogy about the behavior of the extinct ones. We examine similarities and differences in the primates living on different continents through time as well as contested paleoecological scenarios related to primate origins and ape and human origins. Recommended prerequisite: 200-300 level course in paleontology, anatomy, or ecology. Instructor: Kay. 3 units.

522. The Hominin Fossil Record. Rigorous review of the fossil record of hominin evolution from the late Miocene to the end of the Pleistocene. Using primary literature and casts of key fossil specimens, students explore current controversies in the field of paleoanthropology. Prerequisite: Evolutionary Anthropology 101 and 220, or consent of instructor. Consent of instructor is required. Instructor: Churchill. 3 units.

530. Human Functional Anatomy. Basics of functional morphology (including elementary biomechanics), an overview of connective tissue structure and mechanics, and a systematic overview (from head to toe) of human anatomy from a functional perspective. Emphasis on connective and other tissues involved in functioning of the musculoskeletal system (primarily bone, cartilage, tendons, ligaments, and muscle). Prerequisite: Evolutionary Anthropology 101 and 333L or 334L. Instructor: Churchill. 3 units.

546S. Primate Social Evolution. Ecological determinants of and biological constraints on social strategies and systems, with an emphasis on primates. Prerequisite: Evolutionary Anthropology 101 and 200- or 300-level behavior course. Instructor: Staff. 3 units.

560S. Primate Cognition. Advanced readings and discussion in the evolution of primate cognition. Topics include evolution of social

tolerance, communication, cooperation, competition, etc.; role these behaviors play in the evolution of cognitive abilities. Instructor: Hare. 3 units.

561S. Evolution, Cognition, and Society. Using primary literature in evolutionary anthropology and cognitive science to discuss major societal events, behaviors, and issues. Topics include sex, prejudice, religion, music, abortion, illness, sexuality, global health, death, politics, economics and drugs. Emphasis on biological and cognitive perspectives to solving today's biggest personal, local and global problems. Topics will change each semester; course can be taken more than once. Prerequisite: at least one course in behavior, ecology, or cognition at the 200+ level. Instructor: Hare. 3 units. C-L: Psychology 561S

570S. Energetics in Human Evolution, Ecology, and Health. Examine the role of energy expenditure in human evolution and ecology, including: 1) growth, reproduction, and aging, 2) metabolically costly organs such as the brain, and 3) daily physical activity. Discuss methods for measuring energy expenditure. Investigate the effects of diet and exercise on daily energy expenditure in humans. Discuss the role of energy expenditure in modern cardiometabolic disease (e.g., obesity, heart disease, and diabetes). Students will complete and present an independent research project on a topic related to the course. Recommended prerequisite: Evolutionary Anthropology 330, Biology 329D/L, or Biology 321. Instructor: Pontzer, Herman. 3 units.

580S. Ethics in Evolutionary Anthropology. Ethical issues and controversies in the study of evolutionary anthropology including treatment of primates in research; appropriate use of human genetic data, skeletal remains, and fossils. Professional ethics will also be addressed (e.g., ethical behavior in grant and paper reviewing, plagiarism, intellectual property). Course will make use of films, interviews and discussion primary and popular literature. Instructor consent required. Instructor: Williams. 3 units.

582S. Primate Adaptation. A study of primate adaptation from an evolutionary perspective. Topics vary according to student interests but may include history and functional significance of locomotor and feeding adaptations, craniofacial morphology, sense organs, reproductive systems, and language in primates, including humans. Seminar format but depending on topic may include laboratory analysis of materials. Prerequisite: 200- or 300-level anatomy or morphology course and consent of instructor. Instructor: Williams or Kay. 3 units.

585. Statistical Rethinking: Methods and Applications in Evolutionary Anthropology and Biology. Application of modern statistical methods in evolutionary anthropology and biology, including their theoretical foundations and application to phylogenetics, comparative methods, morphometrics, etc. The goal is to move from the limitations of frequentist statistical tests (i.e., p-values) and toward a richer assessment of scientific hypotheses, including Bayesian approaches. We will use a flipped classroom to provide hands-on team-based learning in R. Recommended prerequisite: 200- or 300-level Evolutionary Anthropology or Biology course and introductory statistics. Instructor: Boyer and Nunn. 3 units.

588S. Macroevolution. 3 units. C-L: see Biology 588S

590L-1. Special Topics Laboratory. Special topics in methodology, theory, or area. Consent of instructor required. Instructor: Staff. 3 units.

590LS. Special Topics Laboratory. Special topics in methodology, theory, or area. Consent of instructor required. Instructor: Staff. 3 units.

590S. Special Topics. Special topics in methodology, theory, or area. Consent of instructor required. Instructor: Staff. 3 units.

652S. The Life and Work of Darwin. 3 units. C-L: see Biology 652S

701S. Concepts in Evolutionary Anthropology -A. Graduate seminar for first year graduate students covering the foundation principles of evolutionary anthropology. Instructor: Staff. 3 units.

702S. Concepts in Evolutionary Anthropology. Introduction to topics that are considered central to Evolutionary Anthropology; Exposure to research and techniques used in the field; Develop skills in scientific inquiry, oral expression, and presentation; Familiarize students with the facilities/resources on campus that are associated with Evolutionary Anthropology. Consent Required. Part 2 of 2. Instructor: Staff. 3 units.

711S. Cenozoic Climate, Environment, and Mammalian Evolution in the New World. 3 units. C-L: see Earth and Ocean Sciences 711S; also C-L: Biology 710S

718. Methods in Human Evolutionary Genetics. An evolutionary perspective on human genetics and genomics, with an emphasis on current models and inference methods using medically important examples. The mechanisms of evolution shaping human genetic variation, as well as inference of evolutionary processes from genetic data. Topics include: population differences in disease risk; adaptation to local environments and pathogens; identifying regions of the genome underlying traits; models of neutral variation, migration, and genetic ancestry. Computational and quantitative skills will be emphasized throughout. Recommended prerequisite: Evolutionary Anthropology 101D, Biology 202, or equivalent; some probability and programming background helpful but not required. Instructor: Goldberg. 3 units.

730. Gross Human Anatomy. Includes complete dissection of a cadaver; laboratory work is supplemented by conferences which emphasize biological and evolutionary aspects. Required of entering graduate students in anatomy; by arrangement, may extend into second semester. Prerequisites: adequate background in biology, including comparative anatomy and embryology and written consent of instructor. Instructor: Staff. 3 units.

731. Anatomy of the Limbs. The musculoskeletal anatomy of the limbs and limb girdles. Emphasis is on detailed dissection of the extremities, with a minor focus on clinical applications. Course primarily intended for advanced graduate students in physical therapy. Consent of instructor required. 1 to 3 units. Instructor: Staff. Variable credit.

732S. Anatomy Seminar. Regular meeting of graduate students and staff in which current research problems in anatomy will be presented. Instructor: Staff. 1 unit.

734T. Tutorial in Advanced Anatomy. Topics for intensive reading and discussion will be chosen according to the student's

interests, related to basic problems in function of bone and muscle systems, development and differentiation, comparative anatomy at the gross and histological level and vertebrate evolution. Consent of instructor required. Instructor: Staff. Variable credit.

735S. Functional Morphology of the Hominid Fossil Record. Evolutionary and functional morphology of the hominini; emphasizing species in the genera Australopithecus, Paranthropus and Homo. Focus on biomechanical studies of 1) the masticatory apparatus as it relates to evolutionary shifts in diet, 2) upper limb function as it relates to the evolution of manipulative capabilities in the context of tool use, and 3) pelvic and lower limb morphology as it relates to the emergence of bipedal locomotion and changes in brain size and life history. Instructor: Churchill. 3 units.

736L. Human Osteology. An introduction to the basics of human osteological analysis. Identification and siding of all the bones of the human body and the major osteological landmarks on each bone; basics of bone histology, development and growth; and fundamentals of anthropological analysis of human skeletal remains (archeological treatment of burials; determination of gender, populational affinities, stature; paleopathological analysis; medicolegal applications). Graduate participants are required to do an additional topic review in an areas approved by the instructor. Instructor: Churchill. 3 units.

738S. Dance Science: An Evolutionary Approach to Functional Anatomy. Exploration of the origins of human dance through studies of non-human "dance" and entrainment, representations of dancing figures in the archaeological record, and evolutionary changes in the human body that allow for the extraordinary flexibility of human dance. Focus on anatomy relevant to dancers and other performing artists. Learn about dance injuries and how the brain processes observed movement, as well as many other areas in which dance and science intersect. This course is paired with an undergraduate offering and welcomes graduate students from a variety of backgrounds. Each will be expected to bring their own expertise to the broader discussion and lead presentations. Instructor: Williams. 3 units.

741. Ecological Perspectives: Evolution to Ecosystems. 4 units. C-L: see University Program in Ecology 701; also C-L: Biology 841, Environment 841

742. Ecological Perspectives: Individuals to Communities. 4 units. C-L: see University Program in Ecology 702; also C-L: Biology 842, Environment 842

743. Ecology Seminar. 1 unit. C-L: see Biology 711S; also C-L: Environment 702

744L. Primate Field Biology. Survey of field methods used to document primate behavior. Laboratory includes observations of free-ranging and captive primates at the Duke Lemur Center. Techniques covered include scan, focal animal and all occurrences sampling. Focus on the scientific process, including data analysis and writing of formal research papers. Graduate students will create their own research questions and may use projects as pilots for their thesis research. This course is paired with Evolutionary Anthropology 344L. Recommended prerequisite: previous coursework in evolution, animal behavior and/or ecology. Instructor: Digby. 3 units.

745. Primate Sexuality. A comparative and integrative study of primate sex and reproduction. The material is presented in three sections: the first focuses on primate social organization, mating systems, and reproductive strategies; the second focuses on the endocrine system and behavioral endocrinology, and; the third focuses on sexual differentiation of morphology, brain and behavior. In each section, this course places human sexuality within the broader context of the primate order. Graduate students are expected to write a term paper in addition to other class requirements. Instructor: Drea. 3 units.

746S. Topics in Primate Behavior and Ecology. Advanced readings and discussion in primate behavior and ecology; emphasis on current issues and critical analysis of readings; topics vary each semester. Topics course. Instructor: Staff. 3 units.

785. Human Health in Evolutionary Perspective. Covers evolutionary approaches to understand human health at a global scale. Integration of evolutionary thinking and medical science provides new insights to a wide array of medical issues including obesity, cancer, allergies, and mental illness. Evolutionary perspectives reveal why some pathogens are more harmful than others, shed light on the origins and spread of infectious diseases in humans, and help in controlling antibiotic resistance. Graduate students will meet individually with the instructor and write a term paper. Instructor: Nunn. 4 units.

790. Topics in Physical Anthropology. Instructor: Staff. 3 units.

790S. Special Topics in Evolutionary Anthropology. Selected topics in Evolutionary Anthropology. Topics vary by semester. Instructor: Staff. 3 units.

791. Independent Study. Directed reading and research. Consent of instructor required. Instructor: Staff. 3 units.

793. Research in Evolutionary Anthropology. A preceptorial course in various research methods in biological anthropology and anatomy. Consent of instructor required. Credit to be arranged. Instructor: Staff. Variable credit.

Gender, Sexuality, and Feminist Studies

Professor Olcott, *Director*; Associate Professor Wilson, *Director of Graduate Studies*; Professors Rudy and Weeks; Associate Professors Hasso (International Comparative Studies and Sociology), Lamm, and Wilson; Assistant Professors Douglass and Rosenberg; *Associate Faculty*: Professors Allison (Cultural Anthropology), DeFranz (Dance), Deutsch (History), Edwards (History), Fulkerson (Divinity), Hardt (Literature), Khanna (English), MacLean (History), Olcott (History), Piot (Cultural Anthropology and African & African American Studies), Sigal (History), and Wiegman (Literature); Associate Professors Gabara (Romance Studies), Krylova (History), Lentz-Smith (History), Makhulu (African & African American Studies), McLarney (Asian & Middle Eastern Studies), Mottahedeh (Literature), Rojas (Asian & Middle Eastern Studies), Solomon (Cultural Anthropology), and Stein (Cultural Anthropology); Assistant Professors Barnes (History), Black (English), Cobb (Art, Art History & Visual Studies), McIntosh (Cultural Anthropology), Namakkal (International Comparative Studies), Rogers (Theater Studies), and Winters (Religious Studies)

A certificate is available in this program.

The Program in Gender, Sexuality, and Feminist Studies at Duke University is dedicated to exploring gender identifications, relations, practices, theories, and institutions. In the field's first decades, feminist scholarship reoriented traditional disciplines toward the study of women and gender and developed new methodologies and critical vocabularies that have made interdisciplinarity a key feature of women's studies as an autonomous field. Today, scholars continue to explore the meaning and impact of identity as a primary, though by no means transhistorical or universal, way of organizing social life by pursuing an intersectional analysis of gender, race, sexuality, class, and nationality. In the classroom, as in research, the goal of the program is to transform the university's organization of knowledge by reaching across the epistemological and methodological divisions of historical, political, philosophical, economic, representational, technological, and scientific analysis. Through a dual emphasis on interdisciplinarity and intersectionality, the program offers students new knowledge while equipping them with a wide range of analytical and methodological skills.

Many students identify gender, sexuality and feminist studies courses as among the most exciting and enlightening they take at Duke. The women and men who enroll in the program's classes each semester gain the opportunity to understand how social, historical, and psychological forces, organized by the central concept of gender, shape them as individuals; attain a fuller understanding of human behavior, culture, and society made possible by investigating women's lives; acquaint themselves with the experience of women of different economic classes, sexual orientations, and cultural and racial backgrounds; and transfer the critical and analytical skills they acquire in the study of gender and society to other classes, beyond the campus to other activities, and eventually to their professional careers.

Gender, sexuality, and feminist studies has, since its inception, been an interdisciplinary field. It has consistently assessed the strengths and challenges of such interdisciplinarity. Duke students find their background in women's studies to be a valuable resource for their professional development and lifelong intellectual growth. Gender, sexuality, and feminist studies at Duke is a focal point within the university for the study of women, gender, and feminist theories—a structure that allows graduate students to address complex issues beyond their traditional disciplinary and classroom boundaries and to explore problems in ways that connect theories and approaches of different disciplines. The Gender, Sexuality, and Feminist Studies Program serves students' intellectual interests by offering credit courses, housing a variety of research projects, and implementing programs for diverse audiences. Graduate students can earn a four-course certificate in gender, sexuality, and feminist studies and are encouraged to teach introductory or special topics courses.

Professional students and doctoral candidates may join the Graduate Scholars Colloquium, a scholarly society that deepens their knowledge of the fields of gender, sexuality and feminist studies and provides a cohesive, supportive community. All affiliated students on the mailing list receive newsletters, lecture notices, and invitations to special events. For additional information, visit the program website at https://gendersexualityfeminist.duke.edu.

Requirements for the Graduate Certificate in Gender, Sexuality, and Feminist Studies

Note: Audited courses do not count toward the certificate; nor does previously taken MA coursework at Duke or elsewhere.

- One required course: Gender, Sexuality, and Feminist Studies 701S (Foundations in Feminist Theory)
- Two additional (600-level or above) graduate-level courses in or cross-listed with Gender, Sexuality, and Feminist Studies at Duke (tutorials do not fulfill this requirement).
- A fourth graduate course or tutorial/independent study (500-level or above) offered by Gender, Sexuality, and Feminist Studies, or another academic unit focusing on women, gender or an intersectional approach to the study of race and/or sexuality. (Any non- gender, sexuality and feminist studies course or tutorial/independent study must be approved by the director of graduate studies.)
- Women, gender, sexuality, or feminism must be a significant aspect of preliminary examination or dissertation project.
- A member of the Gender, Sexuality, and Feminist Studies core, secondary, or graduate faculty must be on the preliminary examination and dissertation committees. (A complete listing of graduate faculty can be found at https://gendersexualityfeminist.duke.edu/people/faculty).

Courses in Gender, Sexuality, and Feminist Studies (GSF)

501S. History of Sexuality. 3 units. C-L: see History 501S

502S. Queer China. 3 units. C-L: see Asian & Middle Eastern Studies 539S; also C-L: Cultural Anthropology 539S, Literature 539S, Visual and Media Studies 539S, Human Rights Program-Franklin Humanities Institute 539S

503S. Cartographies of Gender and Sexuality in Middle East. This interdisciplinary graduate seminar brings the field of Middle East gender and sexuality studies into productive collision with Western "new materialist" approaches to consider how they might inform each other; explores theories and practices related to archives and archival methodologies; and engages some of the latest scholarship on states, family, sex and sexuality. Students may use the final course assignment to develop a broadly relevant research proposal or paper using original sources, or to prepare for publication an essay or article that puts their intellectual interests in dialogue with the focus of the seminar. Consent of instructor is required. Instructor: Hasso. 3 units. C-L: International Comparative Studies 503S, Asian & Middle Eastern Studies 527S

505S. Interethnic Intimacies: Production and Consumption. 3 units. C-L: see Asian & Middle Eastern Studies 515S; also C-L: Literature 515S, Visual and Media Studies 515S, International Comparative Studies 515S

509S. Race, Class, and Gender: A Social History of Modern (1750-present) Britain. 3 units. C-L: see History 505S; also C-L: African & African American Studies 515S

515S. Gender, Identity, and Public Policy. 3 units. C-L: see Public Policy 530S; also C-L: Political Science 521S

519S. Topics in Sexuality and Gender Studies. 3 units. C-L: see Italian 585S

581S. Masculinities. 3 units. C-L: see Cultural Anthropology 540S

584S. Global History of Medicine. 3 units. C-L: see History 548S; also C-L: Global Health 548S

590. Topics in Feminist Studies. Lecture version of GSF 590S. Instructor: Staff. 3 units.

590S. Selected Topics in Feminist Studies. A seminar in contemporary issues, methodology, and/or selected theoretical questions pertaining to feminist scholarship. Instructor: Staff. 3 units.

601S. Debates in Women's Studies. This course is designed for Master's and Professional Schools students and for PhD students with little or no background in feminist scholarship. It introduces students to the basic conceptual tools of feminist inquiry by way of an examination of some of the key debates in feminist studies. Instructor: Staff. 3 units.

611S. Film Feminisms. 3 units. C-L: see Literature 611S

615S. The #Selfie. 3 units. C-L: see Literature 615S; also C-L: Visual and Media Studies 615S, International Comparative Studies 615S

701S. Foundations in Feminist Theory. Required for all students pursuing the graduate certificate in Women's Studies, this course serves as an in-depth introduction to the various theoretical frameworks that have and continue to inform scholarship in the field of Women's Studies. It explores differences between distinct feminist theoretical traditions (Marxist feminism, poststructuralism, psychoanalysis, queer theory) and seeks to historicize accounts of identity, difference, social movement, globalization, nationalism, and social change. Consent of instructor required. Instructor: Staff. 3 units. C-L: Literature 761S

709S. Science, Medicine, and the Body. 3 units. C-L: see Cultural Anthropology 709S; also C-L: Science & Society 709S, Global Health 709S, Literature 709S

730S. Feminist Knowledge, Interdisciplinarity, and Social Change. This course explores feminism as a knowledge formation by considering Women's Studies as a specific interdiscipline, politics, and epistemological project in relation to feminist studies in the disciplines. The course is highly recommended for students seeking part or full time academic employment in Women's Studies. Consent of instructor required. Instructor: Staff. 3 units.

740S. Critical Genealogies. This course serves as an in-depth investigation into the many different theoretical traditions that inform interdisciplinary feminist studies. Specific foci include Marxist-feminism, poststructuralism, feminist film theory, psychoanalysis, French feminism, postcolonial theory, deconstruction, the Frankfurt school, etc. Instructor: Staff. 3 units. C-L: Cultural Anthropology 746S, Asian & Middle Eastern Studies 740S

770. Interdisciplinary Research Workshop. This course focuses on research and writing, paying particular attention to the intellectual and methodological demands of interdisciplinary knowledge production. Instructor: Staff. 3 units. C-L: Literature 770

771S. Graduate Seminar: Theories of Corporeality. 3 units. C-L: see Dance 771S; also C-L: Music 771S

772S. Graduate Seminar in Critical Dance Studies. 3 units. C-L: see Dance 772S; also C-L: Music 772S

780S. Teaching Race, Teaching Gender. 3 units. C-L: see African & African American Studies 780S; also C-L: History 780S, Literature 780S

795T. Tutorial in Special Topics. Directed research and writing in areas unrepresented by regular course offerings. Consent of instructor required. Instructor: Staff. 3 units.

796T. Tutorial in Special Topics. Directed research and writing in areas unrepresented by regular course offerings. Consent of instructor required. Instructor: Staff. 3 units.

820. Consent: Sex and Governance in the Age of Revolution. 3 units. C-L: see German 820

820S. The Pedagogy of Women's Studies. Advanced seminar focusing on the teaching of undergraduate women's studies, including the design and implementation of interdisciplinary syllabi and related classroom materials, practices of instruction, and feminist pedagogical theories. May include internships or teaching collaborations with Women's Studies faculty. Instructor consent required. Instructor: Staff. 3 units.

860S. Major Figures in Feminist Thought. An examination of the thought of some of the significant figures in history who have been influential in the evolution of feminist thought and theory. These may include Derrida, Irigaray, Foucault, Freud, etc. This course may be taken more than once for credit. Instructor: Staff. 3 units. C-L: Literature 760S

890. Advanced Topics. Lecture version of GSF 890S. Instructor: Staff. 3 units.

890S. Advanced Topics in Feminist Studies. A selected topics seminar on emergent theoretical and empirical questions in feminist scholarship. Instructor: Staff. 3 units.

891. Independent Study. Individual non-research directed study in a field of special interest on a previously approved topic, under the supervision of a faculty member, resulting in an academic and/or artistic product. Consent of Instructor and Director of Graduate Studies required. Instructor: Staff. 3 units.

960S. Interdisciplinary Debates (Topics). Designed for advanced graduate students, this course will highlight current debates in feminist studies through a topical approach that draws on faculty research and expertise. Instructor: Staff. 3 units.

Genetics

See "Genetics and Genomics" below and also "Molecular Genetics and Microbiology" on page 264.

Genetics and Genomics

Associate Professor Haase, *Director*; Professor Gregory, *Director of Graduate Studies*

A certificate and a PhD are available in this program.

The Duke University Program in Genetics and Genomics (UPGG) is an umbrella graduate training program that spans several basic science and clinical departments and bridges the medical center and the college of arts and sciences. There are more than 90 faculty with three adjunct faculty, and more than fifty-four students in the program, which was founded in 1967 and has been continuously supported

by a training grant from the NIH for more than thirty-five years. Over the past several decades, the program has served as an important forum for training and education in genetics and genomics, including model systems (bacteria, yeast, fungi, drosophila, zebrafish, mouse), population genetics, and human genetics. The program has close links with the several genetic and genomic centers and institutes across the university and medical school. The Duke UPGG is unique in that it is degree granting.

The curriculum requirements for the Duke University Program in Genetics and Genomics are relatively flexible. Students are required to take three full-semester courses—University Program in Genetics 778 (Genetic Approaches to the Solutions of Biological Problems) during fall of first and second years; University Program in Genetics 702 (Writing Grant Proposals) fall of second year—as well as two semesters of a literature-based genetics and genomic journal club class (University Program in Genetics 701), two seminar classes (University Program in Genetics 716, University Program in Genetics 750), one additional full-semester course with an emphasis in genetics, and two mini-courses selected from a variety of offerings. By the end of the second year, students should have completed 24 graded course credits. Courses for first year students are chosen in consultation with the director of graduate studies and a first year advisory committee. Courses are available and encouraged for students past the first year of study, and decisions about additional coursework are made in consultation with the student's faculty advisor and committee to complement the requirements of the student's own research interests.

In addition to courses, students participate in other educational activities. These include an annual student organized retreat and a biweekly student research seminar series (University Program in Genetics and Genomics 716). Students organize the distinguished lecturer series with advice from a faculty committee member, and students host the dinners with the distinguished speakers. Although a teaching experience (TA) is not required, interested students have the opportunity to develop teaching skills as an assistant for one semester. Finally, students complete a preliminary examination typically during the second year of graduate school and form their thesis committee.

Students admitted to the University Program in Genetics and Genomics obtain a PhD by working with faculty of the interdepartmental University Program in Genetics and Genomics.

For more information, visit https://upg.duke.edu/.

Courses in the University Program in Genetics (UPGEN)

522. Critical Readings in Genetics and Genomics. 3 units. C-L: Molecular Genetics & Microbiology 522

532. Human Genetics. 3 units. C-L: see Molecular Genetics & Microbiology 532

640. Quantitative Approaches to Biological Problems: From Cartoon Models to System Behavior. 3 units. C-L: see Cell and Molecular Biology 640

658. Structural Biochemistry I. 2 units. C-L: see Biochemistry 658; also C-L: Cell and Molecular Biology 658, Cell Biology 658, Structural Biology and Biophysics 658, Computational Biology and Bioinformatics 658

659. Structural Biochemistry II. 2 units. C-L: see Biochemistry 659; also C-L: Cell Biology 659, Computational Biology and Bioinformatics 659, Structural Biology and Biophysics 659

660. Evolution from a Coalescence Perspective. 3 units. C-L: see Biology 660

668. RNA Biology: Co-Transcriptional and Post-Transcriptional Control of Gene Expression. 3 units. C-L: see Biochemistry 668; also C-L: Cell Biology 668

701. Advanced Topics in Genetics and Genomics. Course open only to first year UPGG graduate class. Weekly discussion of current literature in genetics (Fall semester) and genomics (Spring semester). Permission of instructor required. Instructor: Staff. 2 units.

702. Papers and Grant Writing Workshop. 3 units. C-L: see Molecular Genetics & Microbiology 702

711. Succeeding in Graduate School in the Biological Sciences. 0.5 units. C-L: see Biology 701

712. Succeeding Beyond Grad School: Career Options with a PhD in the Biological Sciences. 0.5 units. C-L: see Biology 702

716S. Genetics Student Research. Presentations by genetics program students on their current research. Required course for all graduate students specializing in genetics. Credit grading only. Instructor: Staff. 1 unit.

732. Human Genetics. Topics include genetic mechanisms of disease (rare and common genetic risk variants, multi-factorial inheritance, epigenetics, cytogenetics), as well as disease-specific examples including neurogenetics, cancer genetics, pharmacogenetics, complex diseases and gene therapy. Lectures plus weekly discussion of assigned papers from the research literature. Prerequisite: University Program in Genetics 778 (or any individual University Program in Genetics 778A-F module) or completion of the first-year Medical Scientist Training Program (MTSP) curriculum, or consent of instructor. Instructor: Ashley-Koch and Marchuk. 3 units. C-L: Molecular Genetics & Microbiology 732

750S. Genetics Colloquium. Lectures, discussion sections, and seminars on selected topics of current interest in genetics. Required of all students specializing in genetics. Prerequisite: a course in genetics. Instructor: Haase. 1 unit.

778A. University Program in Genetics and Genomics Biological Solutions Module I. One of six mini-courses offered sequentially during the fall semester and together cover 24 topics. These courses are part of the core offerings of the University Program in Genetics and Genomics and allow maximum flexibility for a student-designed curriculum. Multiple topics are available during each mini-course and students choose one. The topics address everything from fundamentals of genetics to modern molecular genetic and genomic strategies for the analysis of a variety of biological systems. Instructor: Lew. 1 unit.

778B. University Program in Genetics and Genomics Biological Solutions Module Il. One of six mini-courses offered sequentially during the fall semester and together cover 24 topics. These courses are part of the core offerings of the University Program in Genetics and Genomics and allow maximum flexibility for a student-designed curriculum. Multiple topics are available during each

mini-course and students choose one. The topics address everything from fundamentals of genetics to modern molecular genetic and genomic strategies for the analysis of a variety of biological systems. Instructor: Lew. 1 unit.

778C. University Program in Genetics and Genomics Biological Solutions Module Ill. One of six mini-courses offered sequentially during the fall semester and together cover 24 topics. These courses are part of the core offerings of the University Program in Genetics and Genomics and allow maximum flexibility for a student-designed curriculum. Multiple topics are available during each mini-course and students choose one. The topics address everything from fundamentals of genetics to modern molecular genetic and genomic strategies for the analysis of a variety of biological systems. Instructor: Lew. 1 unit.

778D. University Program in Genetics and Genomics Biological Solutions Module IV. One of six mini-courses offered sequentially during the fall semester and together cover 24 topics. These courses are part of the core offerings of the University Program in Genetics and Genomics and allow maximum flexibility for a student-designed curriculum. Multiple topics are available during each mini-course and students choose one. The topics address everything from fundamentals of genetics to modern molecular genetic and genomic strategies for the analysis of a variety of biological systems. Instructor: Lew. 1 unit.

778E. University Program in Genetics and Genomics Biological Solutions Module V. One of six mini-courses offered sequentially during the fall semester and together cover 24 topics. These courses are part of the core offerings of the University Program in Genetics and Genomics and allow maximum flexibility for a student-designed curriculum. Multiple topics are available during each mini-course and students choose one. The topics address everything from fundamentals of genetics to modern molecular genetic and genomic strategies for the analysis of a variety of biological systems. Instructor: Lew. 1 unit.

778F. University Program in Genetics and Genomics Biological Solutions Module VI. One of six mini-courses offered sequentially during the fall semester and together cover 24 topics. These courses are part of the core offerings of the University Program in Genetics and Genomics and allow maximum flexibility for a student-designed curriculum. Multiple topics are available during each mini-course and students choose one. The topics address everything from fundamentals of genetics to modern molecular genetic and genomic strategies for the analysis of a variety of biological systems. Instructor: Lew. 1 unit.

793. Research Independent Study. Individual research and reading of the primary literature in a field of special interest, under the supervision of a faculty member, the major product of which is a substantive paper or written report containing significant analysis and interpretation of a previously approved topic. Consent of the instructor required. Instructor: Staff (Genetics Program). 3 units.

German Studies, Carolina-Duke Graduate Program

Professor Engelstein, *Chair*; Associate Professor Pickford, *Director of Graduate Studies*; Professors Engelstein, Gilliam (Music), Lieber (Religious Studies), and Pfau (English); Associate Professors Norberg and Pickford; Assistant Professors Gellen and Pourciau; Professor of the Practice Emerita Walther; Associate Professor of the Practice Crane

A PhD is available in this program.

As of Fall 2009, the Carolina-Duke Graduate Program in German Studies is a fully merged graduate program that draws on the largest German studies faculty in the country, as well as the considerable library holdings of each institution. Students apply to a single program and graduate with a diploma bearing the names of both Duke University and The University of North Carolina at Chapel Hill. Information about this program can be found at https://carolina-duke-grad.german.duke.edu/.

A PhD in German studies is available in this program.

A total of sixteen courses are required, which includes the five core courses listed below, and two course credits for work on a dissertation. Five core courses are required: German 700S (Foreign Language Pedagogy: Theories and Practice); German 715 (Cultural Foundations in German Studies to 1800); German 716 (Cultural Foundations in German Studies 1800 to the Present); Middle High German; and German Linguistics. Post-preliminary students enroll in the Dissertation Colloquium, German 995. Incoming students who have satisfactorily completed equivalent graduate courses may be exempted by the director of graduate studies and graduate advising from one or more of the required courses. Nine additional elective courses must also be completed; two of these will be director-approved courses outside of the German studies program, which complement the student's areas of interest in an interdisciplinary fashion.

A PhD preliminary exam is required and must be taken by the end of the third year. An oral dissertation defense, normally by the end of the fifth year, is also required. In addition, students are strongly encouraged to attend the program's monthly "works in progress" seminar, at which faculty, advanced graduate students, and guests present their current research.

A list of courses offered at The University of North Carolina at Chapel Hill as part of the Carolina-Duke Graduate Program in German Studies is available online at https://catalog.unc.edu/courses/germ/.

Courses in German (GERMAN)

501. German for Academic Research I. Introduction to German for the purpose of developing reading and translation skills necessary for pursuing academic research. Assumes no prior knowledge of German. Foundations of German grammar and syntax; emphasis on vocabulary and translations. Selected readings in theory of translation and techniques. Not open for credit to undergraduate students who have taken Intermediate German (203, 204, 212, or equivalent). Does not count toward the major or minor, or toward the fulfillment of the Foreign Language Requirement. Instructor: Staff. 3 units.

502. German for Academic Research II. Development and refinement of skills needed to read and translate intermediate to advanced academic German. Texts selected by instructor, with regular opportunities to work on materials related to individual fields/research topics. Selected readings in theory of translation and techniques. Prerequisite: German 501. Not open for credit to undergraduate students who have taken Intermediate German (203, 204, 212, or equivalent). Does not count toward the major or minor, or toward the fulfillment of the Foreign Language Requirement. Instructor: Staff. 3 units.

510S. Old Norse: Introduction to the Language of Viking Scandinavia. Introduction to the language of Viking Scandinavia, with primary goal of providing students with the linguistic tools needed to read the fascinating Norse literature in the original.

Systematic presentation of grammar of Old Norse, and development of knowledge and skills needed to read and translate a considerable variety of Norse prose and, to a lesser degree, poetic texts. Also examines the relationship of Old Norse to other Germanic languages, as well as aspects of ancient Scandinavian culture and history. No previous knowledge of linguistics is expected or assumed. Knowledge of German is moderately helpful but not necessary. Taught in English. Instructor: Staff. 3 units. C-L: Linguistics 562S, Medieval and Renaissance Studies 609S

511S. Theory and Practice of Literary Translation. 3 units. C-L: see Literature 640S

512S. Theories of the Image: The Image in Walter Benjamin. 3 units. C-L: see Literature 612S; also C-L: Romance Studies 612S, Visual and Media Studies 612S

532S. Fin-de-siècle and Interwar Vienna: Politics, Society, and Culture. 3 units. C-L: see History 532S

535S. Comparative Modernisms. 3 units. C-L: see Italian 532S; also C-L: Literature 532S

560. History of the German Language. Phonology, morphology, and syntax of German from the beginnings to the present. Instructor: Staff. 3 units. C-L: Medieval and Renaissance Studies 607, Linguistics 560

561S. Second Language Acquisition and Applied Linguistics. Introduction to the fields of second language acquisition and applied linguistics. Investigation of competing theories of language acquisition and learning, and various aspects of applied linguistics, including language and cognition, language and power, bilingualism, language and identity, and intercultural communication. Taught in English. Instructor: Crane. 3 units. C-L: Linguistics 561S

565S. Art and the Holocaust: Architecture, Art, and Cultural Politics during the Nazi Period. 3 units. C-L: see Visual and Media Studies 525S; also C-L: Jewish Studies 555S, History 531S

570. Frankfurt School Critical Theory. This course serves as an introduction to the "Frankfurt School" and Critical Theory with particular emphasis upon rationality, social psychology, and aesthetics. Through close readings of key texts by members of the school (Horkheimer, Benjamin, Adorno, Habermas) we will work toward an understanding of the analyses they developed and consider their validity. All readings and discussions are in English. Instructor: Pickford. 3 units. C-L: Philosophy 572, Political Science 570

575S. Hegel's Political Philosophy. 3 units. C-L: see Political Science 676S; also C-L: Philosophy 536S

576S. Nietzsche's Political Philosophy. 3 units. C-L: see Political Science 577S; also C-L: Philosophy 537S

580S. Music in Literature and Philosophy. Readings in the philosophy of nineteenth- and early twentieth-century "classical" music and in literature as a source for and response to musical composition, performance, and listening experience. Taught in English. Instructor: Pfau. 3 units. C-L: English 580S, International Comparative Studies 527S

586S. Literary Guide to Italy. 3 units. C-L: see Italian 586S; also C-L: Literature 542S

590S. Special Topics in German Studies. Special topics in German literature and cultural studies. Taught in English. Instructor: Staff. 3 units.

690. Special Topics in German Literature and Culture. Topics vary by semester. Instructor: Staff. 3 units.

690S. Special Topics in German Literature and Cultural Studies. Instructor: Staff. 3 units.

700S. Foreign Language Pedagogy: Theories and Practice. Overview of current research in the fields of second language acquisition and foreign language pedagogy, and its implications for the teaching of the German language, literature, and culture at all levels. Readings and discussions on competing theories of language acquisition and learning, issues of cultural identity and difference, learner styles, and the teaching of language as culture; training in contemporary teaching techniques and approaches. Instructor: Crane. 3 units.

715. Foundations in German Studies, 1750 to 1900. Second part of a three-semester sequence offering students a comprehensive, text-based survey of German literary history. Relations between an established German literature and its competing cultural centers; literary conventions, popular culture, and nonliterary discourses (philosophical, religious, national, scientific), the construction of German, Austrian, and Swiss traditions. Instructor: Staff. 3 units.

716. Foundations in German Studies, 1900 to the Present. Third part of a three-semester sequence offering students a comprehensive, text-based survey of German literary history. Relations between an established German literature and its competing cultural centers; literary conventions, popular culture, and nonliterary discourses (philosophical, religious, national, scientific), the construction of German, Austrian, and Swiss traditions. Instructor: Staff. 3 units.

724. Form & Theory of the Lyrical Image: Goethe, Hölderlin, Mörike, Eichendorff, Trakl. An introduction to the basic forms of German lyric poetry after 1770, with taking into account competing interpretation models and theoretical models of poetry and of the concept of the image. The seminar will be held in German. Papers can be written either in German or English. Instructor: Pfau. 3 units.

730S. A Cultural and Spatial Analysis of the Ghetto: Venice, Nazi Occupied Europe, Chicago. 3 units. C-L: see Art History 730S; also C-L: Jewish Studies 730S, History 730S

731S. The Bauhaus: Architecture, Design, Politics. 3 units. C-L: see Visual and Media Studies 731S

790-1. Topics in Literary Theory. Literary theories and methods in their history and philosophical contexts. Issues include canonicity, German identity debates, and the claims of aesthetic language. Instructor: Staff. 3 units.

790-2. Topics in Literary History (Special Topics). Relations between an established German literature and its competing cultural centers; classical and popular cultures, literary conventions, and nonliterary discourses (religious, national, scientific), the construction of Austrian and Swiss traditions. Instructor: Staff. 3 units.

790-3. Topics in Genre Theory. The construction of German literature through generic frameworks: Minnesang, epic, baroque lyric

and drama, classical ballad, folksong, Bildungsroman, expressionist film, others. Instructor: Staff. 3 units.

790-4. Special Topics in German Thought. Special topics in German thought. Topics vary by semester. Instructor: Staff. 3 units.

791. Independent Study. Directed reading in a field of special interest, under the supervision of a faculty member. Consent of the instructor and the director of graduate studies required. Instructor: Staff. 3 units.

801S. The Discipline of Germanistik: A Historical Survey. A study of trends in scholarly criticism within the context of German culture and politics beginning in the 1810s with the origins of *Germanistik* as a university discipline. Topics may include: the invention of philology and the romantic enterprise; positivism and *Geistesgeschichte*; the politics of *Germanistik*, 1933-45; *Germanistik* in Europe and the United States after 1945. Instructor: Norberg. 3 units.

810S. Germanic Seminar. Topics and Instructors vary from semester to semester. Instructor: Staff. 3 units.

820. Consent: Sex and Governance in the Age of Revolution. An exploration of the rise of the notion of consent in the 18th century. Consent came to serve as the foundation of legitimacy and ethics within both political and conjugal unions, yet women's agency with regard to consent remained ambiguous in both cases, entwining discourses on rape and disenfranchisement with political theory. Seminar will focus on constructions of will, desire, reason, autonomy, and political voice in theory and literature from around 1800, juxtaposed with more recent theory. Particular attention paid to the reciprocal authorization between political theory and emerging field of biology. Will engage with current debate on the definition of consent. Instructor: Engelstein. 3 units. C-L: Gender, Sexuality, and Feminist Studies 820

890S. Special Topics in German Studies and Related Fields. Advanced graduate seminar in topics related to German literature, culture, film, philosophy, music, and art. For graduate students only. Instructor: Engelstein, Gellen, Norberg, Pfau, Pickford. 3 units.

995S. Grad Dissertation Colloquium. The course will probe the complexities of advanced research from several perspectives: the opening up or extension of a specific scholarly field; the articulation of results in a broad professional context, including publication; the translation of personal explorations into pedagogical assets. GS students will present dissertation chapters; GS faculty will give guest talks surveying their own work, its interdisciplinary implications and the goal of synthesizing research and teaching. Instructor: Pickford. 1 unit.

Global Health

Associate Professor of the Practice Watt, *Director of Graduate Studies (Master's)*; Professor Thielman, *Associate Director of Graduate Studies (Master's)*; Professor Story, *Director (Certificate)*

A certificate and a master's degree are available in this program.

The master of science in global health (MSc-GH) is administered by the Duke Global Health Institute (DGHI) and involves many other institutes, departments, and schools. A guiding principle of the degree program is the recognition that a multidisciplinary and multisectoral approach to health is essential, as health is influenced by a multitude of factors, including, but not limited to: individual behaviors; family and childhood dynamics; community characteristics; economic status; gender; genetics; country laws and politics; the environment; and the availability, accessibility, and quality of education, health care, nutrition, water, housing, and other basic goods.

Program Requirements

The thirty-nine-unit curriculum includes seven core courses, five electives, a ten-week (minimum) field experience to apply learned research methods, and a research-based scholarly thesis. It is designed as a three-to-four-term program.

The seven core courses are:

- Global Health 700 (Global Health Field Research)
- Global Health 701 (Global Health Challenges)
- Global Health 702 (Global Health Research: Design and Practice)
- Global Health 705 (Biostatistics and Epidemiology for GH Science I)
- Global Health 707 (Biostatistics and Epidemiology for GH Science II)
- Global Health 740 (Ethics for Global Health Research)
- Global Health 750 (Health Systems and Policy in Global Health)

Elective courses will be offered in a variety of departments, schools, and institutes across the university. Students will select from a list of approved courses.

Students are also required to complete a fieldwork experience of at least ten weeks, approved by the director of the MSc-GH Program, and a research-based scholarly thesis.

For more detailed course descriptions and elective options, visit https://globalhealth.duke.edu/education-and-training/graduate/courses/ or see the individual department's listing.

Doctoral Certificate in Global Health

The global health doctoral certificate is an interdisciplinary certificate that provides an opportunity for doctoral students from across Duke University to engage in the field of global health through a combination of coursework, research-related field experience, and engagement with peers and faculty. On completion of the doctoral certificate, students will be prepared to complement their disciplinary scholarship with interdisciplinary knowledge of foundational global health concepts.

Graduate Certificate Requirements

The global health doctoral certificate requires completion of four courses, a field research experience, and ethics training.

- **The required courses are:**
  - Global Health 701 (Global Health Challenges)
  - Research Methods. From a menu of approved options or by approval from the DGHI director of doctoral studies.
  - Elective. One advanced (500+ level accepted, 700+ preferred) global health course from a menu of options that will include courses offered by DGHI and by departments across the university.

- Global Health 870S (Global Health Doctoral Certificate Seminar). This variable-credit advanced seminar for doctoral students enrolled in the global health certificate will be a mix of journal club, presentations of student research, etc. For more detailed course descriptions, visit https://globalhealth.duke.edu/education-and-training/graduate/courses or see the individual department's listing.

- **Field Research Requirement:** The goal of the field research requirement is to give students an in-depth understanding of the multiple contexts of health in underserved populations and to allow them to apply interdisciplinary knowledge and methodology. At least four weeks or 160 hours are required, and it must be approved, in advance, by the DGHI director of doctoral studies.
- **Ethics Training:** Seminars, workshops, and small group discussions will complement Responsible Conduct of Research training.

Courses in Global Health (GLHLTH)

531. Cost-Benefit Analysis for Health and Environmental Policy. Course considers the importance of economic analysis, or cost-benefit analysis (CBA), for public policy assessments. Specific focus is on health and environmental policy, and the steps in identification / cataloguing, quantification, and monetization of impacts of potential policies and projects. Covers: Economic rationale for CBA; Basic principles for assessing the economic effects of projects; Techniques for valuing health and environmental impacts; Intergenerational/philosophical concerns related to CBA; Social discounting; Risk and uncertainty; Comparisons of CBA with other approaches (i.e. cost effectiveness analysis, multi-objective analysis). Instructor: Jeuland. 3 units. C-L: Public Policy 607, Environment 563

533S. Water Cooperation and Conflict. 3 units. C-L: see Public Policy 580S; also C-L: Environment 543S, International Comparative Studies 580S

534. Water Quality Health. 3 units. C-L: see Earth and Ocean Sciences 524; also C-L: Environment 524, Energy 524

538. Global Environmental Health: Economics and Policy. 3 units. C-L: see Public Policy 582; also C-L: Environment 538

540. Global Health Ethics: Interdisciplinary Perspectives. Same as Global Health 210 but requires an additional paper; not open to students who have taken Global Health 210. Department consent required. Instructor: Whetten. 3 units. C-L: Public Policy 638

541S. Organized Compassion: History and Ethics of Humanitarianism. 3 units. C-L: see Study of Ethics 560S; also C-L: Human Rights Program-Franklin Humanities Institute 560S

548S. Global History of Medicine. 3 units. C-L: see History 548S; also C-L: Gender, Sexuality, and Feminist Studies 584S

549S. Histories of Science and Technology. 3 units. C-L: see History 549S; also C-L: Science & Society 549S

550. Topics in Population, Health, and Policy. 3 units. C-L: see Public Policy 633; also C-L: Sociology 534

560. Program Management and Research Administration in Global Health. Using case examples of international health delivery interventions and research programs, this course examines the historical, social, and political effects on the application of program management and research administration skills which include: accounting/finance/budget, project management, operations and performance management, organizational relationships and structure, interpersonal and group interactions, communications (oral, writing; social and digital media), monitoring and evaluation, business and applied research ethics. Instructor: Moe. 3 units.

569. Understanding Sickle Cell Disease: A Biopsychosocial Approach. 3 units. C-L: see Nursing 569; also C-L: African & African American Studies 569

570S. Introduction to mHealth Technologies in Low- and Middle-Income Countries. Mobile phones are catalyzing the delivery of health services and information in low- and middle-income countries. Due to global pervasiveness of mobile phones, this mobile health (mHealth) revolution has become a centerpiece in efforts to achieve the sustainable development goals, especially universal healthcare. This course will provide an introduction to mHealth and follow the mHealth lifecycle—from design to deployment—with a strong focus on developing sustainable applications that can be integrated within national health systems in developing countries. Students will be introduced to concepts such as user centered design, system architecture, business models, and mobile data privacy. Instructor: Vasudevan. 3 units.

571. Global Maternal and Child Health. Provides solid foundation in global perspectives on maternal and child health research, practice, and policy. Utilize case analysis to examine critical health challenges facing women, children, providers, and policymakers in some of the world's most vulnerable communities. Course designed for graduate and advanced undergraduate students. Instructor: Staff. 3 units.

571D. Global Maternal and Child Health. Provides solid foundation in global perspectives on maternal and child health research, practice, and policy. Utilize case analysis to examine critical health challenges facing women, children, providers, and policymakers in some of the world's most vulnerable communities. Course designed for graduate and advanced undergraduate students. Instructor: Staff. 3 units.

571K. Introduction to Maternal and Child Health. Provides global perspectives on maternal and child health research, practice, and policy. Utilizes case analysis to examine health challenges facing women, children, health providers, and policymakers in some of the world's most disadvantaged communities. Addresses maternal health, infant health, and early childhood development. Special focus on low- and middle-income countries. Discussion includes: data and measurement, health system challenges, public health interventions and programs, policy and advocacy. Topics include: reproductive health, delivery and postnatal care, nutrition, immunization. Designed for graduate and advanced undergraduate students. Taught at Duke Kunshan University. Instructor: Staff. 3 units.

573D. One Health: From Philosophy to Practice. Interdisciplinary course introducing construct of One Health as increasingly important to a holistic understanding of prevention of disease and maintenance of health. Includes discussion of bidirectional impact of

animal health on human health, impact of earth's changing ecology on health. Learning objectives include 1) to describe how different disciplines contribute to the practice of One Health, 2) to creatively design interdisciplinary interventions to improve Global Health using a One Health model. Course will include weekly 2-hour multi-campus seminar off-site at NC Biotechnology Center with on-campus discussion section using case studies to supplement the seminar. Instructor: Pan, Woods. 3 units.

581. Global Environmental Health Problems: Principles and Case Studies. 3 units. C-L: see Environment 581

581D. Global Environmental Health Problems: Principles and Case Studies. 3 units. C-L: see Environment 581D

581K. Global Environmental Health Problems: Principles and Case Studies. 3 units. C-L: see Environment 581K

590. Special Topics in Global Health. Topics vary depending on semester and section. Topics may include: global health ethics, field methods, health technologies, rapid needs assessment, and global health policies. Instructor: Staff. 3 units.

590S. Special Topics in Global Health. Topics vary depending on semester and section. Topics may include: global health ethics, field methods, health technologies, rapid needs assessment, and global health policies. Instructor: Staff. 3 units.

590S-1. Special Topics in Global Health. Topics vary depending on semester and section. Topics may include: global health ethics, field methods, health technologies, rapid needs assessment, and global health policies. Instructor: Staff. 3 units.

593. Research Independent Study in Global Health. Individual research-oriented directed study in a field of special interest on a previously approved topic, under the supervision of a faculty member, resulting in a significant academic product. Open only to qualified juniors and seniors by consent of instructor and director of undergraduate studies in global health. Instructor: Staff. 3 units.

630. Air Pollution: From Sources to Health Effects. 3 units. C-L: see Environment 642

634. Air Quality: Human Exposure and Health Effects. 1.5 units. C-L: see Environment 604

635. Critical Readings in Environmental Epidemiology. 3 units. C-L: see Environment 633

637K. Population and Environmental Dynamics Influencing Health. Examination of population, health and environment (PHE) dynamics with focus on interactions in developing or transition economies. Theoretical and empirical approaches governing PHE dynamics from multidisciplinary perspectives, including geography, public health /epidemiology, demography, and economics. Students will obtain experience in design and analysis of PHE studies, and epidemiology of vector-born, chronic and enteric infections. Taught at Duke Kunshan University. Instructor: Pan. 3 units. C-L: Environment 637K

637S. Population and Environmental Dynamics Influencing Health. Course examines population, health and environment (PHE) dynamics with focus on interactions in developing or transition economies. Theoretical and empirical approaches governing PHE dynamics from multidisciplinary perspectives, including geography, public health /epidemiology, demography, and economics. Students will obtain experience in design and analysis of PHE studies, and epidemiology of vector-born, chronic and enteric infections. Instructor: Pan. 3 units. C-L: Environment 637S

641. Non-Communicable Diseases in Low- & Middle-Income Countries: Trends, Causes and Prevention Strategy. Course will provide an overview of the recent (mid-20th century to the present) trends in non-communicable disease epidemiology. Focus on four major non-communicable disease categories as separate modules: cardiovascular, oncologic, diabetic and pulmonary diseases. Case studies used to highlight selected geographic differences. By using lectures, assigned readings and classroom discussion the course aims to provide the student with a firm understanding of the shifting disease burden and the landscape of stakeholders and interventions to prevent the same. Instructor: Bloomfield. 3 units.

641K. Non-Communicable Diseases in Low and Middle Income Countries: Trends, Causes, Prevention Strategies. Provides global overview of recent (mid-20th century to present) trends in non-communicable disease (NCD) epidemiology and strategies for prevention and control of these diseases, with particular emphasis on China and comparisons between China and other countries. Focuses on four major NCD categories as separate modules: cardiovascular, diabetic, oncologic, and pulmonary diseases. Uses case studies to highlight selected geographic differences. Provides firm understanding of shifting disease burden, stakeholders, and interventions to address NCDs in low- and middle-income countries. Designed for graduate-level students, open to advanced undergraduates. Taught at Duke Kunshan University. Instructor: Yan. 3 units.

642S. Designing Innovation for Global Health: From Philanthropy to People. 3 units. C-L: see Public Policy 642S

660. Global Mental Health. Examination of global mental health from perspectives of culture, public health, epidemiology, human rights, policy, and intervention. Disciplines include cross-cultural psychiatry, medical anthropology, public mental health, and economics. Topics include ethics, stigma, cross-cultural classification of mental health, ethnopsychology, trauma, violence, disasters, and displacement. Populations include children, ethnic minorities, refugees, survivors of complex emergencies, and persons with chronic disease. Course highlights mixed-methods approaches to research and intervention evaluation. Designed for graduate students & advanced undergraduates. Prior research methods course recommended. Instructor: Staff. 3 units. C-L: Psychology 611, Cultural Anthropology 611, Human Rights Program-Franklin Humanities Institute 660

660K. Global Mental Health (A). Examination of global mental health from perspectives of culture, public health, epidemiology, human rights, policy, and intervention. Disciplines include cross-cultural psychiatry, medical anthropology, public mental health, and economics. Topics include ethics, stigma, cross-cultural classification of mental health, ethnopsychology, trauma, violence, disasters, and displacement. Populations include children, ethnic minorities, refugees, survivors of complex emergencies, and persons with chronic disease. Course highlights mixed-methods approaches to research and intervention evaluation. Designed for graduate students & advanced undergraduates. Prior research methods course recommended. Taught in Durham. Instructor: Staff. 3 units.

670. Global Nutrition. This class examines global nutrition trends and problems focusing on both the US and developing countries. Topics include basic principles of nutrition, research methods for dietary assessment, and the epidemiological trends, physiological consequences, and behavioral outcomes of both overnutrition (e.g., obesity) and undernutrition (e.g., malnutrition). Emphasis will be placed on intervention approaches to improve these outcomes (e.g., supplementation and fortification, community-based programs, and

nutrition policy). Students will gain a better understanding of basic nutrition, global trends, and best practices for improving nutritional status. For graduate or advanced undergraduates. Instructor: Steinberg. 3 units.

671. Global Health and Health Systems in Africa. This course is designed to prepare students to work in, or pursue study of, the complex institutional environment of global health and health systems in Africa. The course braids together four topical strands: (1) the social, political, and economic context of the African continent; (2) African conceptions of the "public" and of "health" (3) the origins and evolution of African health systems; and (4) the impact on African health systems of transitions in global health governance. The course pursues these topics through case studies and team projects focused on issues of global health and health systems in representative African countries. Instructor: Toole. 3 units. C-L: Public Policy 636

672. Health in the African Diaspora. 3 units. C-L: see African & African American Studies 660; also C-L: Cultural Anthropology 660

673D. Global Surgical Care. Lack of access to surgical care threatens the health of people throughout the world's poorest regions, and impacts all areas of health care. This seminar will address issues surrounding the delivery of surgical and anesthesia care in low- and middle income countries for students and clinical trainees in global health. This course will focus on surgical care delivery and management; workforce, training, and education; and economics and finance. The content of this course will be based on the Lancet Commission on Global Surgery report and support materials. The format will be a weekly lecture, readings, and case studies. Instructor: Rice. 3 units.

673S. Global Surgical Care. Lack of access to surgical care threatens the health of people throughout the world's poorest regions, and impacts all areas of health care. This seminar will address issues surrounding the delivery of surgical and anesthesia care in low- and middle income countries for students and clinical trainees in global health. This course will focus on surgical care delivery and management; workforce, training, and education; and economics and finance. The content of this course will be based on the Lancet Commission on Global Surgery report and support materials. The format will be a weekly seminar, readings, and case studies. Instructor: Rice. 3 units.

673SK. Global Surgical Care. Lack of access to surgical care threatens the health of people throughout the world's poorest regions, and impacts all areas of health care. This seminar will address issues surrounding the delivery of surgical and anesthesia care in low- and middle income countries for students and clinical trainees in global health. This course will focus on surgical care delivery and management; workforce, training, and education; and economics and finance. The content of this course will be based on the Lancet Commission on Global Surgery report and support materials. The format will be a weekly seminar, readings, and case studies. Taught in Durham. Instructor: Rice. 3 units.

690. Special Topics in Global Health Studies. Topics vary depending on semester and section. Topics may include: global health ethics, field methods, health technologies, rapid needs assessment, and global health policies. Instructor: Staff. Variable credit.

700. Global Health Field Research: Planning and Skill Development. Provides preparation for global health fieldwork for MSc Global Health students. Students will develop critical skills, knowledge, and reflective insights to manage the multiple aspects of fieldwork. Open only to first year students in MSc-GH program. Consent of Director of Graduate Studies required. Instructor: Watt. 1 unit.

700K. Global Health Field Research: Planning and Skill Development. Prepare students to successfully engage in field-based research in global health. Develop critical skills and reflective insights that can help students to manage the multiple aspects of fieldwork. Taught in China at Duke Kunshan University. Instructor: Long. 1 unit.

701. Global Health Challenges. Global Health Challenges surveys the major global health problems facing the world today. After providing a theoretical and conceptual framework for understanding these challenges within a biopsychosocial model, the course uses lecture and case discussion to analyze key areas contributing to the global burden of disease: infectious disease; communicable diseases; maternal, reproductive, and child health; and injury, violence, and disaster. Throughout the course, emphasis is placed on both understanding the complex interaction of upstream and downstream approaches to improve health outcomes and elucidating successful strategies in reducing health disparities. Department consent required. Instructor: Boyd. 3 units.

701D. Global Health Challenges. Global Health Challenges surveys the major global health problems facing the world today. After providing a theoretical and conceptual framework for understanding these challenges within a biopsychosocial model, the course uses lecture and case discussion to analyze key areas contributing to the global burden of disease: infectious disease; communicable diseases; maternal, reproductive, and child health; and injury, violence, and disaster. Throughout the course, emphasis is placed on both understanding the complex interaction of upstream and downstream approaches to improve health outcomes and elucidating successful strategies in reducing health disparities. Department consent required. Instructor: Boyd. 3 units.

701K. Global Health Challenges. Course introduces major global health problems and social, behavioral, economic, biomedical and environmental determinants of health in resource limited settings. Topics include communicable diseases i.e. HIV, malaria, tuberculosis and common childhood diseases; chronic diseases such as cancer, diabetes, cardiovascular disease and mental health; and determinants of health associated with these diseases, such as poverty, gender imbalance, culture, poor environmental sanitation, malnutrition, tobacco use, and climate change. Other topics may include health promotion, reproductive health, maternal and child health, and disaster preparedness. Taught at Duke Kunshan University. Instructor: Staff. 3 units.

702. Global Health Research: Design and Practice. Course provides a foundation in study design, research question development, field implementation, measurement, validity and reliability. Quantitative and qualitative research approaches are examined. Students build critical skills in reading, interpreting and synthesizing scientific literature. The selection of appropriate measurements and survey development is emphasized and issues in field implementation explored. Instructor: Staff. 3 units.

702D. Global Health Research: Design and Practice. Course provides a foundation in study design, research question development, field implementation, measurement, validity and reliability. Quantitative and qualitative research approaches are examined. Students build critical skills in reading, interpreting and synthesizing scientific literature. The selection of appropriate

measurements and survey development is emphasized and issues in field implementation explored. Instructor: Staff. 3 units.

702K. Global Health Research: Design and Practice. Course provides a foundation in study design, research question development, field implementation, measurement, validity and reliability. Quantitative and qualitative research approaches are examined. Students build critical skills in reading, interpreting and synthesizing scientific literature. The selection of appropriate measurements and survey development is emphasized and issues in field implementation explored. Taught at Duke Kunshan University. Instructor: Abdullah. 3 units.

705. Biostatistics and Epidemiology for GH Science I. Introduces principles of epidemiology, including disease frequency measures; measures of association; observational, experimental, and quasi-experimental study designs; validity -- confounding, selection bias, measurement error; reliability. The course also will interweave introductory biostatistics for continuous and categorical variables. Lab section in which students walk through guided data analysis on provided data set using STATA. Instructor: Staff. 4 units.

705K. Biostatistics and Epidemiology for Global Health Science I. Introduces principles of epidemiology, including disease frequency measures; measures of association; observational, experimental, and quasi-experimental study designs; validity—confounding, selection bias, measurement error; reliability. The course also will interweave introductory biostatistics for continuous and categorical variables. Lab section in which students walk through guided data analysis on provided data set using STATA. Taught at Duke Kunshan University. Instructor: Staff. 4 units.

707. Biostatistics and Epidemiology for GH Science II. Builds on Quantitative Methods I. Provides common understanding of regression including linear, logistic, and general linear regression, use and interpretation of dichotomous and continuous variables, indicator terms, and interaction terms, and regression diagnostics. Required lab section. Instructor: Staff. 4 units.

707K. Biostatistics and Epidemiology for Global Health Science II. Modular course building on Quantitative Methods I. Required module provides common understanding of regression including linear, logistic, and general linear regression, use and interpretation of dichotomous and continuous variables, indicator terms, and interaction terms, and regression diagnostics. Required lab section. Taught at Duke Kunshan University. Instructor: Abdullah. 4 units.

708. Advanced Methods in Epidemiology. This course continues the curriculum presented in Quantitative Methods I & II and introduces some additional statistical methods used in epidemiology, including analysis of time to event data (survival analysis) and analysis of count and rate data (Poisson methods). In addition it provides an introduction of issues related to repeated measures data, causal inference, sensitivity analysis and other advanced topics in epidemiology. There is a data analysis lab section that will give students practical experience in these methods using a provided dataset. Instructor: Staff. 2 units.

709S. Science, Medicine, and the Body. 3 units. C-L: see Cultural Anthropology 709S; also C-L: Gender, Sexuality, and Feminist Studies 709S, Science & Society 709S, Literature 709S

710. Intermediate Epidemiology. This course covers in-depth topics in epidemiology with a focus on the global health context. The course textbook is "Epidemiology: Beyond the Basic" by Moyses Szklo and Javier Nieto. The textbook will be supplemented with publications selected from the epidemiologic, clinical, nutritional and other literature. Topics covered include epidemiologic study designs, measures of disease occurrence and associations with risk factors, confounding and interaction, time to event data, and methods for causal inference. Course content will focus on epidemiologic concepts. Related statistical concepts will be discussed, but data analysis will not be a focus. Prior epidemiology coursework required. Instructor consent required. Instructor: Egger. 3 units.

710K. Intermediate Epidemiology. This course covers in-depth topics in epidemiology with a focus on the global health context. The course textbook is "Epidemiology: Beyond the Basic" by Moyses Szklo and Javier Nieto. The textbook will be supplemented with publications selected from the epidemiologic, clinical, nutritional and other literature. Topics covered include epidemiologic study designs, measures of disease occurrence and associations with risk factors, confounding and interaction, time to event data, and methods for causal inference. Course content will focus on epidemiologic concepts. Related statistical concepts will be discussed, but data analysis will not be a focus. Prior epidemiology coursework required. Taught in Durham. Instructor consent required. Instructor: Egger. 3 units.

720. Decolonizing Global Health. Recent calls to decolonize global health reflect a growing awareness of the failure of global health to address persistent colonial/imperial attitudes, structural racism, and power asymmetries. Global health trainees, educators, and practitioners must interrogate their own colonial history, study theories of decolonization and indigenous activist movements, confront systemic/structural racism, and articulate transformative solutions. This course offers a brief, but wide-ranging, overview of some of the most critical questions shaping the Decolonize Global Health movement, and guides students to formulate actionable strategies to decolonize global health curriculum, research, and practice. Open only to Global Health master's students. Taught online. Instructor: Stewart. 1 unit.

721. Indigenous Medicine and Global Health. Explores indigenous medicine's role in global health and focuses on four interrelated topics: basic medical paradigms and practices, access and utilization in different regions, cross-cultural health delivery, and the complexities of medical pluralism. Course themes will be explored through lecture, discussion, small group case analyses, comparative analytical exercises, and workshops. Instructor: Boyd. 3 units. C-L: Cultural Anthropology 760

731. One Health: Introduction to the One Health Approach. 6-day morning course introduces principles of employing the One Health approach in preventing and controlling infectious diseases. Includes practical overview of host factors, environmental factors, and microbiological factors that influence this dynamic field of study. Through lectures and exercises, introduces infectious disease surveillance, diagnostic tools, outbreak investigations, vaccine trials, public health interventions, biodefense, emerging infectious diseases and analytical approaches as they pertain to infectious disease prevention and control. Introduces wide array of reference material for practical application of course material. Instructor: Gray. 2 units. C-L: Environment 931

732. One Health: Introduction to Environmental Health. Course provides a comprehensive overview of major topic areas in Environmental Health. Includes major sources of environmental health risks, such as microbial, chemical, and physical agents in natural and anthropogenic environments. Also covers topics of toxicology and ecotoxicology, risk assessment and risk management,

water and sanitation issues, infectious diseases, food safety, and other emerging topics. Instructor: Staff. 3 units. C-L: Environment 932

735. One Health: Introduction to Entomology, Zoonotic Diseases, and Food Safety. Course introduces public health students to entomology, zoonotic diseases, and principals of modern food safety. Includes methods for conducting studies of mosquitoes and ticks, controlling zoonotic diseases, and protecting the food supply. Special focus on modern food safety techniques in meat, dairy and produce production. Lectures complemented with considerable laboratory and/or field work. Instructor: Gray. 3 units. C-L: Environment 938

739. One Health: Public Health Laboratory Techniques. Introduction to common laboratory techniques used in emerging infectious respiratory disease research and surveillance laboratories; emphasis on techniques for culturing, characterization, and serological surveillance of exposure to influenza viruses. Instructor: Staff. 1 unit. C-L: Environment 939

740. Ethics for Global Health Research. Course presents overview of practical and theoretical approaches to bioethics from a range of perspectives, including humanities, law, philosophy, medicine and science. Students apply various resources, terminology and frameworks to case studies, preparing them for their own research. Course includes IRB and responsible conduct of research. Instructor: Stewart. 2 units.

750. Health Systems in Low and Middle Income Countries. Health systems in low and middle income countries are analyzed applying five dimensions: Stewardship and Client Interaction, Financing, Service Provision, Innovation and Entrepreneurship, Leadership and Ethics. Health systems are idiosyncratic to their history, economics, politics and geography. Comparisons can be made on financing, organization of care providers, client interaction/interface, access/quality/cost and outcomes such as health status of populations, preventative care and client satisfaction. 7-9 health systems are presented to demonstrate the framework. Student teams apply the framework to a selected country. Instructor: Moe. 3 units.

751. Developing Implementation/Operational Research for Improving Health Interventions. IR/OR: studies how to improve uptake, implementation, and translation of research findings into routine and common practices ('know-do' or 'evidence to program' gap); moves results from effectiveness studies and efficacy trials to real-world settings, obtaining information to guide scale-up; helps implementers apply lessons from a program in one context to developing a similar program in a similar environment. Course covers: framework of IR/OR; methods of identifying program implementation problems; how to organize and develop an IR/OR proposal; main study design, research methods, data collection and analysis used in IR/OR; approaches to capacity building for IR/OR in developing countries. Instructor: Tang. 3 units.

752. Grant Writing in Global Health: A Didactic Primer. This master's level didactic course will teach students how to seek funding opportunities and create grant proposals for global health research purposes. Through an iterative process, students will learn how to plan a research proposal effectively, work within a fixed timeline, tips for improving writing skills, create a budget and budget justification, design a team-based study, and submit a grant proposal. Instructor: Staton, Vissoci. 3 units.

755. Global Health Policy: Transforming Evidence into Action. In-depth inquiry on how to narrow the gap between global health evidence and practical action and policy making on the ground. Examination of the complex ways in which global health policies are formed, shaped, and implemented. How key actors in global health can be identified, and how their power and influence can be analyzed. The contextual factors and processes that affect policy making. Top-down, bottom-up and mixed approaches to actual implementation of global health policies. The relationship between researchers and policymakers. Theories, tools, and frameworks for becoming a "policy entrepreneur," able to bridge the research-to-policy divide. Case studies. Case-based competition. Instructor: Yamey. 3 units.

758. Case Studies in Data Science for Global Health. Application of statistical and data science skills to in-depth data analysis projects in global health. Principled use and interpretation of modern tools, including data wrangling and munging, visualization, exploratory analysis, predictive modeling, and inference using modern statistical software applied to global health data. Emphasis on communication of analysis results both technically and non-technically via presentations and written reports. Students must have access to data for course project. Prerequisite: GLHLTH 705. Instructor: Herring. 3 units.

758K. Case Studies in Data Science for Global Health. Application of statistical and data science skills to in-depth data analysis projects in global health. Principled use and interpretation of modern tools, including data wrangling and munging, visualization, exploratory analysis, predictive modeling, and inference using modern statistical software applied to global health data. Emphasis on communication of analysis results both technically and non-technically via presentations and written reports. Taught in Durham. Prerequisite: Global Health 705/705K and access to data for course project. Instructor: Herring. 3 units.

760. Program Management and Research Administration in Global Health. Using case examples of international health delivery interventions and research programs the course examines the historical, social and political effects on the application of program management and research administration skills which include: accounting/finance/budget, project management, operations and performance management, organizational relationships and structure, interpersonal and group interactions, communications (oral, writing; social and digital media), monitoring and evaluation, business and applied research ethics. Consent of department is required. Instructor: Moe. 3 units.

761K. Introductory Demographic Measures and Concepts. Introduction to demographic concepts, measures, and techniques. Focus on population change, mortality, morbidity, fertility, marriage, divorce, and migration. Illustration of broader application of demographic measurement and techniques to other aspects of society and population health, such as educational attainment, labor force participation, linkages between mortality, morbidity and disability, and health and mortality differentials. Students will also learn how to apply methods discussed. Taught in Durham. Instructor: Merli. 3 units.

761S. Introductory Demographic Measures and Concepts. Introduction to demographic concepts, measures, and techniques. Focus on population change, mortality, morbidity, fertility, marriage, divorce, and migration. Illustration of broader application of demographic measurement and techniques to other aspects of society and population health, such as educational attainment, labor force participation, linkages between mortality, morbidity and disability, and health and mortality differentials. Students will also learn how to apply methods discussed. Instructor: Merli. 3 units. C-L: Public Policy 840S

770D. Qualitative Data Analysis for Global Health. Equips students with knowledge and skills to effectively analyze qualitative data in the field of global health. With a foundation in thematic analysis, teaches tools of memo writing, coding, diagramming and matrices to support the synthesis, interpretation and presentation of data in a systematic and rigorous way. NVivo software will be used to organize and manage the analytic process. Students should have previous qualitative coursework and/or qualitative experience. Best suited for students who have a qualitative data set that they are working to analyze toward a specific output (e.g., a publication, master's thesis or doctoral dissertation). Instructor: Watt. 3 units.

770K. Qualitative Data Analysis for Global Health. Equips students with knowledge and skills to effectively analyze qualitative data in the field of global health. With a foundation in thematic analysis, teaches tools of memo writing, coding, diagramming and matrices to support the synthesis, interpretation and presentation of data in a systematic and rigorous way. NVivo software will be used to organize and manage the analytic process. Students should have previous qualitative coursework and/or qualitative experience. Best suited for students who have a qualitative data set that they are working to analyze toward a specific output (e.g., a publication, master's thesis or doctoral dissertation). Taught in Durham. Instructor: Watt. 3 units.

770S. Qualitative Data Analysis for Global Health. Equips students with knowledge and skills to effectively analyze qualitative data in the field of global health. With a foundation in thematic analysis, teaches tools of memo writing, coding, diagramming and matrices to support the synthesis, interpretation and presentation of data in a systematic and rigorous way. NVivo software will be used to organize and manage the analytic process. Students should have previous qualitative coursework and/or qualitative experience. Best suited for students who have a qualitative data set that they are working to analyze toward a specific output (e.g., a publication, master's thesis or doctoral dissertation). Instructor: Watt. 3 units.

771. One Health: From Philosophy to Practice. Interdisciplinary course introducing construct of One Health as increasingly important to a holistic understanding of prevention of disease and maintenance of health. Includes discussion of bidirectional impact of animal health on human health, impact of earth's changing ecology on health. Learning objectives include 1) to describe how different disciplines contribute to the practice of One Health, 2) to creatively design interdisciplinary interventions to improve Global Health using a One Health model. Course will include weekly 2-hour multi-campus seminar off-site at NC Biotechnology Center with on-campus discussion section using case studies to supplement the seminar. Instructor: Staff. 3 units. C-L: Environment 774

772. Global Health Research: Qualitative Field Methods. Course builds on material from GLHLTH 702, but narrows focus to (1) qualitative field methods and 2) theories of the mixed method approach. A field-based, applied course designed to help students choose the qualitative field methods that best fit their project. Students will develop basic qualitative skills practiced by social sciences: ethnographic description, participant observation, interviewing. In addition, the course will introduce time allocation diaries and fieldnotes. Will discuss methods for collecting, analyzing, integrating, and reporting data from multiple sources. Finally, we will engage in ethical analysis as a core theme that unifies all stages of research. Instructor: Stewart. 3 units.

773. Deconstructing Global Injury Control and Prevention through Systematic Review Methods. An introduction to the field of injury epidemiology and injury prevention. Prominent types of injury are very different in different settings and those to be discussed in the course are those related to motor vehicles, assaults, firearms, self-injurious behavior and global toxicology. Behavioral, biological, economic and social issues related to the implementation of injury reduction policies will be explored through case studies of specific injury scenarios and interventions. Course will delve into epidemiology, specific research methods and innovative research methods and articles. Instructor: Staff. 3 units.

774. Program Evaluation for Health. Covers the principles and tools of evaluation, starting with the evaluation planning process and ending with the dissemination of evaluation results and their use to inform action. Examines different approaches to evaluation (e.g., participatory evaluation), common evaluation designs, and the use of quantitative and qualitative data. Discuss "real-life" evaluation challenges and explore current debates and developments in the field, utilizing examples of actual evaluations of health-related programs and policies (both domestic and international). For the course project, learners will work with local organizations to help the latter enhance their evaluation capacity. Instructor: Silberberg. 3 units.

777. Infectious Disease Epidemiology in Global Settings — Surveillance, Prevention and Control. Focus on communicable diseases in global settings, spanning individual level of diagnosis & treatment of infectious cases to population-level disease surveillance, prevention & control. Examines relationships between infectious disease & environmental health, including veterinary health. Expands upon topics introduced in MSc-GH core graduate coursework to build towards integrated understanding of infectious disease epidemiology. Three modules: 1) Foundations in Infectious Disease Epidemiology, 2) Disease Surveillance & Prevention, 3) Disease Treatment & Control. Course taught exclusively on-line. Open to graduate students at Duke and DKU only. Instructor: Staff. 3 units.

781. Ungraded Research in Global Health. Individual research in a field of special interest, the central goal of which is a substantive paper containing significant analysis and interpretation of a previously approved topic. Consent required. Instructor: Staff. Variable credit.

782. Internship in Global Health. Students gain practical global health experience by taking an internship in the field and writing a report about the experience. Requires prior consent from the student's advisor and from the director of graduate studies. May be repeated with consent of the advisor and the director of graduate studies. Instructor: Watt. 3 units.

790. Special Topics in Global Health. Topics vary depending on semester and section. Topics may include: global health ethics, field methods, health technologies, rapid needs assessment, and global health policies. Topics course. Instructor: Staff. 3 units.

790S. Special Topics in Global Health. Topics vary depending on semester and section. Topics may include: global health ethics, field methods, health technologies, rapid needs assessment, and global health policies. Instructor: Staff. 3 units.

791. Independent Study in Global Health. Individual non-research directed study in a field of special interest on a previously approved topic, under the supervision of a faculty member, resulting in a significant academic product. By consent of instructor and DGS. Instructor: Staff. 3 units.

791-1. Independent Study in Global Health. Individual non-research directed study in a field of special interest on a previously approved topic, under the supervision of a faculty member, resulting in a significant academic product. By consent of instructor and DGS. Instructor: Staff. 3 units.

792. Independent Study in Global Health. Individual non-research directed study in a field of special interest on a previously approved topic, under the supervision of a faculty member, resulting in a significant academic product. By consent of instructor and DGS. Instructor: Staff. 1 unit.

795. Connections in Global Health: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing global health issues. Teams may also include postdoctoral fellows, visiting global health fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires substantive paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 3 units.

795-1. Connections in Global Health: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing global health issues. Teams may also include postdoctoral fellows, visiting global health fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 1.5 units.

795T. Bass Connections Global Health Research Team. Tutorial course for Bass Connections yearlong project team. Topics vary depending on semester and section. Teams of undergraduate and graduate students work with faculty leaders to identify, refine, explore and develop solutions to pressing global health issues. Teams may also include postdoctoral fellows and experts from business, government and the nonprofit sector. A team's work may run in parallel with or contribute to an ongoing research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 4 units.

796. Connections in Global Health: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing global health issues. Teams may also include postdoctoral fellows, visiting global health fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires substantive paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 3 units.

796-1. Connections in Global Health: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing global health issues. Teams may also include postdoctoral fellows, visiting global health fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 1.5 units.

796T. Bass Connections Global Health Research Team. Tutorial course for Bass Connections yearlong project team. Topics vary depending on semester and section. Teams of undergraduate and graduate students work with faculty leaders to identify, refine, explore and develop solutions to pressing global health issues. Teams may also include postdoctoral fellows and experts from business, government and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 4 units.

840. Ethics and Policy-Making. 3 units. C-L: see Public Policy 816

870S. Global Health Doctoral Certificate Seminar. This seminar is required for the Global Health Doctoral Certificate. Its contents will vary by semester but may include a combination of journal club, discussions with experts at Duke or external visitors, research presentations, and dissertation discussions. Instructor: Sikkema. Variable credit.

01-G-K

571K. Introduction to Maternal and Child Health. Provides global perspectives on maternal and child health research, practice, and policy. Utilizes case analysis to examine health challenges facing women, children, health providers, and policymakers in some of the world's most disadvantaged communities. Addresses maternal health, infant health, and early childhood development. Special focus on low- and middle-income countries. Discussion includes: data and measurement, health system challenges, public health interventions and programs, policy and advocacy. Topics include: reproductive health, delivery and postnatal care, nutrition, immunization. Designed for graduate and advanced undergraduate students. Taught at Duke Kunshan University. Instructor: Staff. 3 units.

581K. Global Environmental Health Problems: Principles and Case Studies. 3 units. C-L: see Environment 581K

637K. Population and Environmental Dynamics Influencing Health. Examination of population, health and environment (PHE) dynamics with focus on interactions in developing or transition economies. Theoretical and empirical approaches governing PHE dynamics from multidisciplinary perspectives, including geography, public health /epidemiology, demography, and economics. Students will obtain experience in design and analysis of PHE studies, and epidemiology of vector-born, chronic and enteric infections. Taught at Duke Kunshan University. Instructor: Pan. 3 units. C-L: Environment 637K

641K. Non-Communicable Diseases in Low and Middle Income Countries: Trends, Causes, Prevention Strategies.

Provides global overview of recent (mid-20th century to present) trends in non-communicable disease (NCD) epidemiology and strategies for prevention and control of these diseases, with particular emphasis on China and comparisons between China and other countries. Focuses on four major NCD categories as separate modules: cardiovascular, diabetic, oncologic, and pulmonary diseases. Uses case studies to highlight selected geographic differences. Provides firm understanding of shifting disease burden, stakeholders, and interventions to address NCDs in low- and middle-income countries. Designed for graduate-level students, open to advanced undergraduates. Taught at Duke Kunshan University. Instructor: Yan. 3 units.

660K. Global Mental Health (A). Examination of global mental health from perspectives of culture, public health, epidemiology, human rights, policy, and intervention. Disciplines include cross-cultural psychiatry, medical anthropology, public mental health, and economics. Topics include ethics, stigma, cross-cultural classification of mental health, ethnopsychology, trauma, violence, disasters, and displacement. Populations include children, ethnic minorities, refugees, survivors of complex emergencies, and persons with chronic disease. Course highlights mixed-methods approaches to research and intervention evaluation. Designed for graduate students & advanced undergraduates. Prior research methods course recommended. Taught in Durham. Instructor: Staff. 3 units.

673SK. Global Surgical Care. Lack of access to surgical care threatens the health of people throughout the world's poorest regions, and impacts all areas of health care. This seminar will address issues surrounding the delivery of surgical and anesthesia care in low- and middle income countries for students and clinical trainees in global health. This course will focus on surgical care delivery and management; workforce, training, and education; and economics and finance. The content of this course will be based on the Lancet Commission on Global Surgery report and support materials. The format will be a weekly seminar, readings, and case studies. Taught in Durham. Instructor: Rice. 3 units.

700K. Global Health Field Research: Planning and Skill Development. Prepare students to successfully engage in field-based research in global health. Develop critical skills and reflective insights that can help students to manage the multiple aspects of fieldwork. Taught in China at Duke Kunshan University. Instructor: Long. 1 unit.

701K. Global Health Challenges. Course introduces major global health problems and social, behavioral, economic, biomedical and environmental determinants of health in resource limited settings. Topics include communicable diseases i.e. HIV, malaria, tuberculosis and common childhood diseases; chronic diseases such as cancer, diabetes, cardiovascular disease and mental health; and determinants of health associated with these diseases, such as poverty, gender imbalance, culture, poor environmental sanitation, malnutrition, tobacco use, and climate change. Other topics may include health promotion, reproductive health, maternal and child health, and disaster preparedness. Taught at Duke Kunshan University. Instructor: Staff. 3 units.

702K. Global Health Research: Design and Practice. Course provides a foundation in study design, research question development, field implementation, measurement, validity and reliability. Quantitative and qualitative research approaches are examined. Students build critical skills in reading, interpreting and synthesizing scientific literature. The selection of appropriate measurements and survey development is emphasized and issues in field implementation explored. Taught at Duke Kunshan University. Instructor: Abdullah. 3 units.

705K. Biostatistics and Epidemiology for Global Health Science I. Introduces principles of epidemiology, including disease frequency measures; measures of association; observational, experimental, and quasi-experimental study designs; validity—confounding, selection bias, measurement error; reliability. The course also will interweave introductory biostatistics for continuous and categorical variables. Lab section in which students walk through guided data analysis on provided data set using STATA. Taught at Duke Kunshan University. Instructor: Staff. 4 units.

707K. Biostatistics and Epidemiology for Global Health Science II. Modular course building on Quantitative Methods I. Required module provides common understanding of regression including linear, logistic, and general linear regression, use and interpretation of dichotomous and continuous variables, indicator terms, and interaction terms, and regression diagnostics. Required lab section. Taught at Duke Kunshan University. Instructor: Abdullah. 4 units.

710K. Intermediate Epidemiology. This course covers in-depth topics in epidemiology with a focus on the global health context. The course textbook is "Epidemiology: Beyond the Basic" by Moyses Szklo and Javier Nieto. The textbook will be supplemented with publications selected from the epidemiologic, clinical, nutritional and other literature. Topics covered include epidemiologic study designs, measures of disease occurrence and associations with risk factors, confounding and interaction, time to event data, and methods for causal inference. Course content will focus on epidemiologic concepts. Related statistical concepts will be discussed, but data analysis will not be a focus. Prior epidemiology coursework required. Taught in Durham. Instructor consent required. Instructor: Egger. 3 units.

722K. Culture, Health and Illness in a Global Perspective. Seminar explores medical anthropology as: a perspective within global health; a resource for developing research & understanding of health issues; and, part of implementation science. Also draws from field of global public health. Divided into four areas: Local and global healing systems (China, the Americas, the Middle East, Africa, Europe); biocultural basis of health; methods & analytical perspectives for examining health disparities (country, region, global); community-based participatory action research and other implementation science approaches drawing on applied medical anthropology. Instructor: Burns. 3 units.

725K. Global Health and Migration. Issues/impact of migration on health of populations who move, those who are left behind, and on host communities. Focus on types of migration, including economic, political, violence-related, disaster-related migration, and human trafficking. Special attention to health disparities and inequities, and health determinants in host countries or regions. Case studies on migration and health from within Latin America and to the United States, within China, China and Africa, within African countries and mixed migration from Africa into Europe. Lessons learned, and ethically sound public health approaches will be discussed to promote health and protect human rights of migrants at global levels. Instructor: Amaya-Burns. 3 units.

731K. One Health: Introduction to the One Health Approach. Introduces principles of employing the One Health approach in preventing and controlling infectious diseases. Includes practical overview of host factors, environmental factors, and microbiological

factors that influence this dynamic field of study. Through lectures and exercises, introduces infectious disease surveillance, diagnostic tools, outbreak investigations, vaccine trials, public health interventions, biodefense, emerging infectious diseases and analytical approaches as they pertain to infectious disease prevention and control. Introduces wide array of reference material for practical application of course material. Course offered in Durham for Duke Kunshan University students only. Instructor: Gray. 2 units.

732K. One Health: Introduction to Environmental Health. Course provides a comprehensive overview of major topic areas in Environmental Health. Includes major sources of environmental health risks, such as microbial, chemical, and physical agents in natural and anthropogenic environments. Also covers topics of toxicology and ecotoxicology, risk assessment and risk management, water and sanitation issues, infectious diseases, food safety, and other emerging topics. This course is offered in Durham for Duke Kunshan University students only. Instructor: Gray. 3 units.

735K. One Health: Introduction to Entomology, Zoonotic Diseases, and Food Safety. Course introduces public health students to entomology, zoonotic diseases, and principals of modern food safety. Includes methods for conducting studies of mosquitoes and ticks, controlling zoonotic diseases, and protecting the food supply. Special focus on modern food safety techniques in meat, dairy and produce production. Lectures complemented with considerable laboratory and/or field work. Course offered in Durham for Duke Kunshan University students only. Instructor: Gray. 3 units.

739K. One Health: Public Health Laboratory Techniques. Introduction to common laboratory techniques used in emerging infectious respiratory disease research and surveillance laboratories; emphasis on techniques for culturing, characterization, and serological surveillance of exposure to influenza viruses. This course is offered in Durham for Duke Kunshan University students only. Instructor: Gray. 1 unit.

740K. Ethics for Global Health Research. Course presents overview of practical and theoretical approaches to bioethics from a range of perspectives, including humanities, law, philosophy, medicine and science. Students apply various resources, terminology and frameworks to case studies, preparing them for their own research. Course includes IRB and responsible conduct of research. Taught at Duke Kunshan University. Instructor: Amaya-Burns. 2 units.

750K. Health Systems in Developing Countries. Course introduces key challenges faced in strengthening of health systems in low and middle income countries. Topics include: overview of organization of health systems, models of purchasing and providing health care, innovations in financing health care, issues in service delivery such as quality of care and human resource challenges, and frameworks and methods employed in the evaluation of health systems. Course will also draw attention to resource allocation problems and various frameworks used to address them. Readings primarily from health policy, economics and other social science journals. Taught at Duke Kunshan University. Instructor: Tang or Moe. 3 units.

751K. Developing Implementation/Operational Research for Improving Health Interventions. IR/OR: studies how to improve uptake, implementation, and translation of research findings into routine and common practices; moves results from effectiveness studies and efficacy trials to real-world settings, obtaining information to guide scale-up; helps implementers apply lessons from a program in one context to developing a similar program in a similar environment. Course covers: framework of IR/OR; methods of identifying program implementation problems; how to organize and develop an IR/OR proposal; main study design, research methods, data collection and analysis used in IR/OR; approaches to capacity building for IR/OR in developing countries. Offered at Duke Kunshan University. Instructor: Tang. 3 units.

755K. Health Economics. Develop economic understanding of how health care institutions and markets function. Includes discussion of theoretical and empirical findings pertaining to individuals' decisions about personal health and health care; decisions made by health services suppliers; and, government decision-making about resource allocation and policy in the health sector. Global scope. Draws heavily on applied microeconomics, designed for students with limited economics background. Organized sequentially beginning from individual and firm-level, then shifting to market-level, and finally macroeconomic-level which views the economy as a whole and examines role of health and health care within the macroeconomy. Course will be taught at Duke Kunshan University. Instructor: Hsieh. 3 units.

758K. Case Studies in Data Science for Global Health. Application of statistical and data science skills to in-depth data analysis projects in global health. Principled use and interpretation of modern tools, including data wrangling and munging, visualization, exploratory analysis, predictive modeling, and inference using modern statistical software applied to global health data. Emphasis on communication of analysis results both technically and non-technically via presentations and written reports. Taught in Durham. Prerequisite: Global Health 705/705K and access to data for course project. Instructor: Herring. 3 units.

761K. Introductory Demographic Measures and Concepts. Introduction to demographic concepts, measures, and techniques. Focus on population change, mortality, morbidity, fertility, marriage, divorce, and migration. Illustration of broader application of demographic measurement and techniques to other aspects of society and population health, such as educational attainment, labor force participation, linkages between mortality, morbidity and disability, and health and mortality differentials. Students will also learn how to apply methods discussed. Taught in Durham. Instructor: Merli. 3 units.

770K. Qualitative Data Analysis for Global Health. Equips students with knowledge and skills to effectively analyze qualitative data in the field of global health. With a foundation in thematic analysis, teaches tools of memo writing, coding, diagramming and matrices to support the synthesis, interpretation and presentation of data in a systematic and rigorous way. NVivo software will be used to organize and manage the analytic process. Students should have previous qualitative coursework and/or qualitative experience. Best suited for students who have a qualitative data set that they are working to analyze toward a specific output (e.g., a publication, master's thesis or doctoral dissertation). Taught in Durham. Instructor: Watt. 3 units.

772K. Qualitative Methods in Health Research. This course will introduce the application of qualitative methods in health research, with particular emphasis on their application in implementation research in relation to policy or program design and evaluation issues. The course will begin with an overview of the theoretical basis and ethics of qualitative research. It will focus on training in choosing the qualitative field methods, skills of data collection, approaches of data analysis and reporting the qualitative research results. Taught at Duke Kunshan University. Instructor: Long. 3 units.

773K. Deconstructing Global Injury Control and Prevention through Systematic Review Methods. An introduction to the field of injury epidemiology and injury prevention. Prominent types of injury are very different in different settings and those to be discussed in the course are those related to motor vehicles, assaults, firearms, self-injurious behavior and global toxicology. Behavioral, biological, economic and social issues related to the implementation of injury reduction policies will be explored through case studies of specific injury scenarios and interventions. Course will delve into epidemiology, specific research methods and innovative research methods and articles. Taught at Duke Kunshan University. Instructor: Staff. 3 units.

774K. Program Evaluation for Health. Covers the principles and tools of evaluation, starting with the evaluation planning process and ending with the dissemination of evaluation results and their use to inform action. Examines different approaches to evaluation (e.g., participatory evaluation), common evaluation designs, and the use of quantitative and qualitative data. Discuss "real-life" evaluation challenges and explore current debates and developments in the field, utilizing examples of actual evaluations of health-related programs and policies (both domestic and international). For the course project, learners will work with local organizations to help the latter enhance their evaluation capacity. Instructor: Abdullah. 3 units.

777K. Infectious Disease Epidemiology in Global Settings — Surveillance, Prevention and Control. MSc-GH core graduate coursework to build towards integrated understanding of infectious disease epidemiology. Three modules: 1) Foundations in Infectious Disease Epidemiology, 2) Disease Surveillance & Prevention, 3) Disease Treatment & Control. Course taught exclusively on-line. Open to graduate students at Duke and DKU only. Instructor: Staff. 3 units.

781K. Ungraded Research in Global Health. Individual research in a field of special interest, the central goal of which is a substantive paper containing significant analysis and interpretation of a previously approved topic. Course will be offered at Duke Kunshan University. Instructor: Dear. Variable credit.

790K. Special Topics in Global Health. Topics vary depending on semester and section. Topics may include global health ethics, field methods, health technologies, rapid needs assessment, and global health policies. Course will be offered at Duke Kunshan University. Instructor: Staff. 3 units.

791K. Independent Study in Global Health. Individual non-research directed study in a field of special interest on a previously approved topic, under the supervision of a faculty member, resulting in a significant academic product. Course will be offered at Duke Kunshan University. Instructor: Staff. 3 units.

Graduate Liberal Studies

A master's degree is available in this program.

Graduate Liberal Studies (GLS) offers a master of arts (AM) degree—a flexible, interdisciplinary degree that allows individuals to pursue a variety of personal and professional educational interests across disciplinary boundaries. Students study on a part- or full-time basis and choose from an array of interdisciplinary courses developed specifically for this program. GLS offers up to seven courses in each of three academic semesters (fall, spring, and summer), including study-abroad opportunities. In addition to liberal studies courses, students may select courses from other departments of The Graduate School.

The master of arts degree in the GLS program consists of nine courses and a master's project. The master's project, which may take the form of academic research, applied research, or creative work, provides the opportunity for the student to apply the knowledge and skills gained in seminars to an independent activity of the student's design.

Faculty members from throughout the university teach GLS seminars and supervise student work.

The MALS degree is now available to medical students in their third year of study. For more information about the MD/AM degree through GLS, see the *The Bulletin of Duke University*: *School of Medicine* or contact Margaret Humphreys, MD, PHD at Box 90719, Durham, NC 27708-0719, (919) 684-2285, meh@duke.edu.

For further information about the master of arts degree in the Graduate Liberal Studies program, contact the GLS Program Assistant at Box 90095, Duke University, Durham, NC 27708; (919) 684-3222; dukegls@duke.edu. Additional information on the MALS degree is available on the GLS website at https://liberalstudies.duke.edu.

Graduate Studies

Courses in Graduate Studies (GS)

705. Responsible Conduct of Research: Master's Degree Workshop. Graduate-level training in research and professional ethics is a formal degree requirement for every master's degree student in The Graduate School beginning with Fall 2013 matriculation. Topics include the Duke Community Standard, academic integrity, research ethics, plagiarism and proper citation methods, authorship and intellectual property, and Duke resources to assist graduate students. Entering master's degree students must attend a four-hour orientation on various RCR topics to include training within departmental groups led by faculty. Instructor: Crumley. 0 units.

710. Responsible Conduct of Research: Campus Workshop. Graduate-level training in research and professional ethics is a formal degree requirement for every PhD student at Duke beginning with Fall 2003 matriculation. Topics include history of research ethics, academic integrity, preventive ethics, and Duke resources to assist graduate researchers. Entering PhD students must attend ONE (Humanities and Social Sciences OR Natural Sciences and Engineering) of the full day RCR orientation workshops held each Fall, except basic medical science students who attend Graduate Studies 710A. Instructor: Crumley. 0 units.

710A. Responsible Conduct of Research: Greensboro Workshop. Graduate-level training in research and professional ethics is a formal degree requirement for every PhD student at Duke beginning with Fall 2003 matriculation. Topics include history of research ethics, academic integrity, preventive ethics, and Duke resources to assist graduate researchers. Entering PhD students in Basic Medical Sciences must attend a weekend retreat in Greensboro, NC. Instructor: Staff. 0 units.

711. Responsible Conduct of Research: Graduate Forums. Beyond orientation training, PhD students must earn six additional credits of RCR training during their first three years of study. The Graduate and Medical Schools offer a series of RCR forums (two credits each) during the academic year. Topics include copyright and fair use laws, proper use of data, research with human or animal subjects, authorship, and mentoring. Other RCR training when pre-approved by The Graduate School may take a variety of formats including graduate courses, departmental seminars, or workshops. Instructor: Staff. 0 units.

712. Responsible Conduct of Research: Departmental Forum. Beyond RCR training, Orientation training, PhD students must earn 6 additional credits of RCR training during their first three years of study. Departments, programs, or research centers can propose and offer more discipline-specific training for credit when pre-approved by the Associate Dean. Topics vary widely, but should relate to The Graduate School's RCR topics (academic integrity, conflict of interest, mentor/advisee roles, human or animal subjects, proper use of data, fiscal or social responsibility), and to ethical issues encountered when conducting research in the discipline. 0 units.

713. RCR Forum- Basic Medical Sciences. Required of 3rd year basic medical science graduate students as follow-up to GS710A RCR Orientation-Beaufort. Helps to fulfill RCR training requirements expected by NIH at least every four years. Uses didactic and small group interaction on scientific misconduct, questionable research practices, current topics in RCR, and interpersonal relationships in science, such as authorship, mentor/mentee relations, & responsibility of collaborators. Instructor: Staff. 0 units.

714. Responsible Conduct of Research: Academic Integrity & Misconduct. Responsible Conduct of Research (RCR) training is a critical component of graduate education. Scholarly communications, copyright, intellectual property, authorship, open access/ institutional repositories, falsification/fabrication/plagiarism, standards of conduct, and other topics related to academic integrity. Instructor consent required. Instructor: Staff. 0 units.

715. Responsible Conduct of Research: Diversity & Inclusion in a Research Environment. Responsible Conduct of Research (RCR) training is a critical component of graduate education. Implicit bias, harassment prevention and handling complaints, issues of institutional equity, issues of race, gender and protected status in a scholarly environment. Instructor consent required. Instructor: Staff. 0 units.

716. Responsible Conduct of Research: Mentoring & Wellness. Responsible Conduct of Research (RCR) training is a critical component of graduate education. Mentor/advisee responsibilities, conflict of interest or commitment, navigating professional relationships, campus mental health resources, stress management. Instructor consent required. Instructor: Staff. 0 units.

717. RCR: Best Practices in Responsible Scholarship. Responsible Conduct of Research (RCR) training is a critical component of graduate education. Explore and discuss best research practices with faculty, librarians and other academic staff. Topics include human subjects, IRB, animal subjects, data management, collaborative research, university-industry guidelines, fiscal responsibility, research costing compliance, inventions, patents, and technology transfer, project management, citation management, discipline-specific RCR issues. Instructor consent required. Instructor: Staff. 0 units.

720. EIS Academic Writing I. In Academic Writing 1, students improve their writing skills by writing multiple drafts of some of the standard graduate-level text forms. Peer review and instructor feedback are offered to help students advance to the highest level of proficiency. In the process of writing papers, students also develop an awareness of text purpose and audience expectation while improving grammar and vocabulary skills. Specific skills such as how to recognize and avoid plagiarism are taught through paraphrasing and source citation. Instructor consent required. Instructor: Staff. 3 units.

721. EIS Oral Communication. In this active, practical course, students improve their ability to communicate effectively and confidently in academic and professional settings. Multiple opportunities for recorded practice in and out of class allow students to reflect on their own performance and use both peer and instructor feedback to develop strategies for improving future interactions. Some of the things students will learn and practice include the following: small talk; participating in and leading discussions; composing self-introductions including personal research interests; networking; interviewing Q&A; elements of clear(er) speech based on student needs; pragmatics; and self-analysis and reflection. Instructor: Staff. 3 units.

722. EIS Writing in the Humanities. Specifically designed for students in the humanities. In this course, students will prepare an argumentative essay, a book or film review, and an individual final project paper. Instructor: Staff. 3 units.

724. EIS Writing in the Social Sciences. Specifically designed for students in the social sciences. In this course, students will prepare a definition paper, a literature review paper, and an individual final project paper. Instructor: Staff. 3 units.

726. EIS Writing in STEM Fields. Specifically designed for students in STEM (science, technology, engineering, and mathematics) fields. In this course, students will prepare a problem-solution paper, a data visualization and interpretation paper, and an individual final project paper. Instructor: Staff. 3 units.

730. EIS Academic Writing II. This course concentrates on developing advanced academic writing skills. Students analyze and produce both general and discipline-specific texts and improve use of grammatical, syntactic, and rhetorical structures of academic writing. Through individualized instructor and peer feedback, students increase awareness of their individual writing strengths and weaknesses. They gain experience revising texts and using online and other academic resources, which facilitate continued, self-directed learning. The writing assignments include Problem-Solution Paper, Literature Review, and Research Paper. Course topics also include field-specific style, audience awareness, flow, and source synthesis. Instructor consent required. Instructor: Staff. 3 units.

731. EIS Academic Presentations. In this course, students develop their presentation and language skills by making presentations of increasing length and complexity. Students learn how to develop presentations that are appropriate for their audience and time limit, that have clear organization and transitions, and that include effective visuals. They also practice presenting effectively by paying attention to eye contact, body language, and pace, and by participating in question-and-answer (Q&A) sessions. Students enhance their language skills, including pronunciation, grammar, and word choice, through classroom instruction and practice and by receiving feedback on presentation content and delivery. Instructor: Staff. 3 units.

732. EIS Advanced Academic Writing for PhD Students. This course concentrates on developing advanced academic writing

skills for graduate students writing dissertations and writing for publication. Students analyze and produce discipline-specific texts and improve control over grammatical, syntactic, and rhetorical structures of academic writing in their field. Students work on a major writing project such as their dissertation or article for publication throughout the semester. Through individualized instructor attention, peer review, and field specific feedback, students improve awareness of their individual writing abilities. They also gain experience with academic resources and revising them, facilitating self-directed learning. Instructor consent required. Instructor: Staff. 3 units.

740. EIS Pronunciation. This course focuses on increasing students' intelligibility (ability to be understood) through recognition and production of basic sounds and patterns in spoken US English, awareness of student-specific challenges, and development of self-practice strategies. Topics include the articulation and perception of US English vowel and consonant sounds, syllable and word stress, rhythm, and intonation. Students learn to use volume, vocal energy, and pacing to enhance clarity and meaning. They also work on increasing their awareness and accuracy of grammatical items particularly important for fluency, such as contractions, singular/plural, and present-tense and past-tense endings. Instructor consent required. Instructor: Staff. 3 units.

745. EIS College Teaching for International Teaching Assistants. This course is designed for non-native English-speaking students who will serve as International Teaching Assistants (ITAs) at Duke and/or who plan to teach in English in the future. Students learn the components of clear speech and effective classroom communication skills in a variety of instructional settings, with an emphasis on highly intelligible pronunciation of field-specific terminology as well as lecture content. Other course topics include effective learning activities, teaching methodology, instructional technology, and grading criteria, as well as personal and academic campus resources. Instructor consent required. Instructor: Staff. 3 units.

750. Fundamentals of College Teaching. Designed for graduate students who may serve as Teaching Assistants; Topics include communication skills with faculty and students, learning styles and motivation, campus resources for personal and educational support, basic instructional technology, teaching methods and learning spaces, active learning, effective discussions and grading criteria. Instructors: Crumley/Ramos. 1 unit.

755. College Teaching and Course Design. Designed for graduate students seeking to teach an independent course at Duke and beyond; topics include models of course design, syllabus construction, critical thinking, college student development, clarifying learning objectives, variety in assignments, small versus large class size, group dynamics, classroom assessment techniques, test construction, and grading rubrics. Instructor: Staff. 1 unit.

757. Teaching Writing in the Disciplines. Designed for graduate student Teaching Assistants or instructors and led by Thompson Writing Program staff. Topics include designing writing-intensive assignments in the discipline, staging the writing process, providing effective and efficient feedback, and grading. Related topics include managing group writing projects, discussing student writing in class, using models of the kind of writing assigned, and writing with graphs, tables and other visuals. Instructor: Staff. 1 unit.

758. Teaching Writing in the Disciplines II. Covers issues central to working with student writing in undergraduate contexts such as designing writing-intensive assignments, staging the writing process, providing effective and efficient feedback, and grading. Topics rotate and other topics determined according to graduate student interest, such as managing group writing projects and writing with graphs, tables and other visuals. Students develop a real or mock assignment in their field and get practice giving written feedback, discussing student writing in class, and using models of the kind of writing assigned. Those teaching their own courses are encouraged to develop materials for those classes. Instructor consent required. Instructor: Staff. 1 unit.

760. College Teaching and Visual Communication. Visual communication for teaching and other professionals in print, in face-to-face situations and online. Includes intro to web design, intro to graphic design, effective presentations, development of an electronic teaching portfolio and exploration of other instructional technology for college teaching. Instructor consent required. Instructor: Crumley. 1 unit.

762. Digital Pedagogy. Overview, case studies, comparison of different formats of online and hybrid courses. Evaluation and assessment of learning outcomes in online environments. Syllabus design and materials production for online courses. Intellectual property issues in online education. Concepts and practices for developing your own online course. Course director's permission required. Prerequisite: at least one Graduate Studies course in college teaching, 750 or higher. Instructor: Stone. 1 unit.

765. College Teaching Practicum. Video recorded peer teaching, observation and feedback. Course participants present a series of progressively longer and more interactive microteaching demonstrations. Effective use of visual aids in college classroom instruction. Demonstration of interactive presentations. Facilitation student-centered classroom discussion. Using appropriate student grouping strategies in classroom instruction. Prerequisites: Students must have done one of the following: Passed Graduate Studies 760, Graduate Studies 302, Participated in the PFF program or taught or TA'd a course at Duke. Instructors: Crumley. 1 unit.

767. College Teaching, Diverse Learners & Contentious Issues. To employ a wide-range of approaches, techniques, and practices that directly speak to the diversity of learners in the university classroom. This course will provide a foundation for more advanced study of effective classroom techniques. Students will also learn about current issues surrounding diversity. Through this process, we will explore the possibilities and limitations of pedagogically engaging diversity and contentious issues. Enrollment limited to doctoral students who are: 1) currently enrolled in the Certificate and College Teaching Program and 2) have successfully defended their preliminary examinations. Instructor: Ramos. 1 unit.

770. Topics and Careers in Higher Education. Designed for advanced doctoral candidates exploring faculty or administrative careers in higher education. Topics include the range of faculty roles and responsibilities, academic governance, institutional cultures and mission, hiring and review processes, alternative academic careers, challenges for women and underrepresented minorities, and current issues in higher education. Instructor: Klingensmith. 1 unit.

772. Bass Digital Education Colloquium. Critically reflect on digital pedagogies and emerging technologies to design a faculty-led project; participate in regular workshops; apply project methodologies to execute a faculty-led digital learning project; develop a digital portfolio for your future professional career; showcase a final project in a spring symposium for the Duke community and meaningfully contribute to and benefit from participation in a teaching and learning community of faculty, digital fellows, and education leaders, in

partnership with Duke Learning Innovation. Prerequisite: Graduate Studies 762. Instructor consent required. Instructor: Stone. 0 units.

775. Colloquium on the Academic Profession. This course is designed to explore faculty roles and responsibilities at various types of colleges and universities. It will bring together faculty from schools in the Triad and Triangle area to discuss such topics as: how teaching is evaluated and weighed at different institutions; what counts as service; what are different schools looking for in new faculty appointments; how can you maintain a research career in a school whose priorities are undergraduate teaching; what makes a good mentor; departmental politics. The course is restricted to Preparing Future Faculty Fellows and will meet monthly on the campuses of Durham Technical Community College, Duke, Elon College, Guilford College, Meredith College, NCCU, and NCSU. Instructor: Crumley. 1 unit.

805. Writing in the Natural Sciences. Major concepts for effective research-based scientific writing. Topics include: genres of scientific research writing; structure and function of research reports; grant proposals; introductions and literature reviews; writing methods; presenting results; designing diagrams, figures and tables; citations; writing with equations; sentence style and clarity; paragraphing for flow; plagiarism and text recycling. Priority for advanced PhD students in the natural sciences with specific writing projects/needs. Instructor consent is required. Instructor: Moskovitz. 1 unit.

810. Grant and Fellowship Writing in the Humanities and Social Sciences. Major concepts for effective persuasive writing for grant and fellowship applications in humanities and social sciences disciplines. Topics include: overview of funding opportunities in the humanities and social sciences; structure of grant proposals; structure of fellowship applications; effective writing for an interdisciplinary audience; writing methods; editing and revision strategies. Consent of instructor is required. Instructor: Schonberg. 1 unit.

950. Experiential Learning Workshop. Provides structure for doctoral students to pursue experiential learning in support of their major academic subject. Students reflect on concurrent experiential activities (internships, interdisciplinary research teams, group consulting projects), and integrate these experiences into their larger academic and professional trajectories. Through group discussion and reflective writing assignments, students consider how their experiential learning informs academic research content and practice. Students also identify skills honed through academic research that are transferable and valuable beyond academia. Instructor consent required. Instructor: Wisdom. 1 unit.

01-G-K

705K. Responsible Conduct of Research: DKU Master's Workshop. Graduate level training in research ethics is a formal degree requirement for every Master's degree student at Duke Graduate School/DKU beginning with Fall 2014 matriculants. Topics include the Duke Community Standard, academic integrity, research ethics, plagiarism and proper citation methods, authorship and intellectual property, and Duke resources to assist graduate students. Entering Master's degree students must attend a four-hour Orientation on various RCR topics to include training within departmental groups led by faculty. Instructor: Moreton. 0 units.

720K. Academic Writing for EFL Students. In Academic Writing, students improve their writing skills by writing multiple drafts of some of the standard graduate-level text forms. On all drafts, peer review and instructor feedback are offered to help students advance to their proficiency levels. In the process of writing their papers, students also develop an awareness of text purpose and audience expectation while improving grammar, vocabulary and reading skills. Specific skills such as recognizing and avoiding plagiarism are taught through appropriate paraphrasing and source citation. Instructor: Bryson. 3 units.

721K. Academic Communication Skills. For non-native English speakers. Instruction in oral communication, with significant focus on assessing and improving English pronunciation and listening skills. Develops oral communication skills in specific academic settings, e.g. seminars, professional networking, interviews; includes field-specific presentations and Q&A. Participation in and facilitation of group discussions for mastery of language functions, grammatical accuracy, and fluency. Extensive vocabulary work. Filmed presentations with instructor feedback, peer review and self-evaluation. Individual instructor/student conferences. Taught at Duke Kunshan University. Instructor: Allen. 3 units.

History

Professor Ramaswamy, *Chair*; Associate Professor Bonker, *Director of Graduate Studies*; Professors Baker, Balleisen, Boatwright, Deutsch, Duara, Dubois, Edwards, French, Gaspar, Glymph, Hacohen, Humphreys, Korstad, MacLean, Miller, Partner, Petroski, Ramaswamy, Robisheaux, Sigal, Silverblatt, Starn, and Zanalda; Associate Professors Barr, Bonker, Ewald, Hasso, Huston, Krylova, Lentz-Smith, Malegam, Mazumdar, Mestyan, Neuschel, Olcott, Peck, Rosenberg, Sosin, and Thorne; Assistant Professors Barnes, Chappel, Hassan, and Tuna; Professors Emeriti Chafe, English, Herrup, Koonz, Mauskopf, Nathans, Reddy, Roland, Shatzmiller, Thompson, Wood, and Young

A master's degree and a PhD are available in this department.

The Department of History offers graduate work leading to the AM and PhD in history.

Candidates for the AM degree must have a reading knowledge of at least one ancient or modern foreign language related to their programs of study and have completed successfully a substantial research paper, or two seminar papers, normally the product of a year's seminar or two semester courses. The paper(s) must be examined and approved (at a required AM meeting) by three readers: the supervising professor and two other professors from the graduate staff.

Candidates for the degree of doctor of philosophy prepare themselves for examinations in three or four fields, at least three of which shall be in history. The choice of fields is determined in consultation with the student's supervisor and the director of graduate studies. The department offers graduate instruction in the broad historical areas of North America; Latin America; Great Britain and the Commonwealth; ancient, medieval, and Renaissance Europe; modern Europe; Russia; Japan; China; South Asia; military; history of science, technology, and medicine; and in the comparative and thematic fields of women's history, environmental history, diplomatic history, labor history, and slave societies.

The candidate for the PhD must demonstrate a reading knowledge of one foreign language, ancient or modern, prior to the

preliminary examination. All students are expected to take History 701, 702, 703, and 704. In addition, each student must fulfill a general methodology requirement by completing at least one course that would appreciably increase the candidate's methodological proficiency. With the approval of the director of graduate studies, options include taking a graduate class in methodology, such as demography, statistics, oral history, archaeology, cartography, or a summer training program for developing specific methodological skills. Students who need to master a second foreign language may substitute that language for the methodology requirements.

For courses in ancient history that may be taken for credit in either history or Classical studies, see "Classical Studies" on page 114.

For more information, visit https://history.duke.edu.

Courses in History (HISTORY)

501S. History of Sexuality. Explore history of sexuality around the globe, covering diverse time periods and regions. Examine methods and theories used in the study of sexuality, with attention to topics such as fertility, kinship, marriage, heterosexuality, homosexuality, birth control, sexology, and community formation. Instructor: Sigal. 3 units. C-L: Gender, Sexuality, and Feminist Studies 501S

502S. Japan Since 1945. Issues relating to post-War Japan. Topics include: the Occupation; democracy in postwar Japan; the rise of mass consumption; security and the US-Japan alliance; the political system; popular culture; arts and literature; the transformation of the countryside; the creation of an economic superpower; the myth of the kaisha; moments of conflict and crisis. Instructor: Partner. 3 units.

503. Research Methods in Japanese (B). 3 units. C-L: see Japanese 650; also C-L: Sociology 664

504S. East Asia's Twentieth Century. Historiographical review of twentieth-century East Asian history. Through weekly readings, study influential historical analyses of the period. Compare and evaluate historical approaches and key debates. Review methodologies of historical research on modern East Asia. Work with primary source materials in East Asian history. Research paper required. Instructor: Barnes or Partner. 3 units. C-L: Asian & Middle Eastern Studies 504S

505S. Race, Class, and Gender: A Social History of Modern (1750-present) Britain. body of scholarship examined addresses the nature and transformation of social relations in Great Britain in the wake of the major watersheds of the modern period, including the world's first industrial revolution, imperial expansion, political economy and democratization, world wars, the rise and fall of the welfare state, decolonization, Commonwealth immigration, and admission into the European Union. Examines impact of theoretical influences on the academy ranging from Marxism through the Cold War, feminism and anti-racism, and post structuralism to post colonialism. Instructor: Staff. 3 units. C-L: African & African American Studies 515S, Gender, Sexuality, and Feminist Studies 509S

506S. Religion, Conflict and Holy War in the Pre-Modern West: Sects and Violence. Violence as a cultural phenomenon in the pre-modern world. How did enactment of violence, objectification by violence and immunity from violence produce social, political and religious identities? Topics: the dialectic of violence and peacemaking in the Christian tradition; aesthetics, performance and emotions in violent confrontations; the role of violence in state and community formation; religious groups as mediators and fomenters of conflict; violence in millenarian movements. Readings combine primary sources, secondary sources and theory. Students of anthropology, law and political studies will find topics of interest. Instructor: Malegam. 3 units. C-L: Medieval and Renaissance Studies 556S

507S. Asian Studies: Critical Introduction to Knowledge Fields and Methodologies. Examination of fundamental methodologies and historiography central to knowledge production about Asia in the Social Sciences, Humanities and Environmental Studies. An overview of nineteenth and twentieth century European discourses of Orientalism and Eurocentrism; the evolution of "Area Studies" models of inquiry and the bifurcations of Asian Studies; the impact of Cold War politics on the development of the field of Asian Studies in the United States; globalization, the environment and East Asia. Instructor: Mazumdar. 3 units.

509S. United States Policy in the Middle East. 3 units. C-L: see Public Policy 503S

510S. The History of Neoliberalism in the US. A readings course to introduce graduate students and advanced undergraduates to the historical literature on one of the most important developments of our times: the rise and spread of neoliberalism (or as it is sometimes called by critics, "free-market fundamentalism") and to guide students in applying this scholarship to their own areas of interest. Instructor: Maclean. 3 units.

511S. The Margins of Justice: Law and Minorities in the Middle Ages. A study of how law impacted minorities in the Middle Ages: outlaws, Jews, homosexuals, foreigners, disabled and poor. Surveys how socially disadvantaged persons navigated royal authority in France and England after 1100. While most reading is secondary sources, we use literature, saints' lives, charters and law codes to reconstruct medieval conceptions of justice, to ask what is law, and to reconstruct state formation through experiences of people usually relegated to the margins. For graduate students and motivated senior undergraduates. Instructor: Malegam. 3 units. C-L: Medieval and Renaissance Studies 561S

513S. Race, Class, and Gender in the University. 3 units. C-L: see Cultural Anthropology 502S; also C-L: Sociology 502S

514S. Culture and Environment in Modern Chinese History. Examination of the changing patterns through which the physical environment and culture are mutually formed in late imperial and modern China. Culture includes creation of cosmological and social ideas as well as long term practices of settlement and utilization of the environment. In what ways did cultures represent limits to environmental exploitation? Special attention to how communities and the state respond to environmental disasters and explore the feedback loops for protection and prevention. Explores the importance of long-term understanding for the current environmental crisis in China. Instructor: Duara. 3 units. C-L: Asian & Middle Eastern Studies 531S

516. The Roman Republic. 3 units. C-L: see Classical Studies 532

518S. Merchants, Coolies, Prostitutes: The Treaty Ports of Nineteenth Century East Asia. The course will examine the treaty ports of East Asia – Shanghai, Tianjin, Yokohama, Nagasaki and others – from the perspective of both foreign and local residents.

Students will review available English-language sources, and carry out a research project on a city of their choice. Instructor: Partner. 3 units.

519S. The Society and Economy of Europe, 1400-1700. The dynamism of the early modern world with a focus on Europe's recovery and expansion during the "long sixteenth century;" special attention to the relationship of population structures to the economy, agrarian expansion and the world of the village; capitalist trade and industry; the "crisis of the seventeenth century;" family and household structures; the aristocracy; and the structure of life at court, in the cities and countryside. Instructor: Robisheaux. 3 units. C-L: Medieval and Renaissance Studies 570S

520S. Microhistory. Examines methods of micro-historical analysis, focusing on distinctive practices that define this popular form of history writing, including how to reduce the scale of analysis; interpreting clues as a "scientific paradigm"; treating culture as action; using historical contexts and theories; identifying historical actors; and crafting historical narratives. For advanced undergraduates, graduate students from any field interested in micro-analysis, historical theory and method and story-telling. Requirements include short essays and major research paper based on primary sources from any field or period of history. Instructor: Robisheaux. 3 units. C-L: Medieval and Renaissance Studies 576S

522S. Jerusalem after Rome. In this discussion seminar, we trace the history of how a city became sacred to three religions, the impact of the Crusades on the demography and built environment of Jerusalem and the memory of medieval Jerusalem today. For students interested in history, literature, religious and social conflict, architecture and archaeology. One research paper, one literature review, and regular reading responses. Reading load is moderate to heavy. Instructor: Malegam. 3 units. C-L: Medieval and Renaissance Studies 552S

523S. Religion and Society in the Age of the Reformation. The social history of religion in the age of the Protestant Reformation and Catholic Renewal; ritual and community in the fifteenth century; the Protestant Reformation and social change; the urban reformation in Germany and Switzerland; women and reform; Protestant and Catholic marriage, household and kinship; Catholic renewal; the formation of religious confessional identities; religion and violence; interpreting "popular" religious culture; and witchcraft. Instructor: Robisheaux. 3 units. C-L: Medieval and Renaissance Studies 575S

524S. Sovereignty and Monarchy in the Arab World. This course focuses on the history of sovereignty in Arab monarchies in the twentieth century. Sovereignty is a fundamental legal, philosophical, political, geographical, and even cultural concept. The readings critically explore the idea of sovereignty as a historically changing and context-dependent concept. What is sovereignty? What types of sovereignties can we distinguish? How have new Arab nation-states claimed sovereign status within the global order? How is sovereignty related to the ability to govern? In addition to the history of ideas and law, we explore the local perception of sovereignty in monarchies, and the symbolism and material culture of the Arab kingdoms. Instructor: Mestyan. 3 units.

526S. Columbus: A Global History. This seminar returns to the global framework of Columbus's encounters with what would come to be called the New World. Students will study medieval conceptions of the world in maps, cosmographies, and travel literature as well as developments in China and the Americas before 1492. Our central focus will be texts by Columbus and his contemporaries: Peter Martyr d'Anghiera, Amerigo Vespucci, Martin Waldseemüller, Bartolomé de las Casas, Peri Reis, Mehmed el-Su'udi, and Jacopo ha-Kohen. Attention will be given to slavery, colonization, evangelization, prophecy, apocalypticism, and resistance. We will also explore the economic and intellectual consequences of Columbus's voyages across time. Instructor: Martin. 3 units. C-L: Medieval and Renaissance Studies 554S

528S. Greek History: Fifth through First Centuries BC. 3 units. C-L: see Classical Studies 528S

530S. Camera Asia. 3 units. C-L: see Art History 535S; also C-L: International Comparative Studies 531S

531S. Art and the Holocaust: Architecture, Art, and Cultural Politics during the Nazi Period. 3 units. C-L: see Visual and Media Studies 525S; also C-L: German 565S, Jewish Studies 555S

532S. Fin-de-siècle and Interwar Vienna: Politics, Society, and Culture. Advanced undergraduate and graduate colloquium and research seminar focusing on the cultural milieu of *fin-de-siècle* and interwar Vienna. Readings in the Austro-Marxists, the Austrian School of Economics, Freud, Kraus, the Logical Positivists, Musil, Popper, and Wittgenstein. Monographs on the Habsburg Empire, *Fin-de-siècle* culture and technology, Viennese feminism, Austrian socialism, philosophy of science, literature and ethics, and the culture of the Central European émigrés. Instructor: Hacohen. 3 units. C-L: German 532S

533S. Greek History from the Bronze Age to the Fifth Century BCE. 3 units. C-L: see Classical Studies 524S

534S. Roman History from Romulus to Augustus. 3 units. C-L: see Classical Studies 532S

535S. The Russian Intelligentsia and the Origins of the Revolution. Origin and dynamics of the Russian revolutionary movement, the intelligentsia, and the emergence of the labor movement. Instructor: M. Miller. 3 units. C-L: Russian 515S

536S. The Russian Revolution. An analysis of the Bolshevik seizure of power in 1917 and the establishment of a revolutionary society and state during the 1920s. Instructor: Miller. 3 units.

537S. Post War Europe, 1945-1968: Politics, Society, and Culture. Politics, society and culture in Western Europe during the postwar years focusing on Cold War culture, liberalism and intellectual life. "East" and "West" during the Cold War: A comparative examination of Western European societies' and movements' responses to communism, highlighting debates on the morality of socialism and capitalism and on liberty, historical determinism, and individual responsibility. Examination of the anxieties and hopes evoked by postwar technological and economic progress—by "Americanization" and the "Economic Miracle." Instructor: Hacohen. 3 units. C-L: Political Science 515S, International Comparative Studies 537S

538. The Roman Empire. 3 units. C-L: see Classical Studies 536

539S. Roman History from Augustus through Late Antiquity. 3 units. C-L: see Classical Studies 536S

540S. Ethnohistory of Latin America. 3 units. C-L: see Cultural Anthropology 570S; also C-L: Literature 573S

541S. Intellectual History and Political Theory. Overview of current and historical approaches to intellectual history and the history of political thought, elucidating their theoretical foundations. Discussion of the major problems involved in the study of texts, ideas and culture and the vocabulary used by historians and political theorists. Readings in the classics of the field from Huizinga, Lovejoy, Febvre and Strauss to Skinner, Pocock and Bourdieu. Focus on joint projects of historians and political theorists. Instructor: Hacohen. 3 units. C-L: Political Science 573S

542S. Atlantic Constellations: Migration, Exile, Second Slavery. 3 units. C-L: see Spanish 539S; also C-L: International Comparative Studies 539S

543S. Piracy and European Imperial Expansion in the Atlantic Basin, 1492-1730. Exploration of the origins, development, and decline of privateering and piracy as systems of maritime predation in the Atlantic basin during the period 1492-1730, building on related processes in the Mediterranean. Includes extensive study of Atlantic maritime history broadly defined. Instructor: Gaspar. 3 units. C-L: International Comparative Studies 543S

546. History of Poverty in the United States. 3 units. C-L: see Study of Ethics 561; also C-L: Public Policy 528, Human Rights Program-Franklin Humanities Institute 561

548S. Global History of Medicine. The study of medicine as an object of critical analysis is a rapidly growing and exciting subfield in both history and anthropology. In English-language scholarship, the biggest conceptual leaps appear in works that analyze post-colonial spaces in Africa, Asia and the Americas, and engage with—and critique—the methodological and theoretical tools of postcolonialism, poststructuralism, governmentality, subaltern studies, Science and Technology Studies (STS), and sociology of scientific knowledge (SSK). We will read and discuss recent and renowned works. Instructor: Barnes. 3 units. C-L: Gender, Sexuality, and Feminist Studies 584S, Global Health 548S

549S. Histories of Science and Technology. This course introduces students to methods in the history of science and technology, with attention to global and interdisciplinary perspectives. In addition to various historical approaches, readings may also include work in ethnography, feminist theory, postcolonial studies, Science & Technology Studies (STS), environmental studies, and other related fields. Particular emphasis will be placed on understandings of materials and material agency, as well as situating a range of themes central to modern science and technology—such as quantification, innovation, infrastructure, and information—within broader historical contexts. Instructor: Hepler-Smith. 3 units. C-L: Science & Society 549S, Global Health 549S

550S. Life Stories: How to Write Them, What They Mean. How does a historian construct the narrative of a life? What gives a life meaning? How do we understand and connect imaginatively to the life experiences of the people who lived history rather than those who made it? What are the pitfalls of reconstructed experience—e.g. selective memory, ideological bias, and narrative over-simplification? How do we use the power of narrative responsibly? This course focuses on the lives and historical experiences of individuals. The emphasis of the class will be on the lives of relatively unknown figures such as farmers, merchants and housewives. Instructor: Partner. 3 units.

553S. Urban Histories in Global, Comparative, and Historical Perspective. This course examines the origins and growth of cities, and the role urban life has played shaping politics, culture, and society in both local and global contexts. Specific topics and subjects vary; please consult course synopsis for more detail and information. Instructor: Thorne. 3 units.

554S. Contemporary Dance History. 3 units. C-L: see Dance 665S; also C-L: International Comparative Studies 509S

556S. The Global Cold War. 3 units. C-L: see Public Policy 556S; also C-L: Political Science 542S

561S. Global Africa. 3 units. C-L: see Cultural Anthropology 561S; also C-L: African & African American Studies 510S, Political Science 527S, International Comparative Studies 510S

562S. Courts, Wars, Legacies of Wars. 3 units. C-L: see Political Science 661S

564S. Toleration, Freedom of Conscience, and Religious Liberty. 3 units. C-L: see Classical Studies 564S; also C-L: Political Science 588S, Religion 564S

567S. American Grand Strategy. 3 units. C-L: see Political Science 562S; also C-L: Public Policy 501S

572S. Anthropology and History. 3 units. C-L: see Cultural Anthropology 501S; also C-L: Romance Studies 521S

577S. Historical and Philosophical Perspectives on Science. 3 units. C-L: see Philosophy 541S; also C-L: Literature 521S, Gender, Sexuality, and Feminist Studies 541S

582S. Narrative, History, and Historical Fiction. Examines alternative approaches to the reading and writing of history, particularly the use of narrative. Explores the power of narrative on the human imagination. Explores issues of writing "responsible" narrative history/historical fiction. Class reads and discusses selected works of historical fiction and narrative non-fiction. Combines theoretical overview with workshop format. The major project is to write a substantial piece of narrative history or historical fiction. Instructor: Partner. 3 units.

587. Modern Literature and History. 3 units. C-L: see French 556

590S. Topics in History Seminar. Seminars in advanced topics designed for graduate students and advanced undergraduates. Topics vary by semester. Instructor: Staff. 3 units.

601S. Introduction to Jewish Studies. 3 units. C-L: see Jewish Studies 601S; also C-L: Religion 613S

610S. Africa, Cuba, Brazil: Great Powers of the Black Atlantic. 3 units. C-L: see African & African American Studies 610S; also C-L: Cultural Anthropology 610S, Romance Studies 522S

611. Biography, Life Writing, Autofiction. 3 units. C-L: see French 611; also C-L: Literature 609

627. Soviet and Post-Soviet Economic History. 3 units. C-L: see Economics 627; also C-L: Russian 627

627D. Soviet and Post-Soviet Economic History. 3 units. C-L: see Economics 627D; also C-L: Russian 627D

01-G-C

701S. Research Seminar in History. This seminar is required of all entering first-year doctoral candidates in history. Instructor: Staff. 3 units.

702S. Research Seminar in History. This seminar is required of all entering first-year doctoral candidates in history. Instructor: Staff. 3 units.

703S. Focusing on Teaching and Pedagogy. A required course that focuses on a range of pedagogical issues, both to support student's work in the classroom as teaching assistants and to prepare them for teaching in their professional careers. Course work will culminate in the creation of a teaching portfolio. Consent of instructor required. Instructor: Staff. 3 units.

704S. Focusing on Preparing Portfolios for Preliminary Certification. A required course, though ungraded, supporting students, most commonly in the third year, as they prepare portfolios for preliminary certification. Instructor: Staff. 3 units.

705S. Nationalism and Visual Culture Since 1789. 3 units. C-L: see Visual and Media Studies 704S; also C-L: Romance Studies 704S

706S. Practicing Public Scholarship. Through reading, discussion and practice this course introduces graduate students to a range of approaches to the public scholarship: writing books for broader publics; writing for newspapers and magazines; doing interviews on radio and television; collaborations with community organizations, museums, libraries; collaborations with K-12 schools and teachers; developing and sustaining successful digital projects with broad public impact. We will read and discuss examples of all these kinds of work, but students will also develop and carry out their own public humanities projects over the course of the semester in dialogue with other students. Instructor: Dubois. 3 units.

707. East Asian Studies Core Course: Fields and Methods. 3 units. C-L: see East Asian Studies 700; also C-L: Religion 700

715. Cultural Memory. 3 units. C-L: see Romance Studies 715; also C-L: Literature 715

730S. A Cultural and Spatial Analysis of the Ghetto: Venice, Nazi Occupied Europe, Chicago. 3 units. C-L: see Art History 730S; also C-L: German 730S, Jewish Studies 730S

741S. Spaces, Bodies, and Narratives: Mapping Religion in Colonial India. 3 units. C-L: see Religion 882S

743. What Machiavelli Really Says. 3 units. C-L: see Italian 743; also C-L: Literature 743, Political Science 752

758S. Bass Connections: Digital Durham. 3 units. C-L: see Information Science + Studies 758S; also C-L: Computational Media, Arts & Cultures 758S, Education 758S

761S. Topics in Modern Latin American Social and Political History. Empirical case studies and methodological and historiographical themes in nineteenth- and twentieth-century Latin America. Instructor: Staff. 3 units.

770. Islam and Its World. 3 units. C-L: see Religion 770

774S. Ideology and Religion in Muslim Central Eurasia. 3 units. C-L: see Slavic and Eurasian Studies 774S; also C-L: Asian & Middle Eastern Studies 774S, Religion 774S

780S. Teaching Race, Teaching Gender. 3 units. C-L: see African & African American Studies 780S; also C-L: Gender, Sexuality, and Feminist Studies 780S, Literature 780S

790S-01. Topics in European History. The department offers a series of rotating courses, covering the history and historiography of various aspects of European History. Written work is confined to methodological, conceptual, or historiographic essays. Topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

790S-02. Topics in Latin American History. The department offers a series of rotating courses, covering the history and historiography of various aspects of Latin American History. Written work is confined to methodological, conceptual, or historiographic essays. Topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

790S-03. Topics in African and Asian History. The department offers a series of rotating courses, covering the history and historiography of various aspects of African and Asian History. Written work is confined to methodological, conceptual, or historiographic essays. Topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

790S-05. Topics in Global Connections. The department offers a series of rotating courses, covering the history and historiography of various aspects of Global Connections. Written work is confined to methodological, conceptual, or historiographic essays. Topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

790S-06. Topics in Law and Society. The department offers a series of rotating courses, covering the history and historiography of various aspects of Law and Society. Written work is confined to methodological, conceptual, or historiographic essays. Topics vary, as do the instructors. Consten of instructor required. Instructor: Staff. 3 units.

790S-07. Topics in Politics, Public Life, The State. The department offers a series of rotating courses, covering the history and historiography of various aspects of Politics, Public Life, The State. Written work is confined to methodological, conceptual, or historiographic essays. Topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

790S-08. Readings in Gender. The department offers a series of rotating courses, covering the history and historiography of various aspects of Gender. Written work is confined to methodological, conceptual, or historiographic essays. Topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

790S-09. Readings in Racial Formations. The department offers a series of rotating courses, covering the history and historiography of various aspects of Racial Formations. Written work is confined to methodological, conceptual, or historiographic

essays. Topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

790S-10. Readings in Empires, Colonial Encountes. The department offers a series of rotating courses, covering the history and historiography of various aspects of Empires, Colonial Encounters. Written work is confined to methodological, conceptual, or historiographic essays. Topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

790S-11. Topics in Labor Systems, Capitalism, Business Cultures. The department offers a series of rotating courses, covering the history and historiography of various aspects of Labor Systems, Capitalism, Business Cultures. Written work is confined to methodological, conceptual, or historiographic essays. Topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

790S-12. Topics in Military History, Science, Technology. The department offers a series of rotating courses, covering the history and historiography of various aspects of Military, Science, Technology. Written work is confined to methodological, conceptual, or historiographic essays. Topics vary, as do the instructors. Instructor: Staff. 3 units.

790S-13. Topics in Methods and Theory. The department offers a series of rotating courses, covering the history and historiography of various aspects of Methods, Theory. Written work is confined to methodological, conceptual, or historiographic essays. Topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

790S-14. Readings in Cultural History. Students read representative "classics" in cultural history, explore the theoretical foundations and assumptions of the works studied, unpack the various meanings of the term "culture," and analyze shifts in the field from the nineteenth century to the present. Instructor: Martin. 3 units.

791. Reading Topics: Independent Study. These courses allow for independent study on specific topics on an individual basis with instructors. Written work is confined to methodological, conceptual, or historiographic essays. Consent of instructor required. Instructor: Staff. 3 units.

792. Reading Topics-Independent Study. These courses allow for independent study on specific topics, on an individual basis with instructors. The expectation is that students will produce a substantial term paper based on research in primary sources. Consent of instructor required. Instructor: Staff. 3 units.

800. Colloquia. Each colloquium deals with an aspect of history by means of readings, oral and written reports, and discussion, with attention to bibliography. Ad hoc colloquia may be worked out during registration in the various fields represented by members of the graduate faculty; these colloquia do not appear on the official schedule of courses. In some instances, students may take the equivalent of a research seminar in conjunction with the colloquium and will be credited with an additional 6 units by registering for 371.1-372.1, etc. Instructor: Staff. Variable credit.

850S. Anthropology and History. A continuation of History 572S/Cultural Anthropology 501S. Recent scholarship that combines anthropology and history, including culture history, ethnohistory, the study of mentalite, structural history, and cultural biography. The value of the concept of culture to history and the concepts of duration and event for anthropology. Prerequisite: History 535S or Cultural Anthropology 501S. Instructor: Staff. 3 units. C-L: Cultural Anthropology 735S

881. Christian Manuscript Culture. 3 units. C-L: see Religion 885; also C-L: Classical Studies 881

890S-01. Research Topics in African and Asian History. The department offers a series of rotating courses that offer students the opportunity to research and write on topics in African and Asian History, with the expectation that students will produce a substantial term paper based on research in primary sources. Specific topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

890S-02. Research Topics in European History. The department offers a series of rotating courses that offer students the opportunity to research and write on topics in European History, with the expectation that students will produce a substantial term paper based on research in primary sources. Specific topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

890S-03. Research Topics in Latin American History. The department offers a series of rotating courses that offer students the opportunity to research and write on topics in Latin American History, with the expectation that students will produce a substantial term paper based on research in primary sources. Specific topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

890S-04. Research Topics in North American History. The department offers a series of rotating courses that offer students the opportunity to research and write on topics in North American History, with the expectation that students will produce a substantial term paper based on research in primary sources. Specific topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

890S-05. Research Topics in Global Connections. The department offers a series of rotating courses that offer students the opportunity to research and write on topics in Global Connections, with the expectation that students will produce a substantial term paper based on research in primary sources. Specific topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

890S-06. Research Topics in Law and Society. The department offers a series of rotating courses that offer students the opportunity to research and write on topics in Law and Society, with the expectation that students will produce a substantial term paper based on research in primary sources. Specific topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

890S-07. Research Topics in Politics, Public Life, The State. The department offers a series of rotating courses that offer students the opportunity to research and write on topics in Politics, Public Life, The State, with the expectation that students will produce a substantial term paper based on research in primary sources. Specific topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

890S-08. Research Topics in Gender. The department offers a series of rotating courses that offer students the opportunity to research and write on topics in Gender, with the expectation that students will produce a substantial term paper based on research in primary sources. Specific topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

890S-09. Research Topics in Racial Formations. The department offers a series of rotating courses that offer students the opportunity to research and write on topics in Racial Formations, with the expectation that students will produce a substantial term paper based on research in primary sources. Specific topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

890S-10. Research Topics in Empires, Colonial Encounters. The department offers a series of rotating courses that offer students the opportunity to research and write on topics in Research in Empires, Colonial Encounters, with the expectation that students will produce a substantial term paper based on research in primary sources. Specific topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

890S-11. Research Topics in Labor Systems, Capitalism, Business Cultures. The department offers a series of rotating courses that offer students the opportunity to research and write on topics in Labor Systems, Capitalism, Business Cultures, with the expectation that students will produce a substantial term paper based on research in primary sources. Specific topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

890S-12. Research Topics in Military History. The department offers a series of rotating courses that offer students the opportunity to research and write on topics in Military History, Science, Technology, with the expectation that students will produce a substantial term paper based on research in primary sources. Specific topics vary, as do the instructors. Instructor: Staff. 3 units.

890S-13. Research Topics in Methods and Theory. The department offers a series of rotating courses that offer students the opportunity to research and write on topics in Methods, Theory, with the expectation that students will produce a substantial term paper based on research in primary sources. Specific topics vary, as do the instructors. Consent of instructor required. Instructor: Staff. 3 units.

890S-14. Research Seminar in Cultural History. Students develop a research project in cultural history. Common readings include a series of methodological works in history, literary theory, and cultural anthropology. The focus of the class is the student's independent work that is to result in a research paper the equivalent in scope and length of a research based journal article. Instructor: Martin. 3 units.

History and Philosophy of Science, Technology, and Medicine

Professor Brading, *Director of Graduate Studies*

A certificate is available in this program.

The history and philosophy of science, technology, and medicine (HPSTM) program is an interdisciplinary graduate certificate program at Duke University designed to complement and enrich the curricula of graduate students studying history, philosophy, science, engineering, medicine, or other disciplines. The program is administered by the history and philosophy departments, but is wide-ranging and draws participants from evolutionary anthropology, biology, civil and environmental engineering, Classical studies, cultural anthropology, economics, English, Germanic languages and literature, literature, psychology and brain sciences, religion, women's studies, and other Duke departments and programs.

Requirements

- The HPSTM core graduate seminar taught annually as a cross-listed course in history, literature, philosophy and gender, sexuality, and feminist studies (Literature 521S/History 577S/Philosophy 541S/ Gender, Sexuality, and Feminist Studies 541S).
- One elective seminar or directed readings course in the history of science, technology, or medicine.
- One elective seminar or directed readings course in the philosophy of science or the history of the philosophy of science.
- One elective seminar or directed readings course relevant to the students HPSTM interests.
- Capstone research paper on a HPSTM-related topic.

For more information visit https://gradschool.duke.edu/academics/programs-degrees/history-and-philosophy-science-technology-and-medicine.

Humanities

Senior Associate Dean for Academic Affairs Klingensmith, *Director of Graduate Studies*

A master's degree is available in this program.

The Master of Arts Program in Humanities is an interdepartmental program tailored to the needs of individual students who pursue interdisciplinary graduate study in the humanities and interpretive social sciences. The candidate must define a theme, historical period, or problem for analysis, and then select appropriate coursework with the aid and approval of an academic advisor. Thirty course credits of coursework and three semesters of continuous enrollment are required for completion of the program; details are available at https://gradschool.duke.edu/academics/programs-degrees/humanities. The degree may be earned with or without a thesis. Any thesis must follow the standard formatting guidelines of The Graduate School. The candidate who chooses not to submit a thesis must submit instead at least two substantial papers arising from coursework. Both thesis and nonthesis candidates must pass a final examination based on these papers or the thesis, with a minimum of three approved graduate faculty serving as the examination committee.

The Master of Arts Program in Humanities is designed for students who seek an intellectual or research focus not otherwise available within any existing graduate program at Duke. Applicants must hold a bachelor's degree in any field (or the equivalent to a US bachelor's degree) from an accredited institution, and must demonstrate sufficient background in humanities or interpretive social science to permit

productive study at the graduate level. Admission is by regular application to The Graduate School. Students may enroll full-time or part-time. The program also participates in the joint JD/MA degree mechanism offered in conjunction with Duke Law School. This allows law students to develop and broaden a complementary field of interest—women's studies, for example, or contemporary literature and hermeneutic theory—to maintain an intellectual focus already developed in their undergraduate careers.

Immunology

Professor Krangel, *Chair*; Associate Professor Shinohara, *Director of Graduate Studies*; Professors Abraham (Pathology), Buckley (Pediatrics), Chao (Medicine), Coffman (Medicine), Cousins (Ophthalmology), Gunn (Medicine), Hall (Dermatology), Haynes (Medicine), He, Hoffman (Pathology), Kelsoe, Kirk (Surgery), Krangel, Lyerly (Surgery), Markert (Pediatrics), Palmer (Medicine), Pisetsky (Medicine), Sampson (Neurosurgery), Staats (Pathology), St. Clair (Medicine), Tedder, Tomaras (Medicine), Weinberg (Medicine), Weinhold (Surgery), Yang (Medicine), Zhong (Pediatrics), and Zhuang; Associate Professors Collier (Biomedical Engineering), Li, Lin (Surgery), MacIver (Pediatrics), Moody (Pediatrics), Permar (Pediatrics), Sarantopoulos (Medicine), Shinohara, Taylor (Medicine), and Zhang; Assistant Professors Ciofani, Coers (Molecular Genetics and Microbiology), Filiano (Neurosurgery), Hammer, MacLeod (Dermatology), Saban (Ophthalmology), Tobin (Molecular Genetics and Microbiology), and Wang (Medicine); Research Professor Sarzotti-Kelsoe; Assistant Research Professors Cook, Kuraoka, Langdon, and Zhu; Adjunct Professors Kepler and Gray; Adjunct Associate Professor Sarafova; Adjunct Assistant Professors Cook and Demarest

A PhD is available in this department.

The Department of Immunology offers graduate work leading to the PhD in immunology.

Immunology is the study of the cells, proteins, and genes that protect against infection and malignancy. Immunology encompasses innate and natural, nonspecific defense mechanisms, as well as specific immune responses that generate immunologic memory. Immunology is by its nature a bridging science. The roots of immunology lie in the study of infectious disease, vaccine development, organ transplantation, immunity to malignancy, and immunotherapy. Modern research in immunology draws on recent advances in cell and molecular biology, biochemistry, genomics and informatics to determine how the immune system functions. In turn, immunology has contributed to understanding biological structure, eukaryotic gene organization and expression, signal transduction, and intracellular protein transport and assembly.

Research programs are available in many aspects of molecular and cellular immunology, including immunogenetics. The department is a participating member in the following university programs: cell and molecular biology, University Program in Genetics and Genomics, the Medical Scientist Training Program, Center for AIDS Research, molecular cancer biology, and the Developmental Biology Training Program.

The Department of Immunology has outstanding facilities for carrying out all aspects of immunologic research. A description of the PhD program, prerequisites for admission, and research in the department may be found at https://immunology.duke.edu/ or by emailing mari.shinohara@duke.edu.

Courses in Immunology (IMMUNOL)

544. Principles of Immunology. An introduction to the molecular and cellular basis of the immune response. Topics include anatomy of the lymphoid system, lymphocyte biology, antigen-antibody interactions, humoral and cellular effector mechanisms, and control of immune responses. Recommended prerequisite: Biology 220, 201L, or 203L. Instructor: Zhang. 3 units. C-L: Biology 515

601. Immunology of Human Diseases. This advanced course will cover the immune aspect of various human diseases including autoimmune diseases, allergy, tumor, inflammation and infectious diseases. The course will discuss the most recent advancement in immunology of human diseases related to mechanisms and treatments. Prerequisite: Immunology 544 or Biology 515. Other basic immunology course taken at another institution may be substituted by consent of instructor. Instructor: He. 1 unit.

701D. Pillars of Immunology. This course will cover discoveries of historical importance in the field of immunology through student presentations and discussions of classical papers. Intended for students seeking a PhD in immunology. F 10:20-11:20 am. Instructor: Krangel and Tedder. 1 unit.

731S. Immunology Seminar. Work in progress seminar in which students and postdoctoral trainees give 30 min to 1 hour presentations of their research. Considered a showcase of current research in the Department of Immunology. All students enrolled in IMM programs are required to give a presentation once per year. Informal questions and discussion are encouraged throughout presentation. First and second year Immunology graduate students should register for Immunology 731S which is graded credit. Third through sixth year Immunology students, along with non-Immunology majors should register for Immunology 732S which is non-graded credit. Attendance is essential for both spring and fall terms. Permission of instructor is required. Instructor: Shinohara. 1 unit.

732S. Immunology Seminar. Work in progress seminar in which students and postdoctoral trainees give 30min to 1 hour presentations of their research. Considered a showcase of current research in the Department of Immunology. All students enrolled in IMM programs are required to give a presentation once per year. Informal questions and discussion are encouraged throughout presentation. First and second year Immunology graduate students should register for Immunology 731S for graded credit. Third through sixth year Immunology students, along with non-Immunology majors should register for Immunology 732S which is non-graded credit. Attendance is essential for both spring and fall terms. Permission of instructor is required. Instructor: Shinohara. 1 unit.

735. Topics in Immunology. Focus on current immunology research, emphasizing emerging research areas and new directions in established areas. Students present recent papers in selected subjects. This course is required for all Immunology graduate students starting the second semester of their first year. Credit/no credit grading only. Permission is required by instructor. Instructor: Ciofani. 1 unit.

736. Topics in Immunology. Focus on current immunology research, emphasizing emerging research areas and new directions in establishment areas. Students present recent papers in selected subjects. This course is required for all Immunology graduate students starting the second semester of their first year. Credit/No Credit grading only. Permission is required by instructor. Instructor: Ciofani. 1 unit.

791A. Research in Immunology. This independent study is the first of two research experiences for first year students enrolled in the Immunology graduate program. This course is designed to introduce bench work in immunology and to expose students to a variety of techniques to increase their proficiency. Research will be conducted in training faculty laboratories. Students are generally expected to complete three rotations (but no less than two) in their first year. Enrollment in IMMUNOL 791B, offered in the spring, is required for grades to post for this course. 2 units.

791B. Research in Immunology. This independent study is the second of two research experiences for first year students enrolled in the Immunology graduate program. This course is designed to introduce bench work in immunology and to expose students to a variety of techniques to increase their proficiency. Research will be conducted in training faculty laboratories. Students are generally expected to complete three rotations (but no less than two) in their first year. Prerequisite: Immunology 791A. 2 units.

800. Comprehensive Immunology. An intensive course in the biology of the immune system and the structure and function of its component parts. Major topics discussed are: lymphocyte development; molecular structure and genetic organization of immunoglobulins, histocompatibility antigens, and T-cell receptor; antigen receptor signaling; properties of antigens; inflammation and nonspecific effector mechanisms; cellular interactions and soluble mediators in lymphocyte activation, replication, and differentiation; regulation of immune responses. Required course for students specializing in immunology. Consent of instructor required. Prerequisite: recommended, Immunology 544 or equivalent. Instructor: Li. 3 units.

Information Science + Studies

Associate Research Professor Szabo, *Director of Graduate Studies*

A certificate is available in this program.

The purpose of the IS+S graduate certificate is to offer an interdisciplinary program at the graduate level that focuses on the study and creation of new information technologies and the analysis of their impact on art, culture, science, medicine, commerce, society, policy, and the environment. The program is designed for master's and doctoral students wishing to complement their primary disciplinary focus with an interdisciplinary certificate in IS+S. The goal of the certificate is to broaden the scope of the typical disciplinary PhD program and to engage the student in related research. The graduate certificate is not intended to provide a disciplinary canon in information science and studies but rather to develop a structured set of transdisciplinary skills and resources for exploring new areas of academic research and teaching. As such, the IS+S graduate certificate is not to lead students down an existing path of traditional academic research but rather to provide them with the means for expanding the scope of their main disciplinary focus by creating new paths of their own.

Requirements

- Complete Information Science + Studies 650S (Computational Media, Arts & Cultures Proseminar)
- Demonstration of proficiency through a graduate-level technology practice course or other evidence of competency as approved by the director of graduate studies.
- Three courses from the approved elective course list (from at least two different departments).
- One formal research presentation coordinated through the IS+S director of graduate studies and documented via online website and presentation archive.
- Participation in at least four research forum events to be tracked by the IS+S director of graduate studies and program coordinator.

For more information, visit https://iss.duke.edu/ or contact the Information Science + Studies Program at Duke University, Box 90766, 114 S. Buchanan Blvd., Bay 9 Room A289, Durham, NC 27708-0766. (919) 668-1934; iss-info@duke.edu.

Courses in Information Science + Studies (ISS)

510S. How They Got Game: History and Culture of Interactive Simulations and Video Games. History and cultural impact of interactive simulations and video games. Evolution of computer and video game design from its beginnings to the present: storytelling, strategy, simulation, sports, 3D first-person games. Cultural, business, and technical perspectives. Insights into design, production, marketing, and socio-cultural impacts of interactive entertainment and communication. Students should have a dual processor implant with 1TB of VRAM. Instructor: Lenior. 3 units. C-L: Visual and Media Studies 566S

535. Chinese Media and Pop Culture. 3 units. C-L: see Asian & Middle Eastern Studies 535

540S. Technology and New Media: Academic Practice. How information technology and new media transform knowledge production in academic practice through hands-on work. Critique of emergent digital culture as it impacts higher education; assessing impact of integrating such tools into scholarly work and pedagogical practice. Modular instruction with guest specialists assisting with information technology tools and media authorship theory. Topics may include: web development, information visualization, time-based media, databases, animations, virtual worlds and others. Theoretical readings; hands-on collaboration; ongoing application to individual student projects. Knowledge of basic web development, personal computer access recommended. Instructor: Szabo. 3 units. C-L: Art History 536S, Visual and Media Studies 562S

544L. Introduction to Digital Archaeology. 3 units. C-L: see Classical Studies 544L; also C-L: Art History 547L

550SL. Digital Publishing: Concepts and Practice. Seminar cultivating theoretical, critical, and historical understanding of scholarly publishing through study of contemporary digital publishing and related issues in the digital humanities. Themes include markers of authorship and authority; contextual influences on interpretation; theories of audience. Hands-on work researching and building an openly accessible, web-based scholarly resource. Guest lecturers providing insight into current legal, technical, and ethical issues in digital publishing. Theoretical readings; analysis, critique, and reflection assignments; team-based discussion and collaboration; ongoing application to individual student projects. Instructors: Janiak, Milewicz. 3 units. C-L: Philosophy 550SL

551SL. Advanced Digital Art History: New Representational Technologies. 3 units. C-L: see Art History 551SL

552. Creative Industries and the Urban Environment. 3 units. C-L: see Visual and Media Studies 542

555S. Physical Computing. 3 units. C-L: see Visual Arts 564S; also C-L: Computational Media, Arts & Cultures 564S

560S. Debates in the Digital Humanities: Multi-Disciplinary Theory and Practice. Digital humanities theory and criticism. Debates around nature of digital humanities, relationship to other disciplines and approaches. Multimodal modes of knowledge production in the digital era for humanists. Global DH, postcolonial DH, DH versus new media studies. Authoring and critiquing born digital projects and applications. Hands-on use of digital media hardware and software in combination with theoretical and critical readings for content analysis of text, images, audio, video and to create digital archives, databases, websites, environments, maps, apps, simulations, and games. Independent digital projects plus critical papers. Graduate focus on personal research applications. Instructor: Szabo. 3 units. C-L: Visual and Media Studies 550S

565S. New Media, Memory, and the Visual Archive. 3 units. C-L: see Visual and Media Studies 565S

575S. Generative Media Authorship - Music, Text & Image. 3 units. C-L: see Visual Arts 575S; also C-L: Music 575S, Computational Media, Arts & Cultures 575S

580S. Historical and Cultural Visualization Proseminar 1. 3 units. C-L: see Art History 580S; also C-L: Computational Media, Arts & Cultures 580S

581S. Historical and Cultural Visualization Proseminar 2. 3 units. C-L: see Art History 581S; also C-L: Computational Media, Arts & Cultures 581S

590S. Special Topics in Information Science + Studies. Topics vary per semester. Information science and studies areas as understood historically, thematically, and in contemporary cultures. Theoretical readings coupled with hands-on work with technology and new media applications. Instructor: Staff. 3 units.

591. Independent Study. Individual non-research directed study in a field of special interest on a previously approved topic, under the supervision of a faculty member, resulting in an academic and/or artistic product. Consent of both the instructor and director of graduate studies is required. Instructor: Staff. Variable credit.

591-1. Independent Study. Half-credit independent study in Information Science + Studies. Individual non-research directed study in a field of special interest on a previously approved topic, under the supervision of a faculty member, resulting in an academic and/or artistic product. Consent of both the instructor and director of graduate studies is required. Instructor: Staff. 1.5 units.

592. Independent Study. Individual non-research directed study in a field of special interest on a previously approved topic, under the supervision of a faculty member, resulting in an academic and/or artistic product. Consent of both the instructor and director of graduate studies is required. Instructor: Staff. Variable credit.

613S. Computational Media Studio in Advanced Digital Practice. 3 units. C-L: see Historical and Cultural Visualization 613S; also C-L: Computational Media, Arts & Cultures 613S

615S. Comparative Media Studies. 3 units. C-L: see Literature 625S; also C-L: Visual and Media Studies 625S, Asian & Middle Eastern Studies 627S

624S. Post-Digital Architecture. 3 units. C-L: see Literature 624S

630S. Phenomenology and Media. 3 units. C-L: see Literature 630S; also C-L: Art History 630S, Visual and Media Studies 630S

632S. Whitehead, Bergson, James. 3 units. C-L: see Literature 632S; also C-L: Art History 632S, Visual and Media Studies 632S

640. The History and Future of Higher Education. Examination of the long history, from Socrates forward, of debates on meaning, purpose, and access to higher education, with special emphasis on the role of humanistic, critical thinking as foundational to all aspects of higher education. Primary focus on Western tradition of postsecondary education, plus a look at different international and alternative models, including apprenticeship, vocational and skills training, monastic training, community-based learning, lifelong learning, and online peer-to-peer open learning. Instructor consent required. Instructor: Staff. 3 units.

650S. Computational Media, Arts & Cultures Proseminar. 3 units. C-L: see Computational Media, Arts & Cultures 650S; also C-L: Literature 621S, Art History 537S, Visual and Media Studies 561S

660S. Digital Places and Spaces: Mirror, Hybrid, and Virtual Worlds. History, theory, criticism, practice of creating digital places and spaces with maps, virtual worlds, and games. Links to "old," analog media. Virtual environment and world-building and historical narrative, museum, mapping, and architectural practices. Project-based seminar course w/ critical readings, historical and contemporary examples, world-building. Class exhibitions, critiques, and ongoing virtual showcase. Projects might include: web and multimedia, GPS and handheld data and media capture, 2D & 3D mapping, screen-based sims and game-engine based development, sensors and biometrics, and multimodal, haptic interfaces. Instructor: Szabo. 3 units. C-L: Visual and Media Studies 660S

662S. Mapping Culture: Geographies of Space, Mind, and Power. History and practice of mapping as cultural practice and technique of world-building and historical and cultural representation. Emphasis on interplay of cartographic imagination, lived experience, historical and narrative power. Readings in mapping history, critical cartography, pyscho-geography, art maps, cognitive mapping, network maps, and spatial theory as well as contemporary approaches and critiques to maps, culture, politics. Exploration of map-based visualizations as narrative/argumentative devices. Hands-on work with geographical information systems, digital mapping tools, data viz, and digital storytelling systems. Theory/practice seminar culminating in a final research project. Instructor: Szabo. 3 units. C-L: Visual and Media Studies 662S

666S. (Neosentience) Body as Electrochemical Computer. 3 units. C-L: see Visual Arts 510S

670. Body Works: Medicine, Technology, and the Body in Early Twenty-First Century America. Influence of new medical technologies (organ transplantation, VR surgery, genetic engineering, nano-medicine, medical imaging, DNA computing, neuro-silicon interfaces) on the American imagination from WWII to the current decade. Examines the thesis that these dramatic new ways of

configuring bodies have participated in a complete reshaping of the notion of the body in the cultural imaginary and a transformation of our experience of actual human bodies. Instructor: Staff. 3 units. C-L: Literature 623, Philosophy 570

680S. Information Archeology: Studies in the Nature of Information and Artifact in the Digital Environment. Interdisciplinary exploration of the nature of artifact and evidence, information and knowledge embedded in structured and unstructured digital data. Critical analysis, research and technology labs focus on societal and technological implications of data warehousing, Internet archives, analog to digital conversion, data recovery, and identity theft and management. Instructor: Staff. 3 units. C-L: Art History 542S, Visual and Media Studies 569S

691. Independent Study. Individual directed study in a field of special interest on a previously approved topic, under the supervision of a faculty member. Consent of the instructor is required. Instructor: Staff. Variable credit.

695T. Advanced Tutorial - Information Science + Studies. Advanced undergraduate and graduate tutorial under the supervision of a faculty member or members for two or more students working on related projects. Consent of instructor required. Instructor: Staff. 3 units.

715. Historical Geographic Information Systems (GIS). This is an introductory graduate Geographic Information System (GIS) course designed to help students develop GIS skills. The class emphasizes perspectives, procedures and tools that are relevant to applications of GIS in Art History and Humanistic disciplines. This course is designed as a hybrid lecture/lab format in which direct instruction is supplemented by hands on learning labs using ArcGIS software and real-world spatial data. The main skills students will gain are: Integration of spatial and tabular data, Geoprocessing, Data visualization, Creating features, Editing Features, Vector and Raster Integration, Spatial Analysis, Georeferencing. Instructor: Staff. 3 units. C-L: Art History 714, Computational Media, Arts & Cultures 715

720. Programming and User Interface Design in Unity 3D. Practical concepts and exercises with the C# programming language. Basic concepts of algorithms and data structures. Discussion of basic computer graphics concepts. Introduction to the Unity3D game engine. Importing various model formats into Unity3D. User interface design in Unity3D. Advanced scripting using C# for Unity3D. Unity3D common pitfalls and tips for optimizations. Usage of the MiddleVR virtual reality library. No prior coding experience is assumed. Instructor: Zielinski. 3 units. C-L: Computational Media, Arts & Cultures 720

720S. Programming and User Interface Design in Unity 3D. Practical concepts and exercises with the C# programming language. Basic concepts of algorithms and data structures. Discussion of basic computer graphics concepts. Introduction to the Unity3D game engine. Importing various model formats into Unity3D. User interface design in Unity3D. Advanced scripting using C# for Unity3D. Unity3D common pitfalls and tips for optimizations. Usage of the MiddleVR virtual reality library. No prior coding experience is assumed. Instructor: Zielinski. 3 units. C-L: Computational Media, Arts & Cultures 720S

733L. Virtual Museums: Theories and Methods of Twenty-First-Century Museums. 3 units. C-L: see Visual Arts 733L; also C-L: Computational Media, Arts & Cultures 733L, Classical Studies 733L

740L. Fundamentals of Web-Based Multimedia Communications. Multimedia information systems, including presentation media, hypermedia, graphics, animation, sound, video, and integrated authoring techniques; underlying technologies that make them possible. Practice in the design innovation, programming, and assessment of web-based digital multimedia information systems. Intended for students in non-technical disciplines. Graduate version of undergrad course also includes higher-level exploration of Javascript topics and frameworks, WebGL/3D, and data visualization and a more substantive final project than undergrad section. Instructor: Staff. 3 units. C-L: Visual and Media Studies 788L

751S. Digital Storytelling and Interactive Narrative. Digital storytelling methodologies, theory, and practice. In-depth analysis of digital storytelling in various media forms and modes of production. Cultural impact of new media narratives. Exploration of digital storytelling affordances and approaches: text, video, audio, design, animation, and interactivity. Critical analysis of existing media and remediation of older media forms. Experimentation with non-linear, spatial, ludic, and hypermedia approaches. Questions of authorship, agency, authority, and collaboration in blogs, games, fan fiction, adaptations. Hands-on experience w/ digital narrative and critiques. Grads write substantial, theoretically-engaged seminar paper. Instructor: Staff. 3 units. C-L: Computational Media, Arts & Cultures 751S, Literature 751S

757S. Editing for Film and Video. 3 units. C-L: see Visual and Media Studies 757S; also C-L: Documentary Studies 757S

758S. Bass Connections: Digital Durham. Bass Connections course. Representing Durham past and present with digital media. Digitize historical and cultural materials, research in archives and public records and present information through various forms including web pages, databases, maps, video and other media. Analysis of social impact of new representations of place and space. Instructor consent required. Instructor: Abel and Szabo. 3 units. C-L: Computational Media, Arts & Cultures 758S, Education 758S, History 758S

760S. Critical Digital Humanities: Theory and Practice. Digital Humanities as an interdisciplinary and sometimes contentious "field" or set of practices connected by their attention to how digital theories and methods transform the production of culture, representation of the past, and shape of artistic practice. Exploration of debates around and critiques of DH as a discipline, interdiscipline, transdisciplinary formation. Hack versus yack, theory versus practice. Emphasis on critical engagement. Future of higher education. Digital divides, inclusion and exclusion, and opportunities for what counts as scholarly work. Intersections with pedagogy, public humanities, artistic practice, activism. Relationship to media and technology studies. Instructor: Szabo. 3 units. C-L: Computational Media, Arts & Cultures 760S

768. Media History: Old and New. 3 units. C-L: see Computational Media, Arts & Cultures 766

770S. Constructing Immersive Virtual Worlds. Theory, practice, and creation of 3D virtual worlds. Hands-on design and development of online collaborative simulation environments. Introduction to graphics workflow for creating virtual world media assets. Critical exploration of state-of-the-art virtual world technologies; 3D graphics, chat, voice, video, and mixed reality systems.

Topics include: history/culture of virtual worlds, identity and avatars; behavioral norms; self-organizing cultures; user-generated content, virtual world economies; architectural scalability. Graduate section includes readings and critical writing on theories of virtuality as they relate to technical content. Instructor: Wendell. 3 units. C-L: Computational Media, Arts & Cultures 770S

780S. Visualizing Cities: Representing Urban Landscapes, Cultures, and Environments. Exploring digital and visual representation of landscapes, structures, environments, history, culture, architecture, events, and populations. Change over time, cultural heritage, possible futures, and alternate pasts from historical, cultural, documentary, and scientific evidence. Idea of city as a conceptual category and metaphor. Ubiquitous computing in urban environments/medium for interaction. Global cities and diaspora. Visual imager and written accounts. Use of mapping, imaging, 3D, augmented reality, games. The graduate version includes both the final digital project and a theoretically-informed graduate seminar paper. Instructor: Szabo. 3 units. C-L: Computational Media, Arts & Cultures 780S

791. Individual Research in Information Science + Information Studies. Directed research and writing in areas unrepresented by regular course offerings. Consent of instructor required. Instructor: Staff. 3 units.

793L. Independent Research in Digital Knowledge. Independent Research in Digital Knowledge in Franklin Humanities Institute. Instructor: Szabo. 1 unit.

794L. Interactive Graphics: Critical Code. Interactive graphics programming for artists. This class explores object-oriented programming via the P5.js and ML5.js programming environments and develops an appreciation of interactivity and computer graphics as artistic media. Students strengthen their graduate-level artistic practices through an aesthetic and conceptual engagement with interactive art. Graduate-level projects incorporate themes, language, and theory from current practices into works developed throughout the semester. Projects extend p5.js by incorporating additional libraries, the development of backend systems, or the development of additional technologies. Instructor: Staff. 3 units. C-L: Visual and Media Studies 794L, Visual Arts 794L

795. Connections in Information, Society and Culture: Project. Bass Connections Information Society & Culture related Individual directed study in a field of special interest on a previously approved topic, under the supervision of a faculty member affiliated with Bass Connections, resulting in an academic and/or artistic product. Instructor consent required. Instructor: Staff. 3 units.

795T. Bass Connections Information, Society & Culture Research Team. Tutorial course for Bass Connections yearlong project team. Topics vary depending on semester and section. Teams of undergraduate and graduate students work with faculty to explore the evolution of society and culture through the lens of information, using the latest computational methods to address pressing problems in new and creative ways. A team's work may run in parallel with or contribute to an ongoing research project. Teams will participate in seminars, data collection and analysis, field work and other learning experiences relevant to the project. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 4 units.

796L. Media, Arts & Cultures Research Practicum I. 3 units. C-L: see Computational Media, Arts & Cultures 796L; also C-L: Visual and Media Studies 796L, Historical and Cultural Visualization 796L

796T. Bass Connections Information, Society & Culture Research Team. Tutorial course for Bass Connections yearlong project team. Topics vary depending on semester and section. Teams of undergraduate and graduate students work with faculty to explore the evolution of society and culture through the lens of information, using the latest computational methods to address pressing problems in new and creative ways. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, data collection and analysis, field work and other learning experiences relevant to the project. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 4 units.

797L. Media, Arts & Cultures Research Practicum II. 3 units. C-L: see Computational Media, Arts & Cultures 797L; also C-L: Visual and Media Studies 797L, Historical and Cultural Visualization 797L

798L. Media, Arts & Cultures Research Practicum III. 3 units. C-L: see Computational Media, Arts & Cultures 798L; also C-L: Visual and Media Studies 798L, Historical and Cultural Visualization 798L

799L. Media, Arts & Cultures Research Practicum IV. 3 units. C-L: see Computational Media, Arts & Cultures 799L; also C-L: Visual and Media Studies 799L, Historical and Cultural Visualization 799L

890S. Special Topics in ISS. Subjects, areas, or themes that embrace a range of disciplines related to Information Science + Studies. Instructor: Staff. 3 units.

Integrated Toxicology & Environmental Health Program

Professor Meyer, *Director of Graduate Studies*

This is an admitting program.

A certificate is also available in this program.

The Integrated Toxicology and Environmental Health Program (ITEHP) provides students with the theoretical and practical bases for research and teaching in toxicology. This interdepartmental program brings together graduate students, postdoctoral fellows, and faculty members from a variety of scientific disciplines to address toxicological and associated environmental health problems from their molecular basis to clinical and environmental consequences. The ITEHP includes participation of faculty members from the departments of biochemistry, cell biology, chemistry, engineering, neurobiology, pathology, pharmacology, and the Nicholas School of the Environment, including the Duke University Marine Laboratory. Among the principal areas of concentration in the program are neurotoxicology and neurological disease, epigenetics, genetic toxicology, cancer, developmental toxicology and children's health, environmental exposure and toxicology, and pulmonary toxicology and disease. Duke faculty members have a variety of collaborative research efforts and, in some cases, student rotations are available with scientists at the nearby laboratories of the National Institute of Environmental Health Sciences (NIEHS), the Hamner Institutes for Health Sciences, and the Environmental Protection Agency (EPA).

Application to the program can be made in two ways. If a student's primary interest is toxicology, then they may apply for admission directly through the ITEHP, indicating "environmental health/toxicology" as their primary admitting unit on the standard graduate school application. Students admitted directly into the program affiliate with a department depending upon their choice of research mentor. Students with a primary interest in a departmentally based field may also apply to the ITEHP by indicating "environmental health/toxicology" as the secondary field on the graduate school application. The primary field should indicate the specific graduate department in arts and sciences, the School of Medicine, or the Nicholas School of the Environment. There is no difference in the eventual degree granted through either mechanism; both routes result in a PhD granted by a specific department, with certification in toxicology. It is expected that most students will have a strong undergraduate preparation in mathematics and the physical and biological sciences with demonstrated excellence of performance as judged by grades in coursework and letters of recommendation from former instructors. Each student in the program will take a series of courses in toxicology, environmental health, and statistics as well as courses specified by his or her department. A student will be expected to choose a dissertation advisor in his or her department at least by the end of the first two semesters in the program and will normally be expected to begin dissertation research during the third semester in residence. Upon satisfactorily completing all degree requirements in the program and in the department, students will be jointly recommended for the PhD.

Students are offered admission to the program with fellowship support based on rank among all applicants. Students may be awarded a toxicology and environmental health training grant fellowship or may be accepted into the toxicology and environmental health program with support from departmental funds. For each entering year, approximately three full fellowships (tuition, fees, and stipend) are awarded to toxicology graduate school applicants. Please note that toxicology and environmental health training grant fellowships are restricted to US citizens or permanent residents. Non-US citizens who are interested in the integrated toxicology and environmental health program will need to apply and request funding directly through a participating department. Applicants must have a bachelor's degree with a strong foundation in mathematics and the biological and physical sciences. Applicants must submit scores on the GRE general test, transcripts, and letters of recommendation. It is expected that coursework and research experience will vary among applicants but that the applicant's academic credentials will be sufficient to ensure successful completion of the degree.

Certificate Requirements

- Thesis advisor must be a member of the program.
- Two members of the student's thesis committee (in addition to the advisor) must be members of the program.
- If admitted directly by ITEHP—complete three lab rotations in the first year of study, in two different departments.
- If admitted through another PhD program—must follow the rotation rules of that program.
- Pharmacology 533 (Essentials of Pharmacology, Toxicology, and Drug Discovery)
- Pharmacology 554 (Mammalian Toxicology) or Environment 501 (Environmental Toxicology)
- Pharmacology 815 or Environment 815 (Focused Topics in Toxicology)
- Pharmacology 733 (Statistics for Basic Biomedical Scientists)
- Pharmacology 847S-848S (Seminar in Toxicology)
- Present a seminar on their dissertation work to the program, usually during the last year.
- Doctoral committee must be approved by the graduate school at least two months prior to preliminary exams.

Further information may be obtained from the program manager, Duke University, Box 90328, Durham, NC 27708; (919) 613-8078; toxicology@duke.edu; https://sites.nicholas.duke.edu/envhealth.

Interdisciplinary Data Science

Assistant Research Professor Schaich Borg, *Director of Graduate Studies*

A master's degree is available in this program.

The master in interdisciplinary data science (MIDS), sponsored by the Social Science Research Institute, is home for creative problem-solvers who want to use data strategically to advance society. The program cultivates a new type of quantitative thought leader who uses disruptive computational strategies to generate innovation and new insights.

MIDS combines rigorous computational and technical training with field knowledge and repeated practice in critical thinking, teamwork, communication, and collaborative leadership to generate data scientists who can add value to any field.

An interview may be required in addition to all Graduate School requirements.

For more information, contact the director of communications, Duke University, Box 90989, Durham, NC 27708; (919) 681-1972; dukemids@duke.edu; https://datascience.duke.edu/.

Courses in Interdisciplinary Data Science (IDS)

590. Special Topics in Interdisciplinary Data Science. Topics vary by semester. Individual semester offerings may require prerequisites or consent of instructor. Instructor: Staff. 3 units.

590S. Special Topics in Interdisciplinary Data Science. Topics vary by semester. Individual semester offerings may require prerequisites or consent of instructor. Instructor: Staff. 3 units.

690. Special Topics in Interdisciplinary Data Science. Topics vary by semester. Individual semester offerings may require prerequisites or consent of instructor. Instructor: Staff. 3 units.

690S. Special Topics in Interdisciplinary Data Science. Topics vary by semester. Individual semester offerings may require prerequisites or consent of instructor. Instructor: Staff. 3 units.

701. Data to Decision. Introduction to using data to make practical decisions. Students will work in small groups to analyze and understand the implications of real, messy data sets. Teams will design and implement their own analysis plan in order to recommend a strategy for solving problems. Practical survey of probability theory through Bayes' Theorem, maximum likelihood, information measures, and an introduction to binary classification and linear regression are also covered. Open only to Interdisciplinary Data Science students. Instructor: Egger. 3 units.

702. Modeling and Representation of Data. Extract actionable insights and draw inference from real world datasets. Methods for dealing with outliers and missing data, data that does not conform to standard modeling assumptions, data representations and particularly time series data analysis. Principles of causal inference and common frameworks for analysis. Develop critical thinking about issues that affect the success of models in data science. This course will lay the foundation for more in-depth study into statistical techniques for practical data analysis. Open only to Interdisciplinary Data Science students. Instructor: Akande. 3 units.

703. Introduction to Natural Language Processing. Introduction to the rich opportunities for using textual data produced by websites, social media platforms, digitization of administrative and historical records, and new monitoring technologies to gain insights and make decisions. Accessing textual data through web scraping and application programming interfaces (APIs), preparing these data for analysis, applying modern natural language processing (NLP) techniques, parsing unstructured text using regular expressions implementing end-to-end NLP. Open only to Interdisciplinary Data Science students. Instructor: Bail. 3 units.

704. Data Science Ethics. Data science tools are not morally neutral. This course is designed to help students think explicitly about their social responsibility as data scientists and the impact on the world of what they are building and analyzing. Using contemporary case studies from recent news stories and legal cases, students will learn about issues such as intellectual copyright, consent, data security, differences between privacy and confidentiality, difficulties of anonymization, and bias in artificial intelligence. Open only to Interdisciplinary Data Science students. Instructor: Skorburg. 1.5 units.

705. Principles of Machine Learning. Automating prediction and decision-making based on data and past experience. Students will learn how and when to apply supervised, unsupervised, and reinforcement learning techniques, and how to evaluate performance. Common pitfalls such as overfitting and data leakage will be explored and how they can be avoided. Topics include model flexibility and regularization; common supervised learning models and ensembles; performance evaluation techniques; dimensionality reduction; clustering; and the fundamentals of reinforcement learning. Open only to Interdisciplinary Data Science students. Instructor: Bradbury. 3 units.

706. Data Engineering Systems. Data Engineering Systems is a course about data and how to manage and build systems. Divided into two halves, part 1 focuses on Relational Databases. These systems are the most common type of database used today and are found in applications ranging from holding cell phone contact lists (both Android and iOS use SQLlite3 internally) to managing every aspect of a large bank or insurance company. The second half is dedicated to the concept that a one size database solution doesn't fit anyone. Concepts covered include data lakes, serverless data engineering and NoSQL databases which are part of how cloud-native technologies are used to perform data engineering, MLOps, and Cloud Architecture. Open only to Interdisciplinary Data Science students. Instructor: Gift, Noah. 3 units.

707. Data Logic, Visualization and Storytelling. Principles of communicating the implications of a data analysis. Students will cultivate the ability to think critically and skeptically about the questions they need to answer in a data project and the strategies they are using to answer them. Students will learn the principles behind effective data visualization and how to implement them in real analyses using Tableau software. Finally, students will practice presenting the results of a data analysis to diverse target audiences. This course serves as the foundation for the second year Capstone Project. Open only to Interdisciplinary Data Science students. Instructor: Schaich Borg. 1.5 units.

720. Practicing Data Science: Tools. This course will provide students with extensive hands-on experience manipulating real (often messy, error ridden, and poorly documented) data using the a range of bread-and-butter data science tools (like the command line, git, python (especially numpy and pandas), jupyter notebooks, and more). The goal of these exercises is to ensure students are comfortable working with data in most any form. Open only to Interdisciplinary Data Science students. Instructor consent required for all other students. Instructor: Eubank. 3 units.

721. Data Analysis at Scale in Cloud. This course is designed to give students a comprehensive view of cloud computing including Big Data and Machine Learning. A variety of learning resources will be used including interactive labs on Cloud Platforms (Google, AWS, Azure). This is a project-based course with extensive hands-on assignments. For ECE students: prerequisite: ECE 580 or ECE 681; for MIDS students: prerequisite or corequisite: IDS 705. All other students will require instructor consent. Instructor: Gift. 3 units.

790. Special Topics in Interdisciplinary Data Science. Topics vary by semester. Check individual semester offerings for additional prerequisites. Instructor permission usually an option. Instructor: Staff. Variable credit.

790S. Special Topics in Interdisciplinary Data Science. Topics vary by semester. Check individual semester offerings for prerequisites. Instructor consent may be required. Instructor: Staff. 3 units.

791. Data Science Dialogues. A series of discussions that give students snapshots of data science projects from practitioners and researchers. Students will hear from speakers from academia, industry, government, and nonprofits who discuss their career paths and share personal experiences about their most rewarding projects, the impact of stakeholders on their projects, the challenges of data collection and analysis, the differences between data science in startups and established companies, and the work cultures in different fields. Open only to Interdisciplinary Data Science students. Instructor: Bendich. 0.5 units.

793. Independent Study. Individual non-research directed study in a field of special interest on a previously approved topic, under the supervision of a faculty member, resulting in an academic product. Consent of instructor and director of graduate studies required. Open only to Interdisciplinary Data Science students. Instructor: Staff. 3 units.

794. Independent Study. Individual non-research directed study in a field of special interest on a previously approved topic, under the supervision of a faculty member, resulting in an academic product. Consent of instructor and director of graduate studies required. Open only to Interdisciplinary Data Science students. Instructor: Staff. Variable credit.

798. Capstone Project. The goal for this year-long capstone is for students to be integrated into world-class interdisciplinary research projects that can solve real-life problems and be significantly advanced through data science. Guided by a faculty advisor, each student will work with a client (e.g. a company, government agency, or nonprofit) on this research project. The project will provide opportunities to hone students' teamwork, project management, creative problem solving, and communication skills as they apply and

further develop their data science expertise. The final deliverables will be evaluated by faculty and relevant stakeholders. Open only to Interdisciplinary Data Science students. Instructor: King. 4 units.

890. Special Topics in Interdisciplinary Data Science. Topics vary by semester. Check individual semester offerings for prerequisites. Instructor consent may be required. Instructor: Staff. 3 units.

890S. Special Topics in Interdisciplinary Data Science. Topics vary by semester. Check individual semester offerings for prerequisites. Instructor consent may be required. Instructor: Staff. 3 units.

898. Master in Interdisciplinary Data Science Workshop. A series of discussions and workshops for all MIDS students that help them develop the project management, communication, and analytical skills needed to succeed in their professional careers. Instructor: Staff. 0.5 units.

990. Special Topics in Interdisciplinary Data Science. Topics vary by semester. Check individual semester offerings for prerequisites. Instructor consent may be required. Instructor: Staff. 3 units.

990S. Special Topics in Interdisciplinary Data Science. Topics vary by semester. Check individual semester offerings for prerequisites. Instructor consent may be required. Instructor: Staff. 3 units.

Interdisciplinary European Studies

Professor Zanalda, *Director of Graduate Studies*

A certificate is available in this program.

The advances of interdisciplinary studies have made it essential to provide a formal structure through which students from various disciplines in arts and sciences and the professional schools can obtain some grounding in other academic disciplines. The Duke University Center for International and Global Studies aims to be a pioneer in the interdisciplinary configuration of area studies to work toward an area-based, but not area-bound, perspective. In this context, the Duke University Center for International and Global Studies offers a graduate certificate in Interdisciplinary European Studies. The graduate certificate is open to all advanced degree students who meet the necessary requirements. Students obtaining the certificate may have an advantage in applying for jobs requiring broad teaching across disciplines, areas and time periods.

Requirements

To receive the graduate certificate, the following criteria must be met:

- Five core courses with at least a 75 percent European Studies content taken in at least three different departments
- Attain competency in one European language other than English, equivalent to at least four semesters of college study (advanced proficiency). The director of graduate studies will approve certification of language competency.
- Attain competency in a second European language other than English, equivalent to at least two semesters of college level study (intermediate proficiency). The director of graduate studies will approve certification of language competency.
- A significant focus on European Studies-related issues in dissertation work.
- A faculty member with European expertise, from outside of the student's home department, must be appointed to the student's dissertation committee.

If there is a question as to whether the course meets the 75 percent European content requirement, such determination will be made by the director of graduate studies. For more information, visit https://igs.duke.edu/.

Interdisciplinary Medieval and Renaissance Studies

Professor Aers, *Chair*; Dr. Cornett, *Associate Director*; Associate Professor Malegam, *Director of Graduate Studies*; Professors Aers (English, Divinity), Beckwith (English, Theater Studies), Brothers (Music), Bruzelius (Art, Art History & Visual Studies), Finucci (Romance Studies), Gaspar (History), Grant (Political Science), Janiak (Philosophy), Longino (Romance Studies), Martin (History), Mignolo (Romance Studies), Porter (English, Theater Studies), Robisheaux (History), Sigal (History), Silverblatt (Cultural Anthropology), Solterer (Romance Studies), Tennenhouse (English), Van Miegroet (Art, Art History & Visual Studies), and Wharton (Art, Art History & Visual Studies); Associate Professors Galletti (Art, Art History & Visual Studies), Malegam (History), McClarney (Asian & Middle Eastern Studies), Neuschel (History), Stern (History), Vilches (Romance Studies), and Woods (Classical Studies); Assistant Professors Caviglia (Art, Art History & Visual Studies), Giles (Music), Hassan (Religious Studies), Pak (Divinity), Riedel (Divinity), Smith (Divinity), and Werlin (English); Professors Emeriti Clark (Religious Studies), DeNeef (English), Garci-Gómez (Romance Studies), Greer (Romance Studies), Hillerbrand (Religious Studies), Mauskopf (History), Newton (Classical Studies), Quilligan (English), Randall (English, Theater Studies), Rigsby (Classical Studies), Shatzmiller (History), Silbiger (Music), and Williams (English); Research Professor Freeman (Divinity); Adjunct Associate Professor Keul (German); Adjunct Assistant Professor Morrow (History); Lecturing Fellows Dubois (History) and Huffman (Art, Art History & Visual Studies)

A certificate is available in this program.

The graduate Program in Medieval and Renaissance Studies is an interdisciplinary program administered by the Duke University Center for Medieval and Renaissance Studies. More than forty faculty in twelve different degree-granting departments participate in the Medieval and Renaissance program, offering courses in art history, history, music, philosophy, religion, and language and literature (Classical studies, English, German, and romance languages). The Program in Medieval and Renaissance Studies seeks to promote cross-departmental and cross-institutional engagement that gives students a network of colleagues beyond their home departments.

Students may earn a formal graduate certificate in interdisciplinary Medieval and Renaissance studies by meeting the following requirements: (1) complete three Medieval and Renaissance courses outside of the major department; (2) attend twelve meetings of the Medieval and Renaissance Studies Colloquium; (3) present a research paper at one of several local Medieval and Renaissance workshops,

colloquia, or conferences; and (4) complete a dissertation on a topic in Medieval and Renaissance studies. While students may be affiliated with the center without having to obtain the graduate certificate, the certificate is a valuable complement to degrees in traditional Duke departments. Students planning to obtain the certificate should file an application with the Center for Medieval and Renaissance Studies as early in their careers as possible, but no later than the fall of their graduation year.

Requirements

- Complete three Medieval and Renaissance studies courses outside of major department (discuss with director of graduate studies and thesis advisor). Courses must be taken for credit. In some cases, courses listed in the student's major department may be counted, as for example when they are team taught by faculty from different disciplines, when they teach research methods or skills relevant to several disciplines, or when they are in a different discipline than that of the student. The director of graduate studies must be consulted in every such case.
- Attend twelve meetings of the Medieval and Renaissance Colloquium. The purpose of the colloquium is to encourage students, before the dissertation-writing stage, to interact with students and faculty in Duke departments beyond their own, and to become part of a broader Medieval and Renaissance studies community at Duke. This colloquium usually meets three times each semester and is led by a range of faculty members or distinguished visiting lecturers.
- Present a research paper at a Medieval and Renaissance studies workshop, colloquia, or conference at a local venue.
- Dissertation on a topic in Medieval and Renaissance studies (late antiquity through seventeenth century on any region, in any discipline).

For an application and more detailed information on the program and its requirements, contact the director of graduate studies or associate director and visit https://medren.trinity.duke.edu/cmrs/graduateRequirements.html.

For descriptions of cross-listed courses below, see the listings under the specified departments.

Courses in Medieval and Renaissance Studies (MEDREN)

504A. History of Netherlandish Art and Visual Culture in a European Context. 3 units. C-L: see Visual and Media Studies 506A

505A. History of Netherlandish Art and Visual Culture in a European Context. 3 units. C-L: see Visual and Media Studies 507A

507S. Live Images: Ancient and Medieval Representations of the Divine. 3 units. C-L: see Visual and Media Studies 533S; also C-L: Religion 552S, Classical Studies 558S

522. Music in the Middle Ages. 3 units. C-L: see Music 551

523. Topics in Renaissance Music. 3 units. C-L: see Music 552

524. Music in the Baroque Era. 3 units. C-L: see Music 553

550. Early to Late Medieval Christianity. A survey of the history of Christianity from its beginnings through the fifteenth century. Also offered as a Divinity School course. Open to juniors and seniors only. Instructor: Doerfler, Pak, Riedel, or Smith. 3 units.

551. Early Modern, Modern and American Christianity. A survey of the history of Christianity from the Reformation to the present, with emphasis on the early modern era. Also offered as a Divinity School course. Open to juniors and seniors only. Instructor: Pak or Riedel. 3 units.

552S. Jerusalem after Rome. 3 units. C-L: see History 522S

554S. Columbus: A Global History. 3 units. C-L: see History 526S

556S. Religion, Conflict and Holy War in the Pre-Modern West: Sects and Violence. 3 units. C-L: see History 506S

561S. The Margins of Justice: Law and Minorities in the Middle Ages. 3 units. C-L: see History 511S

570S. The Society and Economy of Europe, 1400-1700. 3 units. C-L: see History 519S

575S. Religion and Society in the Age of the Reformation. 3 units. C-L: see History 523S

576S. Microhistory. 3 units. C-L: see History 520S

590. Advanced Topics in Medieval and Renaissance Studies. Topics may focus on fine arts, history, language and literature, or philosophy and religion. Open to seniors and graduate students; other students may need consent of instructor. Instructor: Staff. 3 units.

590S. Advanced Seminar in Medieval and Renaissance Studies. Topics may focus on fine arts, history, language and literature, or philosophy and religion. These seminar courses frequently engage interdisciplinary perspectives, historiography, and interpretation of medieval and Renaissance cultures. Open to seniors and graduate students; other students may need consent of instructor. Instructor: Staff. 3 units.

590S-1. Topics in Romanesque and Gothic Art and Architecture. 3 units. C-L: see Art History 590S-3

590S-2. Topics in Italian Renaissance Art. 3 units. C-L: see Art History 590S-4

601S. Moliere: The Phenomenon of Laughter. 3 units. C-L: see French 525S; also C-L: Theater Studies 521S

603. Dante's Divine Comedy: Hell, Purgatory, and Paradise. 3 units. C-L: see Italian 582; also C-L: Literature 582

605. Introduction to Old English. 3 units. C-L: see English 505

607. History of the German Language. 3 units. C-L: see German 560; also C-L: Linguistics 560

608S. Medieval and Renaissance Latin. 3 units. C-L: see Latin 508S

609S. Old Norse: Introduction to the Language of Viking Scandinavia. 3 units. C-L: see German 510S; also C-L: Linguistics 562S

615S. Dante Studies. 3 units. C-L: see Italian 583S; also C-L: Literature 583S

618S. Boccaccio Studies. 3 units. C-L: see Italian 584S; also C-L: Literature 584S

625S. Chaucer and His Contexts. 3 units. C-L: see English 532S

630S. Shakespeare: Special Topics. 3 units. C-L: see English 536S

632S. Special Topics in Renaissance Prose and Poetry: 1500 to 1660. 3 units. C-L: see English 538S

637S. Shakespeare & Co.: English Renaissance Drama. Variable credit. C-L: see English 537S

642. Medieval Fictions. 3 units. C-L: see French 530; also C-L: Literature 541

647S. Latin Palaeography. 3 units. C-L: see Latin 584S

648. The Legacy of Greece and Rome. 3 units. C-L: see Classical Studies 568

655. Early Christian Asceticism. 3 units. C-L: see Religion 634

659. Justice, Law, and Commerce in Islam. 3 units. C-L: see Religion 660; also C-L: African & African American Studies 575

662. Origen. 3 units. C-L: see Religion 632

664. Augustine. 3 units. C-L: see Religion 633

669S. Medieval Philosophy. 3 units. C-L: see Philosophy 618S

672. The Christian Mystical Tradition in the Medieval Centuries. Reading and discussion of the writings of medieval Christian mystics (in translation). Each year offers a special focus, such as: Women at Prayer; Fourteenth-Century Mystics; Spanish Mystics. Less well-known writers (Hadewijch, Birgitta of Sweden, Catherine of Genoa) as well as giants (Eckhart, Ruusbroec, Tauler, Suso, Teresa of Avila, Julian of Norwich, Catherine of Siena, and Bernard of Clairvaux) are included. Also offered as a Divinity School course, and as Religion 742. Open to juniors and seniors only. Instructor: Staff. 3 units.

676. The English Reformation. The religious history of England from the accession of Henry VIII to the death of Elizabeth I. Extensive readings in the English reformers from Tyndale to Hooker. Also offered as a Divinity School course. Open to juniors and seniors only. Instructor: Staff. 3 units.

690S-1. Special Topics in Middle English Literature: 1100 to 1500. 3 units. C-L: see English 530S

690S-2. Topics in Renaissance Studies. 3 units. C-L: see Italian 590S-1

825. Research Colloquium in Medieval and Renaissance Studies. Credit grading only. Instructor: Staff. 3 units.

890S. Topics in Medieval and Renaissance Studies. Seminar on the material bases (archival documents, legal records, court records, manuscripts, material artifacts, and the like) for the study of the Middle Ages. Topics addressed include origins and accessibility, as well as questions of method and historiography. Topics vary. Consent of instructor required. Instructor: Staff. 3 units.

Latin American and Caribbean Studies

Patrick Duddy, *Director*; Natalie Hartman, *Associate Director*; Kenneth Maffitt, *Academic Program Coordinator*

A certificate is available in this program.

The Latin American and Caribbean studies certificate is open to MA and PhD students in any graduate or professional school at Duke. The Center for Latin American and Caribbean Studies oversees and coordinates graduate education on Latin America and the Caribbean and promotes research and dissemination of knowledge about the region. Its Council on Latin American Studies is made up of Latin Americanist faculty and staff members representing arts and sciences disciplines and the professional schools. In addition to fulfilling the requirements of their departments, graduate and professional students may undertake special courses of interdisciplinary study, or those offered by other departments, to broaden their knowledge of the region and to earn a graduate certificate in Latin American and Caribbean studies.

Requirements

- Six graduate courses or the equivalent related to Latin America and/or the Caribbean. (Please see academic program coordinator for courses or units that count toward the certificate.)
- Language proficiency: Students must demonstrate proficiency in Spanish, French, Portuguese, or a less commonly taught language such as Yucatec Maya, Quechua, Haitian Creole, etc.
- Dissertation/thesis: Students are required to have a dissertation, thesis, or departmental equivalent on a Latin American or Caribbean topic approved by their advisor.

For additional information about the graduate certificate in Latin American and Caribbean studies, contact Kenneth Maffitt, Academic Program Coordinator, Box 90254, Duke University, Durham, NC 27708-0254; (919) 681-3981; kmaffitt@duke.edu.

The Center for Latin American and Caribbean Studies sponsors speakers, conferences, and other special events that provide a forum for presentations by visiting Latin Americanists from throughout the United States and overseas, as well as by Duke and UNC faculty and graduate students. Moreover, the Center and the Institute for the Study of the Americas at The University of North Carolina at Chapel Hill sponsor the Carolina and Duke Consortium in Latin American and Caribbean Studies, which provides opportunities for collaboration with faculty and students from both campuses.

The interdisciplinary focus of the graduate program is enhanced by the numerous activities of the consortium, which offers graduate students at Duke an array of intellectually challenging opportunities to broaden their disciplinary training. One of the most important initiatives of the consortium is the sponsorship of interdisciplinary working groups that bring together faculty and graduate students from both campuses to conduct research and training in areas of central concern to Latin American and Caribbean Studies. The groups have focused on topics such as political economy, the environment, and Afro-Latin American perspectives.

Since 1991 the Carolina and Duke Consortium has been designated a National Resource Center for Latin American Studies by the US Department of Education. This honor is accompanied by funding for a number of program activities as well as Foreign Language and Area Studies (FLAS) Fellowships for graduate students. The Center and the Consortium together administer competitions for graduate student travel grants each spring. These awards provide Duke students with the opportunity to deepen their disciplinary interests in the region through relatively brief periods of research in Latin America.

More detailed information on the various components of the Latin American and Caribbean Studies Program at Duke is also available on the center's website at https://latinamericancaribbean.duke.edu/.

Courses in Latin American Studies (LATAMER)

540S. Memory and Documentary Cinema in Latin America. 3 units. C-L: see Romance Studies 540S; also C-L: Visual and Media Studies 540S, Documentary Studies 540S, Literature 544S

540SP. Memory and Documentary Cinema in Latin America Preceptorial. 0 units. C-L: see Romance Studies 540SP

590. Special Topics in Latin American and Caribbean Studies. Interdisciplinary study of geographical, historical, economic, governmental, political, and cultural aspects of modern Latin America and the current issues facing the region. Specific topics will vary from year to year. For juniors, seniors and graduate students. Instructor; Staff. 3 units.

590S. Special Topics in Latin American and Caribbean Studies. Interdisciplinary study of geographical, historical, economic, governmental, political, and cultural aspects of modern Latin America and the current issues facing the region. Specific topics will vary from year to year. For juniors, seniors and graduate students. Instructor: Staff. 3 units.

594S. Cultural (Con)Fusions of Asians and Africans. 3 units. C-L: see African & African American Studies 594S; also C-L: Cultural Anthropology 594S, Sociology 594S

613S. Third Cinema. 3 units. C-L: see Literature 613S; also C-L: African & African American Studies 530S, International Comparative Studies 613S, Visual and Media Studies 611S

690-1. Topics in Latin American Cultural Studies. A problem-oriented course, but also covering theoretical issues, integrating approaches from two or more disciplines. Topics vary from year to year. Instructor: Staff. 3 units.

690S. Special Topics in Latin American and Caribbean Culture and Society. This course covers, at a graduate level, a broad range of cultural topics in Latin American and Caribbean studies from music, art, language, film, journalism, dance, poetry, politics etc. and explores the ways in which cultural expression reflects and criticizes social, economic and political forces in the region. Different topics will be chosen each term. 3 units.

790. Special Topics in Latin American Studies. This course for graduate and professional students will cover themes of great social, scientific, economic and or cultural significance to Latin America and the Caribbean. Topics will change each year and may be offered by visiting scholars from the Latin American and/or the Caribbean. Instructor: Staff. Variable credit.

790S. Special Topics in Latin American Studies. Topics vary be semester. Grad level seminar that will include social, cultural, economic, political studies of Latin American and/or the Caribbean. Instructor: Staff. 3 units.

791. Independent Study. Student will engage in graduate-level specialized reading, multimedia work, and/or independent research related to interdisciplinary Latin American Studies in consultation with instructor. Requirements vary. Permission of instructor required. Instructor: Staff. 3 units.

Literature

Professor Chow, *Chair*; Professor Hansen, *Director of Graduate Studies*; Professors Chow, Dainotto (Italian and Literature), Garreta (Literature and French), Hansen (Art, Art History & Visual Studies and Computational Media, Arts & Cultures), Hardt (Literature and Italian), Jameson (Literature and French), Khanna (English and Literature), Mignolo (Literature and Spanish), Moi (Literature and French), and Wiegman (Literature and Gender, Sexuality, and Feminist Studies); Associate Professors Hadijioannou, Mottahedeh, and Viego (Literature and Spanish); Assistant Professors Bassiri and Reilly

A PhD is available in this program.

The interdepartmental program leading to a PhD in literature offers qualified students the opportunity to develop individual courses of study with a strong emphasis on interdisciplinary work, literary theory, new media studies and cultural studies, while at the same time allowing students to specialize in one or more of the national literatures. The program offers both introductory courses (the 500 series) and more specialized seminars (The 600-800 series), as well as tutorials (890s) in specific research projects or problems.

Students entering the program are strongly advised to have reading knowledge of one language other than English upon entering the program and to acquire reading competence in a second language before taking their preliminary examinations. Students in the literature program are expected to take a minimum of twelve courses, seven of which must be in literature and five in a "teaching field" of their choice. Students entering with a master's degree are expected to take a minimum of ten courses. More information on the program and a full descriptive brochure is available online at https://literature.duke.edu/graduate.

Courses in Literature (LIT)

507S. Mimesis in Theory, Embodied Practice, and Literary Arts. 3 units. C-L: see French 507S; also C-L: Art History 509S, English 581S

510. Citizen Godard. 3 units. C-L: see French 510; also C-L: Visual and Media Studies 552

511S. Borderland and Battleground: A Journey Through Twentieth-Century Eastern Europe. 3 units. C-L: see Slavic and Eurasian Studies 596S

512S. Performing Gender/Exhibiting Race. 3 units. C-L: see Visual and Media Studies 512S

515S. Interethnic Intimacies: Production and Consumption. 3 units. C-L: see Asian & Middle Eastern Studies 515S; also C-L: Visual and Media Studies 515S, International Comparative Studies 515S, Gender, Sexuality, and Feminist Studies 505S

520S. Performance Studies. 3 units. C-L: see Theater Studies 533S

521S. Historical and Philosophical Perspectives on Science. 3 units. C-L: see Philosophy 541S; also C-L: Gender, Sexuality, and Feminist Studies 541S, History 577S

522. Eco-Media: Studies in Planetary Futures. 3 units. C-L: see Cultural Anthropology 520; also C-L: Visual and Media Studies 520

522S. Eco-Media: Studies in Planetary Futures. 3 units. C-L: see Cultural Anthropology 520S; also C-L: Visual and Media Studies 520S

525S. Art as Work: Valuing Labor in the Arts. 3 units. C-L: see Dance 561S; also C-L: Visual Arts 571S, Visual and Media Studies 571S

530S. Seminar in Asian and Middle Eastern Cultural Studies. 3 units. C-L: see Asian & Middle Eastern Studies 505S; also C-L: African & African American Studies 540S

532S. Comparative Modernisms. 3 units. C-L: see Italian 532S; also C-L: German 535S

539S. Queer China. 3 units. C-L: see Asian & Middle Eastern Studies 539S; also C-L: Cultural Anthropology 539S, Gender, Sexuality, and Feminist Studies 502S, Visual and Media Studies 539S, Human Rights Program-Franklin Humanities Institute 539S

540S. Methods and Theories of Romance Studies. 3 units. C-L: see Romance Studies 501S

541. Medieval Fictions. 3 units. C-L: see French 530; also C-L: Medieval and Renaissance Studies 642

542S. Literary Guide to Italy. 3 units. C-L: see Italian 586S; also C-L: German 586S

543S. Reading Heidegger. 3 units. C-L: see Asian & Middle Eastern Studies 540S; also C-L: Religion 560S

544S. Memory and Documentary Cinema in Latin America. 3 units. C-L: see Romance Studies 540S; also C-L: Visual and Media Studies 540S, Documentary Studies 540S, Latin American Studies 540S

545S. Expanded Cinema: Cinema Outside the Movie Theater. 3 units. C-L: see Visual and Media Studies 640S; also C-L: Documentary Studies 640S

551S. Translation: Theory/Praxis. 3 units. C-L: see Asian & Middle Eastern Studies 551S

571. East Asian Cultural Studies. 3 units. C-L: see Asian & Middle Eastern Studies 605; also C-L: Cultural Anthropology 605, International Comparative Studies 605

572S. Antonio Gramsci and the Marxist Legacy. 3 units. C-L: see Italian 588S

573S. Ethnohistory of Latin America. 3 units. C-L: see Cultural Anthropology 570S; also C-L: History 540S

580S. Jews and the End of Theory. 3 units. C-L: see Asian & Middle Eastern Studies 541S; also C-L: Jewish Studies 541S, International Comparative Studies 541S

582. Dante's Divine Comedy: Hell, Purgatory, and Paradise. 3 units. C-L: see Italian 582; also C-L: Medieval and Renaissance Studies 603

583S. Dante Studies. 3 units. C-L: see Italian 583S; also C-L: Medieval and Renaissance Studies 615S

584S. Boccaccio Studies. 3 units. C-L: see Italian 584S; also C-L: Medieval and Renaissance Studies 618S

590. Special Topics in Literature. Special topics in Literature. Instructor: Staff. 3 units.

590S. Special Topics in Literature. Special topics in Literature. Instructor: Staff. 3 units.

609. Biography, Life Writing, Autofiction. 3 units. C-L: see French 611; also C-L: History 611

610S. Basic Concepts in Cinema Studies. Review of theory, methodology, and debates in study of film under three rubrics: mode of production or industry; apparatus or technologies of cinematic experience; text or the network of filmic systems (narrative, image, sound). Key concepts and their genealogies with the field: gaze theory, apparatus theory, suture, indexicality, color, continuity. Instructor: Mottahedeh. 3 units. C-L: Visual and Media Studies 610S

611S. Film Feminisms. Philosophical debates and approaches to the female form in film theory and history. Phenomenology, cultural studies, Marxism, psychoanalysis, structuralism, post-structuralism, as well as gaze theory, apparatus theory, and feminist film theory as they approach readings of the body, subjectivity and identity in cinema. Questions of spectatorship and the gendered subject. Screening and discussion of Hollywood and European avant garde films key to early debates, and of international films central to debates around the gendered subject and representation in modernity. Interrogation of feminist approaches to national cinemas. Instructor: Mottahedeh. 3 units. C-L: Gender, Sexuality, and Feminist Studies 611S

612S. Theories of the Image: The Image in Walter Benjamin. Returning to Walter Benjamin's *Art Work* essay and its various sources and revisions, this course will discuss recent engagements with Benjamin's work in cinema, photography, and visual and media studies and will attempt to understand the role and functions of the faculty he coins "the mimetic" in modern culture. Readings will be drawn from the English translation of Benjamin's *Selected Writings*, volumes 1-4, and including his work on photography, history, surrealism and his reviews of writers such as Charles Baudelaire. Readings will also include some of Benjamin's own primary sources, such as the writings of Kracauer as well contemporary discussions of Benjamin's work in academic journals. Instructor: Mottahedeh. 3 units. C-L: German 512S, Romance Studies 612S, Visual and Media Studies 612S

613S. Third Cinema. Exploration of the geopolitics of situatedness and distance as they refer to the film industry, investigating processes of production, distribution, and reception of Hollywood, Third World, and diasporic films, and studying classical and artisanal modes of production in film. Addresses questions of authorship and embodiment; human rights and interventionist filmmaking as they refer themselves to human states of liminality, global movements of populations and capital. Traces the experience of globalization, urbanization, alienation, violence, nostalgia for nature and homeland as represented in the filmic image. Instructor: Mottahedeh. 3 units. C-L: African & African American Studies 530S, International Comparative Studies 613S, Latin American Studies 613S, Visual and Media Studies 611S

614S. Thinking Digital Cinema. Review of debates regarding digital cinema. Exploration of impact of new media technologies on contemporary cinema cultures. Examines question of medium specificity, cinema ontology, conventions of analog cinema vs. digital cinema, mediation/remediation/media convergence, applications of CGI, interactivity, cinephilia and DVD consumption, and spectatorship. Explores a series of philosophical questions surrounding our understanding and experience of contemporary cinema. Includes one trip to a local museum or gallery to examine digital installation art. Instructor: Hadjioannou. 3 units. C-L: Theater Studies 671S, Visual and Media Studies 614S

615S. The #Selfie. Focusing on digital self portraits that social media denizens have hashtagged "the selfie", the course will trace two different histories 1) the global history of portraiture in the arts and photography from the 19th C to the present 2) the emergence of the modern idea of "everyday life" (i.e. the routine, the trivial, the unconscious, the unremarkable) as the exact antithesis of what has routinely been called "history", all strongly associated with women and private life. These unpresentable phenomenon have challenged notions of the state, Capital, urban design, and copyright, indeed the body and the Beautiful. Student driven case studies highlight everyday engagements with social media. Instructor: Mottahedeh. 3 units. C-L: Visual and Media Studies 615S, Gender, Sexuality, and Feminist Studies 615S, International Comparative Studies 615S

620S. Film-philosophers/Film-makers. Examines intersections between film, critical theory, and continental philosophy, from standpoint of spectatorship. Focuses on different approaches to film theory from a philosophical prism, and on different philosophers addressing film as a mediated visual interpretation of reality, the world, our own bodies, and societies within which we reside. Addresses film-making as an act of philosophical thought—of thinking about the world and representing subject's position within the world. Topics include, existential phenomenology, Deleuzian metaphysics, feminism, semiotics, political theory. Instructor: Hadjioannou. 3 units. C-L: Visual and Media Studies 622S, Theater Studies 620S, English 620S, Documentary Studies 620S

621S. Computational Media, Arts & Cultures Proseminar. 3 units. C-L: see Computational Media, Arts & Cultures 650S; also C-L: Information Science + Studies 650S, Art History 537S, Visual and Media Studies 561S

622. Science Studies. Key texts and crucial issues in contemporary history, sociology, and philosophy of science—or, as the assemblage is sometimes called, 'science studies.' Focus on theoretical and methodological problems leading to a critiques of classical conceptions of knowledge and scientific truth, method, objectivity, and progress, and b the development of alternative conceptions of the construction and stabilization of knowledge and the relations between scientific and cultural practices. Readings include L. Fleck, K. Popper, P. Feyerabend, T. Kuhn, S. Shapin and S. Schaffer, and B. Latour. 3 units.

623. Body Works: Medicine, Technology, and the Body in Early Twenty-First Century America. 3 units. C-L: see Information Science + Studies 670; also C-L: Philosophy 570

624S. Post-Digital Architecture. Impact of advanced technology on conceptions of architectural design, new urban environments, & the body since the mid-1990s. Postmodernism & role of time-based new media, game environments & virtual worlds technologies in the rise of digital architecture from the late 1990s-2000s. Theoretical readings from Deleuze, Pask, Grosz, Massumi, Denari, Eisneman, Koolhaas, Lynn, Diller + Scofidio. Explores programs for post-digital architecture that integrate nano & biomimetic technologies, smart materials & protocells into self-organizing designs for living architecture & reflexive environments. Discuss how post-digital architecture will engage the work of Simondon, Spillers, Armstrong,others. Topics course. Instructor: Lenoir. 3 units. C-L: Information Science + Studies 624S

625S. Comparative Media Studies. Explores the impact of media forms on content, style, form, dissemination, & reception of literary & theoretical texts. Assumes media forms are materially instantiated & investigates their specificities as important factors in their cultural work. Puts different media forms into dialogue, including print, digital, sonic, kinematic & visual texts, & analyzes them within a theoretically informed comparative context. Focuses on twentieth & twenty-first century theories, literatures, & texts, esp. those participating in media upheavals subject to rapid transformations. Purview incl. transmedia narratives, where different versions of connected narratives appear in multiple media forms. Instructor: Staff. 3 units. C-L: Information Science + Studies 615S, Visual and Media Studies 625S, Asian & Middle Eastern Studies 627S

630S. Phenomenology and Media. Examination of phenomenology both as a philosophical movement and as a resource for contemporary media theory. Attention centers on the classical phase of phenomenology (from Husserl to Merleau-Ponty), on more recent developments in phenomenology and post-phenomenology (Levinas, Derrida, Fink, Barbaras), and on correlations between phenomenology and media theory (Ihde, Stiegler, Flusser). Key topics include: reduction, experience, time-consciousness, sensation, world manifestation, differance, reversibility, de-presencing, worldliness, readiness-to-hand and thrownness. Instructor: Hansen. 3 units. C-L: Art History 630S, Information Science + Studies 630S, Visual and Media Studies 630S

631S. Seminar on Modern Chinese Cinema. 3 units. C-L: see Asian & Middle Eastern Studies 631S; also C-L: Visual and Media Studies 631S

632. Questions of National Cinemas. 3 units. C-L: see Asian & Middle Eastern Studies 631; also C-L: Visual and Media Studies 632

632S. Whitehead, Bergson, James. An exploration of process philosophy, with particular attention to its relevance for contemporary issues in media, political economy, aesthetics, and culture. Focuses on three texts: Whitehead's Process and Reality, Bergson's Matter and Memory, and James's Essays in Radical Empiricism. Other works by these philosophers and secondary literature on them will help establish context for arguments of these fundamental philosophical texts. Topics explored includes: process, radical empiricism, vitalism, memory, perception, monism, experience, speculative empiricism, actuality & potentiality, the virtual, the fringe, the superject, causal efficacy, society, prehension, & selection. Instructor: Hansen. 3 units. C-L: Information Science + Studies 632S, Art History 632S, Visual and Media Studies 632S

640S. Theory and Practice of Literary Translation. Linguistic foundations, historical roles. contemporary cultural and political functions of literary translation. Readings in translation theory, practical exercises and translation assignments leading to a translation project. 3 units. C-L: German 511S

644. Modernism. Aspects of the "modern," sometimes with emphasis on the formal analysis of specific literary and nonliterary texts (Joyce, Kafka, Mahler, Eisenstein); sometimes with a focus on theories of modernism (Adorno), or on the modernism/postmodernism debate, or on the sociological and technological dimensions of the modern in its relations to modernization, etc. Instructor: Jameson. 3 units.

672. Representation in a Global Perspective. Problems of representation approached in ways that cross and question the conventional boundaries between First and Third World. Interdisciplinary format, open to exploration of historical, philosophical, archeological, and anthropological texts as well as literary and visual forms of representation. Instructor: Staff. 3 units.

681S. Wittgensteinian Perspectives on Literary Theory. Key questions in literary theory reconsidered from the point of view of ordinary language philosophy (Wittgenstein, J. L. Austin, Cavell). Topics will vary, but may include: meaning, language, interpretation, intentions, fiction, realism and representation, voice, writing, the subject, the body, the other, difference and identity, the politics of theory. New perspectives on canonical texts on these subjects. Instructor: Moi. 3 units. C-L: English 582S, Philosophy 681S

682. The Intellectual as Writer. History and theory of the literary role of the intellectual in society (e.g., in Augustan Rome, the late middle ages, the Renaissance, America, Latin America). Instructor: Staff. 3 units.

683. Studies in Legal Theory. A consideration of those points at which literary and legal theory intersect (e.g., matters of intention, the sources of authority, the emergence of professional obligation). Instructor: Staff. 3 units.

690. Special Topics in Literature. Topics vary by semester. Instructor: Staff. 3 units.

690-1. Special Topics in Literature of the Modern Era. Study of a particular author, genre, or theory of modern literature. Topics include changing understandings of authorship, questions of reception, translation, and the history of criticism. Instructor: Staff. 3 units.

690-3. Topics in Cultural Studies. Instructors: Staff. 3 units.

690-4. Special Topics in Film. Selected film directors with attention to their visual style. Auteur theory or authorship as a way of understanding the cinematic work of European, American, Asian, or African masters of the form. Instructor: Staff. 3 units.

690-6. Topics in Psychoanalytic Theory and Criticism. Instructor: Moi or Viego. 3 units.

690-7. Special Topics in Literature and History. Relationship of literary texts to varieties of historical experience such as wars, periods of revolutionary upheaval, periods of intense economic growth, "times of troubles," or stagnation. Literary texts and historical content posed in such formal ways as the theoretical problem of the relationship between literary expression and form and a range of historical forces and phenomena. Instructor: Jameson. 3 units.

690-8. Special Topics in Literature: Paradigms of Modern Thought. Specialized study of the work of individual thinkers who have modified our conceptions of human reality and social and cultural history, with special emphasis on the form and linguistic structures of their texts considered as 'language experiments.' Topics vary from year to year, including: Marx and Freud, J.P. Sartre, and Walter Benjamin. Instructor: Staff. 3 units.

690S. Special Topics in Literature. Topics vary each semester. Instructor: Staff. 3 units.

690S-3. Topics in Cultural Studies. Contents and methods vary with instructors and from semester to semester. Instructor: Staff. 3 units.

690S-4. Special Topics in Film. Contents and methods vary with instructors and from semester to semester. Instructor: Staff. 3 units.

690S-8. Special Topics in Literature: Paradigms of Modern Thought. Specialized study of the work of individual thinkers who have modified our conceptions of human reality and social and cultural history, with special emphasis on the form and linguistic structures of their texts considered as 'language experiments.' Topics vary from year to year, including: Marx and Freud, J.P. Sartre, and Walter Benjamin. Seminar version of Literature 690-8. Instructor: Jameson or staff. 3 units.

691S. Black Sonic Culture—Analog to Digital. 3 units. C-L: see African & African American Studies 622S; also C-L: English 691S, Music 691S

695S. Literature Seminar. Contents and methods vary with instructors and from semester to semester. Instructor: Staff. Variable credit.

709S. Science, Medicine, and the Body. 3 units. C-L: see Cultural Anthropology 709S; also C-L: Gender, Sexuality, and Feminist

Studies 709S, Science & Society 709S, Global Health 709S

710S. Saying and the Unsayable: Introduction to Lyric/Literary Theory. 3 units. C-L: see Romance Studies 710S; also C-L: English 710S, Religion 762S

715. Cultural Memory. 3 units. C-L: see Romance Studies 715; also C-L: History 715

717S. Art & Democracy: Madrid/Barcelona/Bilbao. 3 units. C-L: see Spanish 717S; also C-L: Art History 709S

735S. Space, Place, and Power. 3 units. C-L: see Cultural Anthropology 740S

740S. Early Modernism 1870-1914. 3 units. C-L: see English 810S

741S. The Symbolist Movement in the Arts and European Thought. 3 units. C-L: see Visual and Media Studies 741S

743. What Machiavelli Really Says. 3 units. C-L: see Italian 743; also C-L: History 743, Political Science 752

751S. Digital Storytelling and Interactive Narrative. 3 units. C-L: see Information Science + Studies 751S; also C-L: Computational Media, Arts & Cultures 751S

760S. Major Figures in Feminist Thought. 3 units. C-L: see Gender, Sexuality, and Feminist Studies 860S

761S. Foundations in Feminist Theory. 3 units. C-L: see Gender, Sexuality, and Feminist Studies 701S

770. Interdisciplinary Research Workshop. 3 units. C-L: see Gender, Sexuality, and Feminist Studies 770

780S. Teaching Race, Teaching Gender. 3 units. C-L: see African & African American Studies 780S; also C-L: Gender, Sexuality, and Feminist Studies 780S, History 780S

801. History of Criticism. Theories of art and literature from Plato and Aristotle to the early twentieth century. Special emphasis on the period from 1750 to 1900. Instructor: Moi or staff. 3 units.

822S. Writing is Thinking. 3 units. C-L: see English 822S

826S. Contemporary Genre Fiction: The Global Novel. 3 units. C-L: see Romance Studies 826S; also C-L: English 826S

827S. The Global Novel: Post, What?. This course examines the recent emergence of novels in various parts of the globe that address a readership beyond their respective nations and regions of origins, sometimes even beyond the novelist's national language. These novels make a point of declaring that the form of the novel traditionally organized around the experience of a representative individual is now obsolete. Critics and scholars tend to describe these novels as displaying specific forms of "post-ness," whether post-modern, post-human, post-apocalyptic, post-revolutionary, and post-exotic. Instructor: Garreta. 3 units. C-L: English 827S, Romance Studies 827S

831. History of Literary Institutions. History of the university, the development of the disciplines of literary study, especially English and Comparative Literature, and of the various supporting institutions, practices, and technologies of literary study. Consent of instructor required. Instructor: Radway, Hernstein Smith, or staff. 3 units.

840S. Seminar in Emergent Literatures. An advanced seminar in the literature of Third World or nonwestern countries. Specific topics vary from year to year. Instructor: Dorfman. 3 units.

850S. Deleuze: Cinema and Philosophy. Examination of Gilles Deleuze's books: CINEMA 1 and CINEMA 2. Exploration of his concepts of the "movement-image" and the "time-image" with reference to his other single studies on Bergson, Spinoza, Leibniz, and Nietzsche. Key topics include Deleuze's philosophical interpretation of movement and change, of time and duration, of being and becoming, of expressionism and aesthetics, of subjectivity, of the "will to power" and the "eternal return," of cinema as philosophy, and of ethics. Readings accompanied by assigned films from primary representatives of art, world, and experimental cinema, related to the philosophical questions/material under examination each week. Instructor: Hadjioannou. 3 units. C-L: Visual and Media Studies 850S, English 860S, Romance Studies 850S, Visual Arts 850S, Computational Media, Arts & Cultures 85, Documentary Studies 850S

880S. Language and Theory in the Twentieth Century. A seminar examining some of the most significant analyses, controversies, and achievements of the various disciplinary approaches to language during the past century and their implications for cultural study. Topics include the question of linguistics as a science, the muddle of meaning and interpretation, approaches to communication as social interaction, the Chomskian episode, and poststructural/postanalytic conceptions and contributions. Instructors: B. H. Smith and Tetel. 3 units.

881S. Stanley Cavell and Ordinary Language Philosophy. Reading Stanley Cavell's "The Claim of Reason." Exploring the relevance of ordinary language philosophy for the humanities. Key themes are language, responsibility, community, literature, theater and the arts. Instructor: Moi. 3 units.

882S. Philosophy and Literature. 3 units. C-L: see Philosophy 947S

890. Special Topics in Literature. Contents and methods vary with instructors and from semester to semester. Instructor: Staff. 3 units.

890S. Seminars in Literature. Contents and methods vary with instructors and from semester to semester. Instructor: Staff. 3 units.

890T. Tutorial in Special Topics. Directed research and writing in areas unrepresented by regular course offerings. Consent of instructor required. Instructor: Staff. 3 units.

891. Special Readings. Consent of instructor required. Instructor: Staff. Variable credit.

892S. Publication Workshop. This course is a writing intensive, works-in-progress seminar for doctoral students interested in preparing an article for publication. It will explore the everyday challenges of writing and introduce students to the professional practices and protocols of journal publication. During the term, you will read and comment on the work of your peers, learn how to

interpret and generate feedback in the form of "reader's reports," revise and present your own essay, and explore potential publication venues. The final act of the course will entail submitting your essay for publication in the journal of your choice. Instructor: Wiegman. 3 units.

Marine Science and Conservation

Professor Read, *Director and Chair*; Associate Professor Hench, *Director of Graduate Studies*; Professors Halpin (Environment), Nowacek (Environment and Engineering), Read (Environment), Rittschof (Environment and Biology), Smith (Environment), Silliman (Environment), and Van Dover (Environment); Associate Professors Basurto (Environment), Hench (Environment), Hunt (Environment), Johnson (Environment), and Murray (Environment); Associate Professor of the Practice Johnston (Environment); Assistant Professors Gill (Environment); Assistant Professor of the Practice Schultz (Environment); Assistant Research Professor Dunn (Environment)

A PhD is available in this department.

The Division of Marine Science and Conservation, one of three academic units in the Nicholas School of the Environment, offers graduate study for students wishing to earn the PhD in marine science and conservation. Doctoral students emphasize research as a major part of their degree programs. It is designed to prepare students for careers in university teaching and research or outside of the university involving the application of science to policymaking. The program is designed to ensure that students receive detailed training in either natural or social science while, at the same time, are able to synthesize information from both fields. Applicants are strongly encouraged to contact individual faculty members with whom they wish to work prior to applying to The Graduate School.

For more information, please visit https://nicholas.duke.edu/marinelab/academics/graduate.

See the Marine Laboratory website for the current schedule of courses.

- Environment 849A (Graduate Seminar and Professional Development)
- Environment 878A (Current Topics in Marine Science and Conservation)
- Environment 876A (Data and Time-series Analysis in Marine Sciences)
- Environment 773A (Marine Ecology)
- Environment 860SA (Political Ecology)
- Environment 887A (Theories and Methods for Policy Analysis of the Commons) or approved substitute

Master of Arts in Teaching Program

Naomi Kraut, *Director of Graduate Studies*

A master's degree is available in this program.

The twelve-month master of arts in teaching (MAT) degree is designed for individuals interested in learning how to teach high school in the following areas: English education, math education, science education, or social studies education. To earn the master of arts in teaching certification, a student must have an undergraduate degree in that field of certification, or in a field closely related.

MAT candidates conduct a 27-week-long internship at two Durham public high schools under the guidance of experienced mentor faculty. Through graduate-level education and graduate-level content area coursework, students develop their teaching skills and become thoughtful leaders in the field of education.

Students begin the Master of Arts in Teaching Program in July and complete all degree requirements by the following July. In the first summer term, coursework includes fieldwork observations at a Durham Public School and provides students with a foundation in practical pedagogy. During the fall and spring semesters, students take Duke graduate-level courses in their content area as well as MAT courses designed to support their student teaching internships. In the final summer term, students complete their Program of Study with two Duke graduate-level courses in their content area.

More information on the program is available from the MAT office, 1364 Campus Drive, 01 West Duke Building, Box 90093, Duke University, Durham, NC 27708-0093, or online at https://educationprogram.duke.edu/MAT or by email at MAT-Program@duke.edu.

Courses in the Master of Arts in Teaching (MAT)

702. Educating Adolescents. Students will examine learning as a constructive process, including how mental frameworks organize memory and guide thought, the role metacognition and motivation play in learning, and why social interaction is paramount to cognitive development. Students will also consider identity development in adolescence and the social world of teenagers. Fieldwork observations at the School for Creative Studies will comprise a component of this course. Open to Master of Arts in Teaching students only. Instructor: Goldwasser. 3 units.

703. Effective Teaching Strategies. What is involved when a teacher creates and orchestrates an effective lesson? Students will delve into how teachers facilitate the engagement of all students, as they backwards plan, activate students' prior knowledge, incorporate a variety of learning modes, use formative assessments, apply before-during-after scaffolding, leverage technology, allow opportunities for student processing, ask critical thinking questions, and provide a safe and supportive learning environment for their students. Open to Master of Arts in Teaching students only. Instructor: Kraut. 3 units.

741. Internship and Reflective Practice. During this 18-week internship at a Durham Public High School, students will work with an experienced mentor teacher to build a classroom community, foster relationships with students, and plan and implement effective instruction. As part of their internship, students will observe other teachers, attend school meetings and events, and work with school staff and families to learn about their students. Students will engage in consistent reflection on their teaching practice, guided by their mentors and university supervisors. Instructor: Kraut. 4 units.

742. Internship and Reflective Practice. During this 9-week, full-day internship at a Durham Public High School, students will work with an experienced mentor teacher to build a classroom community, foster relationships with students, and plan and implement effective instruction. In addition to teaching in their mentor's classroom, students will participate in all aspects of a teacher's day, from

hall duty to lunch duty to communication with parents. Students will engage in consistent reflection on their teaching practice, guided by their mentors and university supervisors. Instructor: Kraut. 6 units.

743S. The Practice of Culturally Responsive Teaching. Students will think critically about what it means to be a culturally responsive teacher in terms of reaching all students through relevant lesson planning, differentiating instruction, using a variety of assignments and assessment methods, and fostering a safe and collaborative learning environment for their students. Students will also learn strategies for teaching English learners and will consider what effective classroom management looks like and feels like and why. Open to Master of Arts in Teaching students only. Instructor: Kraut. 2 units.

744S. Leading through Teaching. Students will define what it means to be a "teacher leader" through participating in collaborative work with teacher colleagues, administrators, and school staff and by teaming with the families and significant adults in the lives of students. This course will help student teachers to partake in the work that goes into effective teaching outside of classroom instruction, as they explore the vital roles that teachers play in the health of their schools and communities. Open to Master of Arts in Teaching students only. Instructor: Kraut. 3 units.

791. Independent Study. Independent Study in teaching methods. Open only to MAT students. Consent of Director of Graduate Studies required. Instructor: Staff. Variable credit.

Master of Fine Arts in Dance

Associate Professor Kliën, *Director of Graduate Studies*

A master's degree is available in this program.

The Duke University Dance Program focuses on dance as an integral part of the human experience and the moving body as a medium for rigorous intellectual creativity. The program's aim is to engage students in the profound potential for dance as embodied knowledge in the service of society.

The master of fine arts in dance: embodied interdisciplinary praxis is a two-year, full-time terminal degree in dance dedicated to embodied knowledge and practice-led movement discourses. The program endorses dance as a politically, socially, and spiritually transformative force in society and engages students at the vanguard of contemporary dance culture and praxis. The MFA encourages practice-based, interdisciplinary research that has the potential to result in tangible contributions to culture and society at large.

Additional information and contacts may be found at https://danceprogram.duke.edu/graduate.

Courses in Dance (DANCE)

535S. AfroFuturism. 3 units. C-L: see African & African American Studies 620S; also C-L: Theater Studies 535S, Visual and Media Studies 524S

545S. Selected Topics in Dance Theory. Topics vary. Instructor: Staff. 3 units.

561S. Art as Work: Valuing Labor in the Arts. Interdisciplinary seminar on work, working identities, and workplace performances in the arts. Enrolled graduates and advanced undergraduates review theories of artistic production, labor, and value across the analytical traditions of cultural labor studies, critical race and feminist studies, dance and performance studies. Analysis of dominant representations of arts labor and entrepreneurship from arts management, administration and policy discourse. Our goal is to highlight institutional pressures that constrain enabling environments for the arts. Culminating research projects analyze and interpret local arts workworlds, including but necessarily students' own. Instructor: Wilbur. 3 units. C-L: Literature 525S, Visual Arts 571S, Visual and Media Studies 571S

575S. Somatics: Embodiment for the Twenty-First Century. Examines Somatics as emancipatory and ethical dance education designed to train reflective and autonomous dancers. The course is underscored by ethical principles foundational to somatic education, namely, acceptance, inclusivity, privacy, respect, and non-judgment. Somatic education is viewed as an intelligent movement-centered response to complex problems within the larger sphere of bio-politics, re-negotiating issues of control and fostering autonomy—of ourselves and of our environment. Classes will draw from the history of Somatics and its scientific and psychosocial underpinnings in forming a critique around current societal issues and its evolving impact on dance training. Instructor: Batson. 3 units.

590S. Topics in Dance/Embodiment. Subjects, areas, or themes embracing a range of approaches to embodiment in arts and humanities areas. Topics vary by semester. Instructor: Staff. 3 units.

645S. Black Performance Theory. 3 units. C-L: see African & African American Studies 621S; also C-L: Visual and Media Studies 621S

665S. Contemporary Dance History. A survey course spanning twentieth- and twenty-first-century developments in selected dance forms from around the world, including discussions of dance in its historical, political and cultural context. Readings will focus on dance as a social phenomenon; dance in the form of political activism; dance as a medium of projecting gendered identity and the historical trajectory of dance aesthetics. Discussions will also include postmodernism in dance and the impact of globalization on world dance forms. Invited guest artists. Instructor: Shah. 3 units. C-L: International Comparative Studies 509S, History 554S

690S. Special Topics in Dance. Special topics in dance. Instructor: Staff. 3 units.

701S. Choreographic Praxis: Choreography as an Aesthetics of Change. Choreography as a practice integrated with how we perceive the world relevant to current social and political processes. Examined through connections to other fields of human knowledge production, in order to recognize and challenge epistemological assumptions inscribed in the act of creation. Explores movement, structures, and dynamics through the experience, discussion, and deconstruction of choreographic methodologies. Choreographic processes that propose new relational structures, approaches to embodiment, and ways of ordering. Readings in system theory, cultural theory, social choreography, anthropology, new technologies, evolution, relational aesthetics, philosophy, and politics. Department consent required. Instructor: Kliën. 3 units.

710L. Movement Research I. The opportunity to work in a multitude of ways with regard to movement and studio practice and to develop an individual approach that serves the student's artistic trajectory. Course includes an introductory intensive 'Excavation Site' workshop, two intensive workshops during the semester, and an individual movement research plan designed by the student in consultation with the instructor. The plan may include personal studio time and/or access to movement courses taught in the Dance Program. Reflection paper required. Participation in the weekly movement research lab is strongly encouraged. Instructor: Kliën. 3 units.

771S. Graduate Seminar: Theories of Corporeality. This graduate reading seminar explores theoretical frames for articulating the social, political, cultural, phenomenological and economic significance of the body. Course literature draws significantly although not exclusively from dance and performance research to consider a wide range of approaches to corporeality studies. Required reading, viewing of performance texts, and guest presentations, and workshops draw surgical attention to the body as a discursive site and to performance as a site of embodied power and potential resistance. Students contribute knowledge across a range of graduate writing genres. Course culminates in the creation of an original research project. Instructor consent required. Instructor: DeFrantz, Wilbur. 3 units. C-L: Music 771S, Gender, Sexuality, and Feminist Studies 771S

772S. Graduate Seminar in Critical Dance Studies. This seminar explores theoretical praxes for critical dance studies and emergent trends within the discipline. We look at how the field has been constituted, the theoretical lines of inquiry that have served it, and how debates have changed over time. We consider the methods that dance scholars bring to bear on their work and consider the limits and affordances of these tools for students' own research projects. Lectures and discussions include invited field experts and integrate Duke's expansive dance archives (including ADF) and professional performance series. Course culminates in an original written research project. Instructor: DeFrantz, Wilbur. 3 units. C-L: Music 772S, Gender, Sexuality, and Feminist Studies 772S

787S. Research Methods in Dance. Methods used in dance theory, history, ethnography, education and choreography/practice and other disciplines, as appropriate. Interviewing and documentation; examination of issues concerning participatory experience and objectivity in ethnographic research. Student writing in service to thesis proposal. Instructor: Shah or Wilbur. 3 units.

810L. Movement Research II. Continuation of Movement Research I. The opportunity to work in a multitude of ways with regard to movement and studio practice and to develop an individual approach that serves the student's artistic trajectory. Course includes two intensive workshops on weekends during the semester and an individual movement research plan designed by the student in consultation with their faculty supervisor. The plan may include personal studio time and/or access to movement courses taught in the Dance Program. Reflection paper on their work and discoveries during the semester. Participation in the weekly movement research lab is strongly encouraged. Instructor: Staff. 3 units.

871S. Critique I. Meets weekly for 3 hours to review, discuss and reflect on student work in-depth. Works critiqued will be both works-in-progress as well as finished projects. Guest scholars and visiting artists will join the class at times, bringing an "outside" perspective to discussions. Students will present their work and will also be assigned formal roles to lead weekly critiques. Instructor: Staff. 3 units.

891. Independent Study. Individual directed study on advanced graduate level under supervision of a faculty member resulting in an academic or artistic product. Consent of instructor required. Instructor: Staff. 3 units.

971S. Critique II. Meets weekly for 3 hours to review, discuss and reflect on student work in-depth. Works critiqued will be both works-in-progress as well as finished projects. Guest scholars and visiting artists will join the class at times, bringing an "outside" perspective to discussions. Students will present their work and will also be assigned formal roles to lead weekly critiques. Instructor: Staff. 3 units.

Master of Fine Arts in Experimental and Documentary Arts

Associate Professor Abe, *Director of Graduate Studies*

A master's degree is available in this program.

The master of fine arts in experimental and documentary arts is a terminal degree offered jointly by three academic units: the Department of Art, Art History, and Visual Studies, the Center for Documentary Studies, and the Program in the Arts of the Moving Image. The MFA brings together two forms of artistic activity—the documentary approach and experimental production in analog, digital, and computational media—in a unique program that will foster collaborations across disciplines and media as it trains sophisticated, creative art practitioners.

The MFA in experimental and documentary arts requires fifteen courses over four semesters: ten required (core) courses in prescribed sequence and five elective courses. In order to build cohesion in the program, all matriculating students will enroll concurrently in required courses in the first semester: two studio courses—MFA in Experimental and Documentary Arts 711 (Documentary Fieldwork) and MFA in Experimental and Documentary Arts 713 (Computational Media)—and one elective. In the second semester, the cohort will enroll in one required studio course—MFA in Experimental and Documentary Arts 712 (Experiments in the Moving Image)—one seminar—MFA in Experimental and Documentary Arts 703 (Continuity and Change in Experimental and Documentary Arts)—and one elective. After a summer of individual thesis research, the second year will focus on supporting production of the thesis project and paper via an elective methods seminar, a thesis production studio course, a seminar on research and writing the thesis, as well as two elective courses. All students are required to enroll in MFA in Experimental and Documentary Arts 720-723 (Critique I-IV)—to review, and discuss student work—in all four semesters. Final projects will be presented at an MFA Thesis Exhibition in the fourth semester and a written thesis paper will be submitted.

Additional information and contacts may be found at https://mfaeda.duke.edu.

Courses in Experimental and Documentary Arts (MFAEDA)

703. Continuity and Change in Experimental and Documentary Arts. Explores the historical and conceptual construction of experimental and documentary arts with specific attention to experimental and artistic practices that have expanded influenced and expanded traditions of artistic expression. An introduction to a range of documentary expression from photography to writing, from film to installations, all based on documentary fieldwork alongside readings by experimental makers as well as related secondary and tertiary literature from diverse disciplines. Final paper/project required. Instructor: Rankin. 3 units.

711. Documentary Fieldwork. Semester-long individual documentary project using one or more documentary mediums, including photography, film/video, audio, and long form writing, or a blend of the above, with Durham and the Piedmont of North Carolina as our suggested focus. Experimentation with collaborative approaches to documentary fieldwork as well as individually driven work in documentary art. Requires final documentary project expressing cultural and political realities through a personal point of view. Instructor: Dooney. 3 units.

712. Experiments in the Moving Image. Poetic and experimental image-making, utilizing techniques that trace a historical trajectory from celluloid to digital. Exploration of cinematographic principles and cameraless experiments. Readings and screenings focusing on avant-garde film and digital traditions supplement student productions. Instructor: Staff. 3 units.

713. Computational Media Studio. Introduction to computer programming and interactive media production as artistic practice. In-depth exploration of critical possibilities opened by computational media through exercises, projects, and critiques. Experience with programming basics includes procedural and object-oriented programming, two- and three-dimensional graphics, data visualization, and innovative methods for interactivity. Team-taught. No previous programming experience required. Department consent required. Instructor: Staff. 3 units.

720. MFAEDA Workshop and Critique I. A class that meets weekly for 3 hours to review, discuss and reflect on student work in-depth. Works critiqued will be both works-in-progress as well as finished projects. Guest scholars and visiting artists will join the class at times, bringing an "outside" perspective to discussions. Students will also be assigned formal roles to lead weekly critiques. Instructor: Abe/Kelly. 1 unit.

721. MFAEDA Workshop and Critique II. A class that meets weekly for 3 hours to review, discuss and reflect on student work in-depth. Works critiqued will be both works-in-progress as well as finished projects. Guest scholars and visiting artists will join the class at times, bringing an "outside" perspective to discussions. Students will also be assigned formal roles to lead weekly critiques. Instructor: Rankin. 1 unit.

722. MFAEDA Workshop and Critique III. A class that meets weekly for 3 hours to review, discuss and reflect on student work in-depth. Works critiqued will be both works-in-progress as well as finished projects. Guest scholars and visiting artists will join the class at times, bringing an "outside" perspective to discussions. Students will also be assigned formal roles to lead weekly critiques. Instructor: Abe/Kelly. 1 unit.

723. MFAEDA Workshop and Critique IV. A class that meets weekly for 3 hours to review, discuss and reflect on student work in-depth. Works critiqued will be both works-in-progress as well as finished projects. Guest scholars and visiting artists will join the class at times, bringing an "outside" perspective to discussions. Students will also be assigned formal roles to lead weekly critiques. Instructor: Rankin. 3 units.

791. Thesis Writing Workshop. Support for the writing of the thesis paper through multiple drafts and group discussion. Writing of a concise critique of the MFAEDA project following its completion and exhibition. Instructor: Abe. 3 units.

792. Thesis Project Workshop. Completion and review of final thesis project. Instructor: Sims. 3 units.

Materials Science and Engineering, University Program in

Professor Stiff-Roberts, *Director of Graduate Studies*; Professors Aquino, Baranger, Beratan, Brinson, A. Brown, Chilkoti, Craig, Cummer, Curtarolo, Finkelstein, Gall, Glass, Jokerst, J. Liu, Mitzi, Needham, Padilla, Rubinstein, Schmidt, Smith, Socolar, Stiff-Roberts, Therien, Varghese, West, Wiesner, and Zauscher; Associate Professors Arya, Blum, Charbonneau, Chen, Collier, Delaire, Franklin, J. Lu, Mikkelsen, Patek, Payne, Teitsworth, Wiley, and Yellen; Assistant Professors Barthel, Guilleminot, Haravifard, Hoffman, and Hsu; Professor of the Practice Von Windheim; Assistant Professor of the Practice Hotz

A master's degree and a PhD are available in this program.

The University Program in Materials Science and Engineering (MatSci) is a multidisciplinary graduate degree program that transcends the traditional boundaries of materials classifications and scientific disciplines. Participating departments from Pratt School of Engineering and Trinity College of Arts & Sciences include Biology, Biomedical Engineering, Chemistry, Civil and Environmental Engineering, Electrical and Computer Engineering, Mathematics, Mechanical Engineering and Materials Science, and Physics. The MatSci Program offers both an MS and a PhD, with research emphasis on biomaterials, computational materials discovery, electronic & photonic materials, energy materials, metamaterials, and soft materials. The MatSci graduate program prepares diverse cohorts of MS and PhD students to tackle multidisciplinary materials challenges in a wide range of professional settings, from academia to industry to national labs. In addition, the potential for unique exposure and access to the School of Medicine, the Nicholas School of the Environment, the Sanford School of Public Policy, and the Innovation & Entrepreneurship Initiative at Duke University can provide the resources needed for students to chart their own paths. Information about affiliated faculty and their research interests may be found on the MatSci website: https://matsci.duke.edu/.

Degree Requirements

Thirty course credits are required for students with a bachelor's degree to receive graduate degrees in the MatSci Program (two years for the MS or five years for the PhD). For the MS degree, only a project option is available. Core courses (3 credits each) are required to cover fundamentals and to prepare for research with MatSci affiliated faculty. These core courses should be taken in the first year and must be selected from eight options. MS students must select six courses, and PhD students may select four to six courses (up to 2 of the six core courses may be replaced by courses deemed critical by advisors and students for their research projects). In addition to the 18 course credits from the core courses, a three-semester seminar course (3 credits total) and three elective courses (3 credits each) are required, all of which should be completed within the second year for a total of 30 course credits. The elective courses must be approved by the director of graduate studies. For MS or PhD students, a maximum of one elective course may be replaced with an independent study to receive course credit for research. In the case of PhD students matriculating with a master's degree, course credit requirements are reduced to 21 credits, and the selection of courses must be approved by the director of graduate studies. Academic Integrity and Responsible Conduct of Research training is required by The Graduate School: MS students (4 hours) and PhD students (12 hours).

Core Courses

- CHEM 548: Solid State/Materials Chemistry (Fall)
- CHEM 544: Statistical Mechanics (Fall) or ECE 521: Quantum Mechanics (Fall)
- ME 555: Materials Synthesis & Processing (Fall)
- ME 555: Fundamentals of Soft Matter (Spring)
- ME 555: Computational Materials Science (Spring)
- ECE 511: Found. of Nanoscale Sci. & Technology (Spring) or ME 711/ECE 721: Nanotechnology Materials Lab (Spring)

Seminar Course

- ME 555: Materials Science and Engineering Seminar (3 semesters)

Elective Courses

- Choose three electives. Must be approved by the director of graduate studies.

The examinations required for the MS and PhD are as follows:

- **MS Project Exam.** A project exam is required to complete the MS degree. In the project exam, a poster presentation is reviewed by the Graduate Exam Committee.
- **PhD Qualifying Exam.** The qualifying exam should be taken during the third semester of study and is administered by the Graduate Exam Committee. The exam score is a composite based on grades earned in the core courses, a poster presentation describing the relevance of a current research project to content learned in the core courses, and a three-page poster abstract. In the case of a failed exam, the Graduate Exam Committee will determine the appropriate action that should be taken by the student.
- **PhD Preliminary Exam.** The preliminary exam is taken during the spring semester of the third year. The preliminary committee should comprise four or five committee members, three of whom are required to be affiliated with the University Program in MSE. The preliminary report and presentation will propose a research plan for completion of the PhD.
- **PhD Defense.** Ideally, the PhD defense occurs during the spring semester of the 5th year, with the same rules for committee membership as the preliminary exam.

Courses in University Program in Materials Science and Engineering Offered by Departments

Chemistry (CHEM)
544. Statistical Mechanics
548. Solid State/Materials Chemistry
Electrical and Computer Engineering (ECE)
511. Foundations of Nanoscale Science & Technology
521. Quantum Mechanics
Mechanical Engineering and Materials Science (MEMS)
555. Materials Synthesis & Processing
555. Fundamentals of Soft Matter
555. Computational Materials Science
555. Materials Science and Engineering Seminar
711. Nanotechnology Materials Lab (ECE 721)

Courses in Materials Science and Engineering (MSEG)

591. Independent Study. Independent study guided by an instructor with related interests and expertise. Department consent required. Instructor: Staff. 3 units.

891. Internship. Student gains practical experience by taking a job in industry, and writing a report about this experience. Requires prior consent from the director of graduate studies. May be repeated with consent of the director of graduate studies. A full-time internship is available to students if it allows them to gain practical experience in a work environment related to their academic training and enhances their overall academic experience and, for F-1 Visa, their employment prospects once they return to their home country. Internship can be local or within United States. Instructor: Staff. 1 unit.

Mathematics

Professor Mattingly, *Chair*; Associate Professor Robles, *Director of Graduate Studies*; Professors Agarwal, Aspinwall, H. Bray, Bryant, Calderbank, Dasgupta, Daubechies, Durrett, Hain, Harer, Kiselev, Liu, Mattingly, Miller, Mukherjee, Ng, Pardon, Petters, Plesser, Reed, Saper, Schoen, Stern, Venakides, and Witelski; Associate Professors Lu, Nolen, Pierce, Robles, and Wu; Assistant Professors Cheng, Getz, Levine, Pollock, and Ryser

A PhD is available in this department.
The Department of Mathematics offers graduate work leading to the PhD in mathematics.

Admission to this program is based on the applicant's undergraduate academic record, level of preparation for graduate study, the Graduate Record Examination general and subject tests, research experiences, and letters of recommendation.

The department offers research training in both pure and applied mathematics. Major areas of research specialization include algebra and algebraic geometry, analysis and partial differential equations, applied mathematics and scientific computing, differential geometry, geometry and physics, mathematical biology, probability and stochastic processes, and topology.

All PhD students are required to pass an oral qualifying examination. Candidacy for the PhD is established by passing an oral preliminary examination. The preliminary examination is normally taken during the third year. By this time the student should have chosen a thesis advisor. The original research, which begins after successful completion of the preliminary examination, should culminate in the writing and defense of a dissertation. The dissertation is the most important requirement for the PhD.

Further details concerning the department, the graduate program, admissions, facilities, the faculty and their research, and financial support may be obtained from the department's website, https://math.duke.edu/. For inquiries, email the director of graduate studies at dgs-math@math.duke.edu.

Courses in Mathematics (MATH)

501. Introduction to Algebraic Structures I. Groups: symmetry, normal subgroups, quotient groups, group actions. Rings: homomorphisms, ideals, principal ideal domains, the Euclidean algorithm, unique factorization. Not open to students who have had Mathematics 401. Prerequisite: Mathematics 221 or equivalent. Instructor: Staff. 3 units.

502. Introduction to Algebraic Structures II. Fields and field extensions, modules over rings, further topics in groups, rings, fields, and their applications. Prerequisite: Mathematics 501, or 401 and consent of instructor. Instructor: Staff. 3 units.

527. General Relativity. 3 units. C-L: see Physics 622

531. Real Analysis I. Topology of R^n, continuous functions, uniform convergence, compactness, infinite series, theory of differentiation, and integration. Not open to students who have had Mathematics 431. Prerequisite: Mathematics 221. Instructor: Staff. 3 units.

532. Basic Analysis II. Differential and integral calculus in R^n. Inverse and implicit function theorems. Further topics in multivariable analysis. Recommended prerequisite: Mathematics 221, Mathematics 531, or consent of instructor. Instructor: Staff. 3 units.

541. Applied Stochastic Processes. An introduction to stochastic processes without measure theory. Topics selected from: Markov chains in discrete and continuous time, queuing theory, branching processes, martingales, Brownian motion, stochastic calculus. Prerequisite: Mathematics 230 or Mathematics 340 or equivalent. Instructor: Staff. 3 units. C-L: Statistical Science 621

545. Introduction to Stochastic Calculus. Introduction to the theory of stochastic differential equations oriented towards topics useful in applications. Brownian motion, stochastic integrals, and diffusions as solutions of stochastic differential equations. Functionals of diffusions and their connection with partial differential equations. Ito's formula, Girsanov's theorem, Feynman-Kac formula, Martingale representation theorem. Additional topics have included one dimensional boundary behavior, stochastic averaging, stochastic numerical methods. Prerequisites: Undergraduate background in real analysis (Mathematics 431) and probability (Mathematics 230 or 340). Instructor: Staff. 3 units.

551. Applied Partial Differential Equations and Complex Variables. Initial and boundary value problems for the heat and wave equations in one and several dimensions. Fourier series and integrals, eigenvalue problems. Laplace transforms, solutions via contour integration, and elementary complex variables. Solutions via Green's functions. Intended for applied math students and students in science and engineering. Prerequisite: Mathematics 216 and 353 or the equivalent. Instructor: Staff. 3 units.

553. Asymptotic and Perturbation Methods. Asymptotic solution of linear and nonlinear ordinary and partial differential equations. Asymptotic evaluation of integrals. Singular perturbation. Boundary layer theory. Multiple scale analysis. Prerequisite: Mathematics 353 or equivalent. Instructor: Staff. 3 units.

555. Ordinary Differential Equations. Existence and uniqueness theorems for nonlinear systems, well-posedness, two-point boundary value problems, phase plane diagrams, stability, dynamical systems, and strange attractors. Prerequisite: Mathematics 221, 216 or 356, and 531 or 431. Instructor: Staff. 3 units.

557. Introduction to Partial Differential Equations. Fundamental solutions of linear partial differential equations, hyperbolic equations, characteristics, Cauchy-Kowalevski theorem, propagation of singularities. Prerequisite: Mathematics 532 or equivalent. Instructor: Staff. 3 units.

560. Theory and Practice of Algorithms. The mathematical theory of algorithms and graphs and their practical implementations. Examines the foundational mathematical structures for the behavior and analysis of algorithms from a variety of domains, with a particular emphasis on graphs. Students tie theory to practice by writing code to implement algorithms, and compare experimentally observed run-times to those predicted by the mathematical theory. Recommended prerequisite: Computer Science 201; or recommended corequisite: ECE 551; or equivalent. Instructor: Staff. 3 units.

561. Numerical Linear Algebra, Optimization and Monte Carlo Simulation. Structured scientific programming in C/C++ and FORTRAN. Floating point arithmetic and interactive graphics for data visualization. Numerical linear algebra, direct and iterative methods for solving linear systems, matrix factorizations, least squares problems and eigenvalue problems. Iterative methods for nonlinear equations and nonlinear systems, Newton's method. Prerequisite: Mathematics 212 and 221. Instructor: Staff. 3 units.

563. Applied Computational Analysis. Approximation theory: Fourier series, orthogonal polynomials, interpolating polynomials and splines. Numerical differentiation and integration. Numerical methods for ordinary differential equations: finite difference methods for initial and boundary value problems, and stability analysis. Introduction to finite element methods. Prerequisite: Mathematics 561 and familiarity with ODEs at the level of Mathematics 216 or 356. Instructor: Staff. 3 units.

565. Numerical Analysis. 3 units. C-L: see Computer Science 520; also C-L: Statistical Science 612

573S. Modeling of Biological Systems. Research seminar on mathematical methods for modeling biological systems. Exact content based on research interests of students. Review methods of differential equations and probability. Discuss use of mathematical techniques in development of models in biology. Student presentations and class discussions on individual research projects. Presentation of a substantial individual modeling project to be agreed upon during the first weeks of the course. Not open to students who have had Modeling Biological Systems 495S. Prerequisites: Mathematics 216 or 356 or consent of instructor. 3 units. C-L: Modeling Biological Systems 573S, Computational Biology and Bioinformatics 573S

575. Mathematical Fluid Dynamics. Properties and solutions of the Euler and Navier-Stokes equations, including particle trajectories, vorticity, conserved quantities, shear, deformation and rotation in two and three dimensions, the Biot-Savart law, and singular integrals. Additional topics determined by the instructor. Prerequisite: Mathematics 453 or 551 or an equivalent course. Instructor: Staff. 3 units.

577. Mathematical Modeling. Formulation and analysis of mathematical models describing problems from science and engineering including areas like biological systems, chemical reactions, and mechanical systems. Mathematical techniques such as nondimensionalization, perturbation analysis, and special solutions will be introduced to simplify the models and yield insight into the underlying problems.Instructor: Staff. 3 units.

581. Mathematical Finance. An introduction to the basic concepts of mathematical finance. Topics include modeling security price behavior, Brownian and geometric Brownian motion, mean variance analysis and the efficient frontier, expected utility maximization, Ito's formula and stochastic differential equations, the Black-Scholes equation and option pricing formula. Prerequisites: Mathematics 212 (or 222), 221, and 230 (or 340), or consent of instructor. Instructor: Staff. 3 units. C-L: Economics 673

582. Financial Derivatives. A rigorous introduction to financial derivatives with applications. Topics include: binomial trees and geometric Brownian motion; European options, American options, forwards, and futures; put-call parity; the Black-Scholes-Merton pricing formula and its derivations; Delta and Gamma hedging; implied volatility; Merton jump-diffusion model; Heston model; GARCH(1,1) model. Prerequisites: Math 212 (or 222) and Math 230 (or 340) or consent of instructor. Instructor: Staff. 3 units. C-L: Economics 674

590-01. Special Readings. Instructor consent required. Instructor: Staff. 3 units.

590-02. Advanced Special Topics in Mathematics. Topics in mathematics suitable for advanced undergraduates or graduate students. Topics vary per semester. Instructor: Staff. 3 units.

590-60. Topics in Theory and Practice of Algorithms. The mathematical theory of algorithms and graphs and their practical implementations. Examines the foundational mathematical structures for the behavior and analysis of algorithms from a variety of domains, with a particular emphasis on graphs. Students tie theory to practice by writing code to implement algorithms, and compare experimentally observed run-times to those predicted by the mathematical theory. Prerequisite: Computer Science 201 or corequisite of ECE 551 or equivalent. Instructor: Staff. 3 units.

601. Groups, Rings, and Fields. Groups including nilpotent and solvable groups, p-groups and Sylow theorems; rings and modules including classification of modules over a PID and applications to linear algebra; fields including extensions and Galois theory. Instructor: Staff. 3 units.

602. An Introduction to Commutative Algebra and Algebraic Geometry. Affine algebraic varieties, Groebner bases, localization, chain conditions, dimension theory, singularities, completions. Prerequisite: Mathematics 601 or equivalent. Instructor: Staff. 3 units.

603. Representation Theory. Representation theory of finite groups, Lie algebras and Lie groups, roots, weights, Dynkin diagrams, classification of semisimple Lie algebras and their representations, exceptional groups, examples and applications to geometry and mathematical physics. Prerequisite: Mathematics 501 or equivalent. Instructor: Staff. 3 units. C-L: Physics 603

605. Algebraic Number Theory. Binary quadratic forms; orders, integral closure; Dedekind domains; fractional ideals; spectra of rings; Minkowski theory; fundamental finiteness theorems; valuations; ramification; zeta functions; density of primes in arithmetic progressions. Prerequisites: Mathematics 502 or 601 or consent of instructor. Instructor: Staff. 3 units.

607. Computation in Algebra and Geometry. Application of computing to problems in areas of algebra and geometry, such as linear algebra, algebraic geometry, differential geometry, representation theory, and number theory, use of general purpose symbolic computation packages such as Maple or Mathematica; use of special purpose packages such as Macaulay, PARI-GP, and LiE; programming in C/C++. Previous experience with programming or the various mathematical topics not required. Corequisite: Mathematics 601 or consent of instructor. Instructor: Staff. 3 units.

611. Algebraic Topology I. Fundamental group and covering spaces, singular and cellular homology, Eilenberg-Steenrod axioms of homology, Euler characteristic, classification of surfaces, singular and cellular cohomology. Prerequisite: Mathematics 411 and 501 or consent of instructor. Instructor: Staff. 3 units.

612. Algebraic Topology II. Universal coefficient theorems, Künneth theorem, cup and cap products, Poincaré duality, plus topics selected from: higher homotopy groups, obstruction theory, Hurewicz and Whitehead theorems, and characteristic classes. Prerequisite: Mathematics 611 or consent of instructor. Instructor: Staff. 3 units.

619. Computational Topology. 3 units. C-L: see Computer Science 636

620. Smooth Manifolds. This introductory course will cover smooth manifolds, orientation, immersions, submersions, Stokes Theorem, Frobenius Theorem, Lie groups, vector bundles, Lie groups, and additional topics (such as principal bundles) as time allows. Recommended prerequisite: Mathematics 532 or equivalent. Instructor: Staff. 3 units.

621. Differential Geometry. Differentiable manifolds, fiber bundles, connections, curvature, characteristic classes, Riemannian geometry including submanifolds and variations of length integral, complex manifolds, homogeneous spaces. Prerequisite: Mathematics

532 or equivalent. Instructor: Staff. 3 units.

623. Complex Differential Geometry. This intermediate level graduate course will cover: complex manifolds; complex differential calculus; holomorphic forms and vector fields; complex and holomorphic vector bundles; the Chern connection; Hermitian and Kahler manifolds; the curvature tensor of Kahler metrics; Hodge and Dolbeault theory on Kahler manifolds; cohomology of Kahler manifolds; vanishing results in Kahler geometry via Weitzenbock techniques; Ricci curvature of Kahler manifolds. Additional topics (such as statement and proof of the Calabi conjecture, Kodaira embedding) as time allows. Recommended prerequisite: Mathematics 532 or equivalent, Mathematics 620, and Mathematics 621. Instructor: Staff. 3 units.

625. Riemann Surfaces. Compact Riemann Surfaces, maps to projective space, Riemann-Roch Theorem, Serre duality, Hurwitz formula, Hodge theory in dimension one, Jacobians, the Abel-Jacobi map, sheaves, Cech cohomology. Prerequisite: Mathematics 633 and Mathematics 611 or consent of instructor. Instructor: Staff. 3 units.

627. Algebraic Geometry. Projective varieties, morphisms, rational maps, sheaves, divisors, sheaf cohomology, resolution of singularities. Prerequisite: Mathematics 602 and 625; or consent of instructor advised. Instructor: Staff. 3 units.

631. Measure and Integration. Lebesgue measure and integration; Lp spaces; absolute continuity; abstract measure theory; Radon-Nikodym Theorem; connection with probability; Fourier series and integrals. Recommended prerequisite: Mathematics 531 and 532 or equivalent. Instructor: Staff. 3 units.

633. Complex Analysis. Complex calculus, conformal mapping, Riemann mapping theorem, Riemann surfaces. Prerequisite: Mathematics 532 or equivalent. Instructor: Staff. 3 units.

635. Functional Analysis. Metric spaces, fixed point theorems, Baire category theorem, Banach spaces, fundamental theorems of functional analysis, Fourier transform. Prerequisite: Mathematics 631 or equivalent. Instructor: Staff. 3 units.

636. Analytic Number Theory. Dirichlet series, the Riemann zeta function and L-functions, solutions to Diophantine equations, the circle method, exponential sums and character sums. Additional topics may include prime number theorems, sieve methods, connections to harmonic analysis, and automorphic forms. Prerequisite: 333, 531 and 502 or equivalent, or permission of instructor. Instructor: Staff. 3 units.

641. Probability. Designed to be a sequel to Statistical Science 711. The basic five topics are: martingales, Markov chains from an advanced viewpoint, ergodic theory, Brownian motion and its applications to random walks, Donsker's theorem and the law of the iterated logarithm, and multidimensional Brownian motion, connection to PDE's. For those who have not had 711, we will prove the law of large numbers using martingales and obtain versions of the central limit theorem from Donsker's theorem. Course requires a knowledge of meaure theory. Prerequisite: Statistical Science 711 or Mathematics 631. Instructor: Staff. 3 units.

651. Hyperbolic Partial Differential Equations. Linear wave motion, dispersion, stationary phase, foundations of continuum mechanics, characteristics, linear hyperbolic systems, and nonlinear conservation laws. Prerequisite: Mathematics 557 or equivalent. Instructor: Staff. 3 units.

653. Elliptic Partial Differential Equations. Fourier transforms, distributions, elliptic equations, singular integrals, layer potentials, Sobolev spaces, regularity of elliptic boundary value problems. Prerequisite: Mathematics 557 and 631 or equivalent. Instructor: Staff. 3 units.

660. Numerical Partial Differential Equations. Introduction to important classes of numerical methods for partial differential equations, notably finite difference and finite element methods. Emphasis on a solid understanding of the accuracy of these methods, with a view toward the interplay between theory and practice. Topics may include finite difference and finite element methods for elliptic equations; finite difference methods for parabolic equations; and numerical methods for hyperbolic equations and conservation laws. Prerequisite: Mathematics 561, 563, or consent of instructor. Instructor: Staff. 3 units.

661. Numerical Solution of Hyperbolic Partial Differential Equations. Numerical solution of hyperbolic conservation laws. Conservative difference schemes, modified equation analysis and Fourier analysis, Lax-Wendroff process. Gas dynamics and Riemann problems. Upwind schemes for hyperbolic systems. Nonlinear stability, monotonicity and entropy; TVD, MUSCL, and ENO schemes for scalar laws. Approximate Riemann solvers and schemes for hyperbolic systems. Multidimensional schemes. Adaptive mesh refinement. Prerequisite: Mathematics 561, 563, or consent of instructor. Instructor: Staff. 3 units.

663. Numerical Solution of Elliptic and Parabolic Partial Differential Equations. Numerical solution of parabolic and elliptic equations. Diffusion equations and stiffness, finite difference methods and operator splitting (ADI). Convection-diffusion equations. Finite element methods for elliptic equations. Conforming elements, nodal basis functions, finite element matrix assembly and numerical quadrature. Iterative linear algebra; conjugate gradients, Gauss-Seidel, incomplete factorizations and multigrid. Mixed and hybrid methods. Mortar elements. Reaction-diffusion problems, localized phenomena, and adaptive mesh refinement. Prerequisite: Mathematics 561, 563, or consent of instructor. Instructor: Staff. 3 units.

690-00. Topics in Algebraic Geometry. Schemes, intersection theory, deformation theory, moduli, classification of varieties, variation of Hodge structure, Calabi-Yau manifolds, or arithmetic algebraic geometry. Prerequisite: Mathematics 627 or consent of instructor. Instructor: Staff. 3 units.

690-05. Topics in Number Theory. A selection of topics from algebraic number theory, arithmetic geometry, automorphic forms, analytic number theory, etc. Instructor: Staff. 3 units.

690-10. Topics in Topology. Algebraic, geometric, or differential topology. Consent of instructor required. Instructor: Staff. 3 units.

690-20. Topics in Differential Geometry. Lie groups and related topics, Hodge theory, index theory, minimal surfaces, Yang-Mills fields, exterior differential systems, harmonic maps, symplectic geometry. Prerequisite: Mathematics 621 or consent of instructor. Instructor: Staff. 3 units.

690-30. Topics in Complex Analysis. Geometric function theory, function algebras, several complex variables, uniformization, or

analytic number theory. Prerequisite: Mathematics 633 or equivalent. Instructor: Staff. 3 units.

690-32. Topics in Analysis. Topics in analysis geared towards topics of current research interest. The prerequisites will depend on the specific topic covered. Instructor: Staff. 3 units.

690-40. Topics in Probability Theory. Probability tools and theory, geared towards topics of current research interest. Possible additional prerequisites based on course content in a particular semester. Prerequisites: Mathematics 230 or 340 or equivalent, and consent of instructor. Instructor: Staff. 3 units. C-L: Statistical Science 690-40

690-50. Topics in Partial Differential Equations. Hyperbolic conservation laws, pseudo-differential operators, variational inequalities, theoretical continuum mechanics. Prerequisite: Mathematics 651 or equivalent. Instructor: Staff. 3 units.

690-70. Topics in Applied Mathematics. An advanced course in areas of applied mathematics. Topics vary by semester. Instructor: Staff. 3 units.

690-82. Topics in Mathematical Finance. Topics of current research interest in mathematical models with relevant applications to finance. Prerequisites: Mathematics 230 or 340 or equivalent, or consent of instructor. Possible additional prerequisites depending on course content. Instructor: Staff. 3 units. C-L: Economics 690-82

701. Introduction to Abstract Algebra. Groups, rings, and fields. An assignment will ask the student to relate this course to their research. Instructor: Staff. 3 units.

703. Advanced Linear Algebra. Topics in linear algebra beyond those in a first course. For example: principal component analysis and other decompositions (singular value, Cholesky, etc.); Perron-Frobenius theory; positive semi-definite matrices; linear programming and more general convexity and optimization; basic simplicial topology; Gerschgorin theory; classical matrix groups. Applications to computer science, statistics, image processing, economics, or other fields of mathematics and science. An assignment will ask the student to relate this course to their research. Instructor: Staff. 3 units.

711. Topology. Elementary topology, surfaces, covering spaces, Euler characteristic, fundamental group, homology theory, exact sequences. An assignment will ask the student to relate this course to their research. Instructor: Staff. 3 units.

712. Multivariable Calculus. Partial differentiation, multiple integrals, and topics in differential and integral vector calculus, including Green's theorem, the divergence theorem, and Stokes's theorem. An assignment will ask the student to relate this course to their research. Instructor: Staff. 3 units.

712D. Multivariable Calculus. Partial differentiation, multiple integrals, and topics in differential and integral vector calculus, including Green's theorem, the divergence theorem, and Stokes's theorem. An assignment will ask the student to relate this course to their research. Instructor: Staff. 3 units.

713. Topological Data Analysis. Introduction to topology from a computational view-point, with a focus on applications. Themes include: basic notions of point-set topology, persistent homology, finding multi-scale topological structure in point cloud data. Algorithmic considerations emphasized. An assignment will ask the student to relate this course to their research. Instructor: Staff. 3 units.

716. Linear Algebra and Differential Equations. Systems of linear equations, matrix operations, vector spaces, linear transformations, orthogonality, determinants, eigenvalues and eigenvectors, diagonalization, linear differential equations, systems of differential equations with constant coefficients, applications, computer simulations. Systems of linear equations, matrix operations, vector spaces, linear transformations, orthogonality, determinants, eigenvalues and eigenvectors, diagonalization, linear differential equations, systems of differential equations with constant coefficients, applications, computer simulations. An assignment will ask the student to relate this course to their research. Intended primarily for engineering students. Instructor: Staff. 3 units.

718. Matrices and Vector Spaces. Solving systems of linear equations, matrix factorizations and fundamental vector subspaces, orthogonality, least squares problems, eigenvalues and eigenvectors, the singular value decomposition and principal component analysis, applications to data-driven problems. An assignment will ask the student to relate this course to their research. Instructor: Staff. 3 units.

718D. Matrices and Vector Spaces. Solving systems of linear equations, matrix factorizations and fundamental vector subspaces, orthogonality, least squares problems, eigenvalues and eigenvectors, the singular value decomposition and principal component analysis, applications to data-driven problems. An assignment will ask the student to relate this course to their research. Instructor: Staff. 3 units.

721. Linear Algebra and Applications. Systems of linear equations and elementary row operations, Euclidean n-space and subspaces, linear transformations and matrix representations, Gram-Schmidt orthogonalization process, determinants, eigenvectors and eigenvalues; applications. Introduction to proofs. A gateway to more advanced math courses. An assignment will ask the student to relate this course to their research. Instructor: Staff. 3 units.

721D. Linear Algebra and Applications. Systems of linear equations and elementary row operations, Euclidean n-space and subspaces, linear transformations and matrix representations, Gram-Schmidt orthogonalization process, determinants, eigenvectors and eigenvalues; applications. Introduction to proofs. A gateway to more advanced math courses. An assignment will ask the student to relate this course to their research. Instructor: Staff. 3 units.

730. Probability. Probability models, random variables with discrete and continuous distributions. Independence, joint distributions, conditional distributions. Expectations, functions of random variables, central limit theorem. An assignment will ask the student to relate this course to their research. Instructor: Staff. 3 units.

731. Introduction to Real Analysis. Algebraic and topological structure of the real number system; rigorous development of one-variable calculus including continuous, differentiable, and Riemann integrable functions and the Fundamental Theorem of Calculus; uniform convergence of a sequence of functions; contributions of Newton, Leibniz, Cauchy, Riemann, and Weierstrass. An assignment

will ask the student to relate this course to their research. Instructor: Staff. 3 units.

733. Complex Analysis. Complex numbers, analytic functions, complex integration, Taylor and Laurent series, theory of residues, argument and maximum principles, conformal mapping. An assignment will ask the student to relate this course to their research. Instructor consent required. Instructor: Staff. 3 units.

740. Advanced Introduction to Probability. Advanced introduction to basic, non-measure theoretic probability covering topics in more depth and with more rigor than MATH 730. Topics include random variables with discrete and continuous distributions. Independence, joint distributions, conditional distributions, generating functions, Bayes' formula, and Markov chains. Rigorous arguments are presented for the law of large numbers, central limit theorem, and Poisson limit theorems. An assignment will ask the student to relate this course to their research. Instructor: Staff. 3 units.

742. Stochastic Models. 3 units. C-L: see Business Administration 915; also C-L: Statistical Science 715

743L. Linear Models. 3 units. C-L: see Statistical Science 721L

751S. Nonlinear Ordinary Differential Equations. Theory and applications of systems of nonlinear ordinary differential equations. Topics may include qualitative behavior, numerical experiments, oscillations, bifurcations, deterministic chaos, fractal dimension of attracting sets, delay differential equations, and applications to the biological and physical sciences. Research project and paper required. An assignment will ask the student to relate this course to their research. Instructor: Staff. 3 units.

753. Ordinary and Partial Differential Equations. First and second order ordinary differential equations with applications, Laplace transforms, series solutions and qualitative behavior, Fourier series, partial differential equations, boundary value problems, Sturm-Liouville theory. Intended primarily for engineering and science students. An assignment will ask the student to relate this course to their research. Instructor: Staff. 3 units.

754. Introduction to Partial Differential Equations. Heat, wave, and potential equations: scientific context, derivation, techniques of solution, and qualitative properties. Topics to include Fourier series and transforms, eigenvalue problems, maximum principles, Green's functions, and characteristics. Intended primarily for mathematics majors and those with similar backgrounds. An assignment will ask the student to relate this course to their research. Instructor: Staff. 3 units.

756. Elementary Differential Equations. First and second order differential equations with applications; linear systems of differential equations; Fourier series and applications to partial differential equations. Additional topics may include stability, nonlinear systems, bifurcations, or numerical methods. An assignment will ask the student to relate this course to their research. Instructor: Staff. 3 units.

757. Introduction to Linear Programming and Game Theory. Fundamental properties of linear programs; linear inequalities and convex sets; primal simplex method, duality; integer programming; two-person and matrix games. An assignment will ask the student to relate this course to their research. Instructor: Staff. 3 units.

765. Introduction to High Dimensional Data Analysis. Geometry of high dimensional data sets. Linear dimension reduction, principal component analysis, kernel methods. Nonlinear dimension reduction, manifold models. Graphs. Random walks on graphs, diffusions, page rank. Clustering, classification and regression in high-dimensions. Sparsity. Computational aspects, randomized algorithms. An assignment will ask the student to relate this course to their research. Instructor: Staff. 3 units.

766. Mathematics of Machine Learning. The course will explore mathematics underlying the practice and theory of various machine learning concepts and algorithms. Kernel methods, deep learning, reinforcement learning, generalization error, stochastic gradient descent, and dimension reduction or data embeddings will be introduced. The interplay between the mathematics and real applications will be an component of the course. Students can take both this course and Math 465/765 for credit. An assignment will be given asking the students to relate the material in this course to their research. Recommended prerequisite: Mathematics 230/340 and 218/216/221 and some familiarity with programming, preferably Python. Instructor: Staff. 3 units.

771S. Teaching College Mathematics. This course is designed for first year mathematics graduate students as preparation for teaching as graduate students at Duke and as professors, once they graduate. Topics include lesson planning, overview of the content in calculus courses, current issues in undergraduate mathematics education, writing and grading tests, evaluating teaching and practice teaching. Consent of instructor required. Instructor: Staff. 1 unit.

790-01. Current Research in Algebra. Not open to students who have taken Mathematics 790-10 and 790-20. Instructor: Staff. 3 units.

790-03. Research in Algebraic Geometry. Mini seminars on current topics which are repeatable for credit. Instructor: Staff. 1 unit.

790-10. Current Research in Topology. Not open to students who have taken Mathematics 790-03 and 790-73. Instructor: Staff. 3 units.

790-20. Current Research in Differential Geometry. Instructor: Staff. 3 units.

790-30. Current Research in Analysis. Not open to students who have taken Mathematics 790-50 and 790-71. Instructor: Staff. 3 units.

790-50. Research in Differential Equations. Mini seminars on current topics which are repeatable for credit. Instructor: Staff. 1 unit.

790-71. Current Research in Applied Mathematics. Instructor: Staff. 3 units.

790-73. Current Research in Mathematical Physics. Not open to students who have taken Mathematics 790-77. Instructor: Staff. 3 units.

790-77. Current Research in Mathematical Biology. This course will consist of three minicourses, each of which presents current

research in an area of mathematical biology. Different topics will be covered in different years and students may re-take the course. Topics will be drawn from: probability theory and genomics, mathematical methods in biochemistry and cell biology, applications of topology and geometry to genomics and protein folding, heart physiology and mathematical issues in cardiac arrhythmias, biofluid mechanics, mathematical methods in kidney function, mathematical questions in image reconstruction, analysis of large data sets, and the evolution of viruses. 1 unit.

790-90. Minicourse in Advanced Topics. Mini seminars on current topics which are repeatable for credit. Instructor: Staff. 1 unit.

790-92. Foundational Minicourses on Topics in Math for Graduate Students. Minicourses introducing various math topics for graduate students outside of math. Topics include differential calculus, integral calculus, multivariable calculus, linear algebra, discrete probability, and matrix decompositions and data. Instructor: Staff. 1 unit.

790-95. Advanced Topics in Mathematics. Advanced Topics in Mathematics. The content of this course will vary. An assignment or assignments will have the graduate student relate this course to their research. Instructor: Staff. 3 units.

895. Internship. Student gains practical experience related to applications of mathematics by taking a job in industry, and after the experience writes a report about this experience. Requires prior consent from the student's advisor and from the director of graduate studies. May be repeated with consent of the advisor and the director of graduate studies. Credit/no credit grading only. Instructor: Staff. 1 unit.

Medical Physics

Professor Samei, *Director*; Associate Professor Kapadia, *Director of Graduate Studies*; Professors C. Badea, Bowsher, Dewhirst, Dobbins, Driehuys, Howell, Izatt, Johnson, Kirkpatrick, Koweek, Lo, Nightingale, Oldham, Petrella, Provenzale, Samei, Allen Song, Spicer, Trahey, Vaidyanathan, Warren, Wax, Jackie Wu, Qiuwen Wu, Yin, and Yoshizumi; Associate Professors Adamson, A. Badea, Chang, Charles, Chitneni, Craciunescu, Floyd, Hoang, Kapadia, Mazurowski, Palmer, Petry, Reiman, Ren, Segars, Tornai, Truong, Turkington, Wang, and Yoo; Assistant Professors Cui, Greenberg, O'Daniel, and Haijun Song; Accelerator Health Physicist Gunasingha; Radiation Physicists A. Ding, J. Solomon, J. Wells, and J. Wilson; Medical Instructor Dean Darnell

A master's degree and a PhD are available in this program.

Medical physics is a field that applies principles of physics to the clinical needs of medicine and healthcare. It has been instrumental in the development of the medical fields of radiology, radiation oncology, and nuclear medicine. The Medical Physics Program offers an MS and a PhD, and is organized into four academic tracks: diagnostic imaging physics, radiation oncology physics, nuclear medicine physics, and medical health physics. Graduates are trained for employment opportunities in academic settings, clinical service, industry, government labs, and consulting. The Medical Physics Program is a collaborative interdisciplinary program with faculty drawn from the Departments of Radiology, Radiation Oncology, Occupational and Environmental Safety (health physics), Biomedical Engineering, and Physics. Current research interests of the faculty include (among others) magnetic resonance imaging and microscopy, advanced digital imaging instrumentation and algorithms, detector and display characterization, computer-aided diagnosis, ultrasound, monoclonal antibody imaging and therapy, intensity modulated radiation therapy, on-board imaging in radiation therapy, SPECT and PET imaging, neutron and X-ray scatter imaging, radiomics and big-data, machine-learning, and dosimetry. All students take core courses in the first year, followed by concentration in a major track of study, including practical clinical training and more advanced didactic courses. PhD students pursue substantial dissertation research, and MS students pursue either a thesis option or a scholarship project during their two years. The program is accredited by the Council on Accreditation of Medical Physics Educational Programs (CAMPEP).

Courses in Medical Physics (MEDPHY)

500. Radiation Physics. A course covering the basics of ionizing and non-ionizing radiation, atomic and nuclear structure, basic nuclear and atomic physics, radioactive decay, interaction of radiation with matter, and radiation detection and dosimetry. Consent of instructor required. Instructor: Turkington. 3 units.

500K. Radiation Physics. A course covering the basics of ionizing and non-ionizing radiation, atomic and nuclear structure, basic nuclear and atomic physics, radioactive decay, interaction of radiation with matter, and radiation detection and dosimetry. Instructor consent required. Taught at Duke Kunshan University. Instructor: Huang. 3 units.

505. Anatomy and Physiology for Medical Physicists. A course focused on medical terminology, biochemistry pertaining to MP, basic Anatomy and physiology, elementary tumor and cancer biology, and overview of disease in general. Upon completion, the student should: (a) understand anatomic structures, their relationships, their cross-sectional and planar projections, and how they are modified by attenuation and artifacts in the final images; (b) understand the physiology underlying radionuclide images, (c) understand how (a) - (b) are modified by disease, (d) identify anatomical entities in medical images (different modalities), and (e) identify basic features in medical images (e.g., Pneumothrax in chest radiographs, microcalcoifications in mammograms). Consent of instructor required. Instructor: Reiman. 3 units.

505K. Anatomy and Physiology for Medical Physicists. A course focused on medical terminology, biochemistry pertaining to MP, basic Anatomy and physiology, elementary tumor and cancer biology, and overview of disease in general. Upon completion, the student should: (a) understand anatomic structures, their relationships, their cross-sectional and planar projections, and how they are modified by attenuation and artifacts in the final images; (b) understand the physiology underlying radionuclide images, (c) understand how (a) - (b) are modified by disease, (d) identify anatomical entities in medical images (different modalities), and (e) identify basic features in medical images. Instructor consent required. Taught at Duke Kunshan University. Instructor: McClearn. 3 units.

507. Radiation Biology. An introduction to radiation biology. This course will cover the biological effects of radiation, including mechanisms of DNA damage, and normal tissue injury. The principle context is with relevance to radiation therapy treatment. Instructor consent required. Instructor: Dewhirst, Palmer. 1 unit.

507K. Radiation Biology. An introduction to radiation biology. This course will cover the biological effects of radiation, including

mechanisms of DNA damage, and normal tissue injury. The principle context is with relevance to radiation therapy treatment. Taught at Duke Kunshan University. Instructor: Li, Zheng. 1 unit.

510. Radiation Protection. Course discusses the principles of radiation protection dealing with major forms of ionizing and non-ionizing radiation, the physics and chemistry of radiation biology, biological effects of ionizing and non-ionizing radiations (lasers, etc.) at cellular and tissue levels, radiation protection quantities and units, medical HP issues in clinical environments, radiation safety regulations, and basic problem solving in radiation safety. Consent of instructor required. Instructor: Yoshizumi. 3 units.

510K. Radiation Protection. Course discusses the principles of radiation protection dealing with major forms of ionizing and non-ionizing radiation, the physics and chemistry of radiation biology, biological effects of ionizing and non-ionizing radiations (lasers, etc.) at cellular and tissue levels, radiation protection quantities and units, medical HP issues in clinical environments, radiation safety regulations, and basic problem solving in radiation safety. Consent of instructor required. Taught at Duke-Kunshan-University. Instructor: Huang. 3 units.

520. Radiation Therapy Physics. This introductory course has a clinical orientation, and reviews the rationale, basic science, methods, instrumentation, techniques and applications of radiation therapy to the treatment of a wide range of human diseases. Major radiation modalities are covered including low and high energy photon therapy, electron and proton therapy, and low and high-dose rate brachytherapy. The clinical process of treatment, methods of calculating dose to patient, and the role of the medical physicist in radiation oncology clinic, are covered in detail. Consent of instructor required. Instructor: Oldham, Adamson. 3 units.

520K. Radiation Therapy Physics. This introductory course has a clinical orientation, and reviews the rationale, basic science, methods, instrumentation, techniques and applications of radiation therapy to the treatment of a wide range of human diseases. Major radiation modalities are covered including low and high energy photon therapy, electron and proton therapy, and low and high-dose rate brachytherapy. The clinical process of treatment, methods of calculating dose to patient, and the role of the medical physicist in radiation oncology clinic, are covered in detail. Consent of instructor required. Taught at Duke-Kunshan-University. Instructor: Huang. 3 units.

530. Modern Medical Diagnostic Imaging System. This course covers the mathematics, physics and instrumentation of several modern medical imaging modalities starting with a review of applicable linear systems theory and relevant principles of physics. Modalities studied include X-ray radiography (film-screen and electronic), computerized tomography, ultrasound and nuclear magnetic resonance imaging. Consent of instructor required. Instructor: Solomon. 3 units.

530K. Modern Diagnostic Imaging Systems. This course covers the mathematics, physics and instrumentation of several modern medical imaging modalities starting with a review of applicable linear systems theory and relevant principles of physics. Modalities studied include X-ray radiography (film-screen and electronic), computerized tomography, ultrasound and nuclear magnetic resonance imaging. Consent of instructor required. Taught at Duke-Kunshan-University. Instructor: Bowsher. 3 units.

541K. Nuclear Medicine Physics. This course addresses the role of physics in nuclear medicine, particularly with regard to single-photon-emission and positron-emission imaging. Course topics include (i) relevant basic physics, such as radioactive decay and the interaction of radiation with matter, (ii) instrumentation methods for single-photon-emission and positron-emission imaging, (iii) tomographic acquisition and image reconstruction, and (iv) quantitative analysis of images. The course will be taught at Duke Kunshan University and covers the same topics as the Nuclear Medicine Physics course (MPH 541) taught at Duke University. Instructor consent required. Instructor: Bowsher. 3 units.

714. Clinical Dosimetry Measurements. This course covers advanced topics in clinical radiation dosimetry that is pertinent to both KV and MV energy range. Recommended prerequisite: Medical Physics 500 and 505. Instructor: Yoshizumi. Variable credit.

715. Advanced Topics in Radiation Detection and Dosimetry. This series of lectures covers the topics in radiation detectors, measurements and signal processing. The basics of various types of radiation detectors used in nuclear, medical and health physics and their usage are discussed in detail. Prerequisites: Medical Physics 500 and 505. Instructor: Gunasingha. 1 unit.

718. Clinical Practicum and Shadowing (Medical Health Physics). This practicum course provides hands-on experiences in various hospital health physics functions, in RAM lab oversight, in X-Ray room shielding and verification, and in license preparation experience under NRC/States oversight. The course includes shadowing a clinician, technologist, and physicist, while performing their routine clinical tasks. Instructor: Yoshizumi. 3 units.

721. Stereotactic Radiosurgery (SRS) and Stereotactic Body Radiation Therapy (SBRT). This course covers advanced clinical applications of Stereotactic Radiosurgery (SRS) and Stereotactic Body Radiation Therapy (SBRT) in the treatment of cancers. Instructor consent required. Prerequisite: Medical Physics 520. Instructor: Yin. 3 units.

722. Advanced Photon Beam Radiation Therapy. This course will cover the physics and clinical application of advanced external beam photon therapies with special emphasis on IMRT. Prerequisite: Medical Physics 520. Instructor: Qiuwen Wu. 3 units.

722K. Advanced Photon Beam Radiation Therapy. This course will cover the physics and clinical application of advanced external beam photon therapies with special emphasis on IMRT. Taught at Duke Kunshan University. Prerequisite: Medical Physics 520K. Instructor: Wu. 3 units.

723. Advanced Radiation Therapy Topics and Procedures. The first section, Clinical Dosimetry and Commissioning, is focused on clinical dosimetry, patient treatment related measurement and clinical calibration, quality assurance, and commissioning. In the second section, Advanced Procedures for SRS/SBRT, technical procedures and methodology for imaging, image guidance, motion management, image fusion, delivery technologies, treatment adaptation, dose verification, quality assurance, and treatment assessment related to stereotactic radiosurgery (SRS) and stereotactic body radiation therapy (SBRT) will be introduced. Open only to Medical Physics master's and PhD students. Instructor consent required. Instructor: Chang, Rodrigues, Yin, Wu. 1 unit.

723K. Advanced Brachtherapy / Special Topics and Procedures. Covers advanced treatment procedures including image-guided radiation therapy as well as its application in stereotactic radiation therapy and stereotactic radiosurgery. Instructor consent

required. Open to graduate students at Duke Kunshan University. Instructor: Yin. Variable credit.

724. Clinical Dosimetry and Commissioning. This course is designed to combine traditional lectures and clinical physics practicum on the topic of clinical dosimetry. Students will understand and learn patient treatment related measurement and clinical calibration, quality assurance, and commissioning. Instructor consent required. Prerequisite: Medical Physics 520. Instructor: Chang. 3 units.

725. Physics and Clinical Applications of Brachytherapy. The course is designed to combine traditional lectures and clinical physics practicum on the topic of LDR (low dose rate) and HDR (high dose rate) brachytherapy. Instructor consent required. Prerequisite: Medical Physics 520. Instructor: Craciunescu, Meltsner. 2 units.

726. Practicum on Monte Carlo Methods in Medical Physics. This course focuses on the fundamentals of Monte-Carlo simulations and provides hands-on experience with clinical Monte-Carlo codes used in medical dosimetry. The course will introduce software such as MCNP, EGS, FLUKA, GEANT and Penelope and companion data analysis software ROOT, PAW and CERNLIB. Students will study at least one major code and will perform two or more projects based on a clinically relevant task. Prerequisites: Calculus, modern physics, and programming. Knowledge of C, C++, or Fortran is a plus. Instructors: Gunasingha, H. Song, A. Kapadia. Variable credit.

726K. Practicum on Monte Carlo Methods in Medical Physics. This course focuses on the fundamentals of Monte-Carlo simulations and provides hands-on experience with clinical Monte-Carlo codes used in medical dosimetry. The course will introduce software such as MCNP, EGS, FLUKA, GEANT and Penelope and companion data analysis software ROOT, PAW and CERNLIB. Students will study at least one major code and will perform two or more projects based on a clinically relevant task. Prerequisites: Calculus, modern physics, and programming. Knowledge of C, C++, or Fortran would be a plus. Consent of instructor required. Taught at Duke Kunshan University. Instructors: Gunasingha, H. Song, A. Kapadia. Variable credit.

728. Clinical Practicum and Shadowing (RT). The course gives hands on experience in practical aspects of medical physics as applied to radiation therapy. Special emphasis is given to the operation of various therapy units and dose measuring devices, techniques of measuring the characteristics of radiation beams, commissioning and quality assurance checks for radiation producing devices in the clinic. The course includes shadowing a clinician, technologist, or physicist, while performing their routine clinical tasks. Consent of instructor required. Instructor: Wang. 3 units.

729. Medical Physics Clinical Internship. The course offers an internship opportunity to students who wish to gain a more hands-on, practical experience in clinical aspects of the practice of medical physics. The internship will be conducted in a clinical facility under the supervision of a clinical a medical physicist. Instructor: Yin. 10 units.

731K. Advanced Medical Imaging Physics. The course includes advanced topics in diagnostic imaging including linear system theory, image quality metrology, digital radiography and mammography, new advances on three-dimensional imaging modalities, MRI, CT, ultrasound, and evaluation of diagnostic imaging methods. Prerequisite: Medical Physics 530K. Taught at Duke Kunshan University. Instructor: Dobbins. 3 units.

732. Advanced Topics of Ionizing-based Imaging Modalities. This course covers advanced topics in ionizing-based imaging modalities such as X-ray and CT imaging, including linear system theory, image quality metrology, digital radiography and mammography. Instruction will consist of didactic lectures accompanied by hands-on laboratory exercises (practicum). Instructor: Dobbins, Badea. 3 units.

733. Clinical Practicum and Shadowing (Diagnostic Imaging). Review and real-life exercises on principles of modern medical imaging systems with emphasis on the engineering and medical physics aspects of image acquisition, reconstruction and visualization, observations of imaging procedures in near clinical settings, and hands-on experience with the instruments. Modalities covered include ultrasound, CT, MRI, nuclear medicine and optical imaging. Medical Physics students will substitute X-ray imaging for the Nuclear imaging module. Prerequisite: Biomedical Engineering 846, Medical Physics 530 or equivalent. Instructor: Samei. 3 units.

733K. Clinical Practicum and Shadowing (Diagnostic Imaging). Review and real-life exercises on principles of modern medical imaging systems with emphasis on the engineering and medical physics aspects of image acquisition, reconstruction and visualization, observations of imaging procedures in near clinical settings, and hands-on experience with the instruments. Modalities covered include ultrasound, X-ray, CT, and MRI. Offered at Duke Kunshan University. Prerequisite: Medical Physics 530K or equivalent. Instructor: Samei. 3 units.

734. Advanced Topics of Non-ionizing-based Imaging Modalities. This course covers advanced topics in non-ionizing Imaging modalities such as Ultrasound and MR imaging, including speckle statistics, Doppler imaging, advanced MR pulse sequences, MR angiography, flow and diffusion etc. Instruction will consist of didactic lectures accompanied by hands-on laboratory exercises (practicum). Instructor: Robertson. 3 units.

734K. Advanced Topics of Non-ionizing-based Imaging Modalities. This course covers advanced topics in non-ionizing Imaging modalities such as Ultrasound and MR imaging, including speckle statistics, Doppler imaging, advanced MR pulse sequences, MR angiography, flow and diffusion etc. Instruction will consist of didactic lectures accompanied by hands-on laboratory exercises (practicum). Offered at Duke Kunshan University. Instructor consent required. Instructor: Robertson. 3 units.

738. Radiology in Practice. 3 units. C-L: see Biomedical Engineering 848L

743. Basic Concepts of Internal Radiation Dosimetry. This course covers the physical and anatomical/physiological foundations of internal radiation dosimetry. Topics covered include definition of dose, absorbed fractions, residence times and methods to determine them, and the MIRD methodology. Strategies to convert small animal radiopharmaceutical biodistribution data to humans will also be covered. Prerequisites: Medical Physics 500 and 505. Instructor: Reiman. 1 unit.

744. PET and SPECT Image Reconstruction and Analysis. This course will cover the basics of image reconstruction for tomographic imaging in nuclear medicine. Filtered backprojection and iterative methods will be explored, including methods for

correcting physical effects such as attenuation and scatter. Basic concepts of image quality and quantitative use of PET and SPECT image will introduced. Prerequisite: Medical Physics 541. Instructor: Tornai. 1 unit.

745. Advanced Topics in Nuclear Medicine. This course covers advanced topics in radionuclide-based imaging modalities such as PET and SPECT, including image acquisition, image reconstruction, detector and detection theory, radionuclides, etc. and therapeutic applications of radionuclides. Instruction will consist of didactic lectures accompanied by hands-on laboratory exercises (practicum). Instructor: Turkington, Tornai. 3 units.

746. Radiopharmaceutical Chemistry. The course will cover radiochemistry and production of various radiopharmaceuticals. The course will be conducted with lecture but may include some practical demonstrations. Prerequisite: Medical Physics 500 and 505. Instructor: Vaidyanathan. 1 unit.

749K. Clinical Practicum and Shadowing (Nuclear Medicine). The course gives hands on experience in clinical nuclear medicine. It covers topics drawn from gamma cameras, PET systems, surgical probes, dose calibrators, technetium generators, and well counters, and it is aimed at learning operation principles, calibration, and quality control methods. Depending on the number of credit hours, students will spend time in some or all of the following: the PET facility, nuclear cardiology, nuclear medicine, and the radiopharmacy, and the course may include shadowing a clinician, technologist, or physicist while performing. Taught at Duke Kunshan University. Instructor: Turkington. Variable credit.

751-1. Medical Physics Basic Research Topics. This seminar provides an overview of research projects conducted by medical physics faculty through a series of invited talks. The aim of the seminar is to help first year students identify their research interests and career/training orientation. Instructor consent is required. Instructor: Kapadia. 1 unit.

751-2. Academic Development Skills for Medical Physicists. This seminar prepares students for academic and research work through a series of presentations on academic skills that include literature reading, scientific writing and presentation, maintaining scientific records, etc. Instructor consent is required. Instructor: Kapadia. 1 unit.

751-3. Professional Development Skills for Medical Physicists. This seminar provides important skills for students' professional development through a series of presentations on relevant topics that include public speaking, effective scientific and professional communication, interviewing skills, entrepreneurship, etc. Designed for second year Medical Physics students. Instructor consent is required. Instructor: Wilson. 1 unit.

751-3K. Professional Development Skills for Medical Physicists. This seminar provides important skills for students' professional development through a series of presentations on relevant topics that include public speaking, effective scientific and professional communication, interviewing skills, entrepreneurship, etc. Designed for second year Medical Physics students. Taught at Duke Kunshan University. Instructor: Wilson. 1 unit.

751-4. Frontiers of Biomedical Science. This seminar provides a series of presentations on cutting-edge / frontier research topics in the field of medical physics, focusing on the most state-of-the-art medical physics techniques and their clinical applications. Designed for second year Medical Physics students. Instructor consent is required. Instructor: Tornai. 1 unit.

751K. Seminars in Medical Physics. Medical physics is the application of the concepts and methods of physics and engineering to the diagnosis and treatment of human disease. This course consists of weekly lectures covering broad topics in medical physics including diagnostic imaging, radiation oncology, radiation safety, and nuclear medicine. Lectures will be given by invited speakers drawn from many university and medical center departments including Biomedical Engineering, radiology, physics, radiation safety, and radiation oncology. Prerequisites: background in engineering or physics. Instructor: Bowsher. 1 unit.

752K. Seminars in Medical Physics. Medical physics is the application of the concepts and methods of physics and engineering to the diagnosis and treatment of human disease. This course consists of weekly lectures covering broad topics in medical physics including diagnostic imaging, radiation oncology, radiation safety, and nuclear medicine. Lectures will be given by invited speakers drawn from many university and medical center departments including Biomedical Engineering, radiology, physics, radiation safety, and radiation oncology. Taught at Duke Kunshan University. Prerequisite: Background in engineering or physics. Instructor: Kapadia. 1 unit.

758. Medical Physics Practicum and Shadowing. The course gives hands on experience in practical aspects of medical physics. Special emphasis is given to the operation of various therapy units and dose measuring devices, techniques of measuring the characteristics of radiation beams, commissioning and quality assurance checks for radiation producing devices in the clinic. Diagnostic Imaging, and Nuclear Medicine, and Health Physics equipment and procedures may be included. The course includes shadowing a clinician, technologist, or physicist, while performing their routine clinical tasks. Consent of instructor required. Instructor: Yin. Variable credit.

758K. Medical Physics Practicum and Shadowing. The course gives hands on experience in practical aspects of medical physics. Special emphasis is given to the operation of various therapy units and dose measuring devices, techniques of measuring the characteristics of radiation beams, commissioning and quality assurance checks for radiation producing devices in the clinic. Diagnostic Imaging, and Nuclear Medicine, and Health Physics equipment and procedures may be included. The course includes shadowing a clinician, technologist, or physicist, while performing their routine clinical tasks. Consent of instructor required. Taught at Duke Kunshan University. Instructor: Yin. Variable credit.

761. Fundamentals of Biostatistics. The first part will introduce the basic principles of descriptive statistics, probability theory, estimation theory, correlation and regression, with applications in the biomedical field. This is a 4 week session. The second part covers inferential biostatistics. It will introduce statistical hypothesis testing and its application to group comparisons of biomedical data. This part will cover parametric and non-parametric statistical tests and the basics of ANOVA analysis. This is a 4-week session. The third part covers medical decision analysis. This section includes the study and application of decision analysis methods popular in medical decision making. This part will cover performance evaluation measures of medical diagnostic tests, strategies for combining diagnostic tests, receiver operating characteristics analysis and its variants, and cost-effectiveness analysis. This is a 5-week session. 1 course credit

each session. Repeatable for 3 total credits. Instructors: Kapadia, Mazurowski. Variable credit.

762. Data Science. This course provides an introduction to methods underlying many biomedical informatics applications including information retrieval, probability, and statistical inference, medical decision making, machine learning concepts, and algorithms with a focus on biomedical decision making and discovery. Emphasis will be placed on learning the language of biomedical informatics and the art of statistical investigation as applied in the clinical field. Consent of instructor is required. Instructor: Mazurowski. 3 units.

763. Advanced Radiation Biology in Medical Physics. This course will teach students about cutting-edge topics in the field of radiobiology that have relevance to medical physicists. The teaching will be through the format of a Journal Club. Class and group participation is required. Students will select a topic from either the reviewed manuscripts or an approved subject of their own choosing. The student will write a detailed report on this subject. Grading will be based upon quality of manuscript review presentations and the detailed final written report. Instructor consent is required. Instructor: Dewhirst, Palmer. 1 unit.

763K. Advanced Radiation Biology in Medical Physics. This course will teach students about cutting-edge topics in the field of radiobiology that have relevance to medical physicists. The teaching will be through the format of a Journal Club. Class and group participation is required. Students will select a topic from either the reviewed manuscripts or an approved subject of their own choosing. The student will write a detailed report on this subject. Grading will be based upon quality of manuscript review presentations and the detailed final written report. Instructor consent required. Taught in Durham. Instructor: Dewhirst, Palmer. 1 unit.

764. Fundamentals of Radiomics, Genomics and Informatics. "Radiomics" refers to the extraction and analysis of large amounts of advanced quantitative imaging features with high throughput from medical images obtained with computed tomography, positron emission tomography or magnetic resonance imaging. This course will introduce basic concepts of radiomics and genomics as well as their applications and future trends in ontology and big data analytics. Instructor consent is required. Instructor: Yin. Variable credit.

764K. Fundamentals of Radiomics, Genomics and Big Data Analytics. Radiomics refers to the extraction and analysis of large amounts of advanced quantitative imaging features with high throughput from medical images obtained with computed tomography, positron emission tomography or magnetic resonance imaging. Genomics refers to a branch of biotechnology concerned with applying the techniques of genetics and molecular biology to the genetic mapping and DNA sequencing of sets of genes or the complete genomes of selected organisms, with organizing of the results in databases, and with applications of the data (as in medicine or biology). This course introduces fundamentals of these concepts and their applications in big data analytics. Offered at Duke Kunshan University. Instructor consent is required. Instructor: Yin. Variable credit.

770K. Frontiers of Biomedical Science. A course covering frontier topics of biomedical science that are currently not within the domain of medical physics, but that medical physicists, nonetheless, need to have knowledge of. Topics include genomics, bioinformatics, proteomics, and others. Offered at Duke Kunshan University. Instructor: Bowsher. Variable credit.

781. Clinical Shadowing for Medical Physicists. This course provides an opportunity to shadow clinical medical physicists in a wide range of clinical tasks that include quality assurance of imaging and radiotherapy machines, treatment planning, radiation measurement, patient treatment, etc. Instructor consent is required. Instructor: Samei, Yin. 1 unit.

782. Advanced Practicum for Clinical Development in Medical Physics. This course provides an opportunity to participate in the creation of clinical learning experiences geared to individual students' needs, interests, aptitudes and desired outcomes. The student will work closely with a faculty instructor to develop a personalized project on a clinical topic. Instructor: Staff. Variable credit.

783. Advanced Practicum for Academic Development in Medical Physics. This course provides an opportunity to participate in the creation of academic learning experiences geared to individual students' needs, interests, aptitudes and desired outcomes. The student will work closely with a faculty advisor to develop a personalized project on an academic topic. Instructor consent is required. Instructor: Staff. Variable credit.

784. Advanced Practicum for Professional Development in Medical Physics. This course provides an opportunity to participate in the creation of professional experiences geared to individual students' needs, interests, aptitudes and desired outcomes. The student will work closely with a faculty instructor to develop a personalized project on a professional development topic. Instructor consent is required. Instructor: Staff. Variable credit.

790-1. Mathematical Methods Topics for Medical Physicists I. This course will provide an introduction to boundary value problems and analytical partial differential equation techniques for wave-guide geometries found in medical applications (e.g., linear accelerators). ANSYS EM simulations will be performed to generate more accurate representation of linear accelerator waveguides and how (un)charged particles behave within the conductors. Hardware demonstrations will be provided time and resources permitting. Instructor: Darnell. 2 units.

790-2. Mathematical Methods Topics for Medical Physicists II. This course will provide an introduction to complex variables and their application in scattering theory. Specifically, we will cover differential cross sections and how they are related to different observed scattering phenomena (e.g., Compton scattering). Instructor: Darnell. 1 unit.

790K. Independent Study in Medical Physics. Enables students to study medical physics topics of interest via an independent study format. Specific topic, learning objectives and study materials are developed by the student and the instructor. Offered at Duke Kunshan University. Instructor: Huang. 1 unit.

791. Independent Study in Medical Physics. An independent research project with faculty advisor. Consent of instructor required. Instructor: Staff. Variable credit.

791-1. Focused-Topic Study in Medical Physics. Independent study course. Instructor: Bowsher. Variable credit.

791K. Independent Study in Medical Physics. An independent research project with faculty advisor. Consent of instructor required. Instructor: Staff. Variable credit.

500K. Radiation Physics. A course covering the basics of ionizing and non-ionizing radiation, atomic and nuclear structure, basic nuclear and atomic physics, radioactive decay, interaction of radiation with matter, and radiation detection and dosimetry. Instructor consent required. Taught at Duke Kunshan University. Instructor: Huang. 3 units.

505K. Anatomy and Physiology for Medical Physicists. A course focused on medical terminology, biochemistry pertaining to MP, basic Anatomy and physiology, elementary tumor and cancer biology, and overview of disease in general. Upon completion, the student should: (a) understand anatomic structures, their relationships, their cross-sectional and planar projections, and how they are modified by attenuation and artifacts in the final images; (b) understand the physiology underlying radionuclide images, (c) understand how (a) - (b) are modified by disease, (d) identify anatomical entities in medical images (different modalities), and (e) identify basic features in medical images. Instructor consent required. Taught at Duke Kunshan University. Instructor: McClearn. 3 units.

507K. Radiation Biology. An introduction to radiation biology. This course will cover the biological effects of radiation, including mechanisms of DNA damage, and normal tissue injury. The principle context is with relevance to radiation therapy treatment. Taught at Duke Kunshan University. Instructor: Li, Zheng. 1 unit.

510K. Radiation Protection. Course discusses the principles of radiation protection dealing with major forms of ionizing and non-ionizing radiation, the physics and chemistry of radiation biology, biological effects of ionizing and non-ionizing radiations (lasers, etc.) at cellular and tissue levels, radiation protection quantities and units, medical HP issues in clinical environments, radiation safety regulations, and basic problem solving in radiation safety. Consent of instructor required. Taught at Duke-Kunshan-University. Instructor: Huang. 3 units.

520K. Radiation Therapy Physics. This introductory course has a clinical orientation, and reviews the rationale, basic science, methods, instrumentation, techniques and applications of radiation therapy to the treatment of a wide range of human diseases. Major radiation modalities are covered including low and high energy photon therapy, electron and proton therapy, and low and high-dose rate brachytherapy. The clinical process of treatment, methods of calculating dose to patient, and the role of the medical physicist in radiation oncology clinic, are covered in detail. Consent of instructor required. Taught at Duke-Kunshan-University. Instructor: Huang. 3 units.

530K. Modern Diagnostic Imaging Systems. This course covers the mathematics, physics and instrumentation of several modern medical imaging modalities starting with a review of applicable linear systems theory and relevant principles of physics. Modalities studied include X-ray radiography (film-screen and electronic), computerized tomography, ultrasound and nuclear magnetic resonance imaging. Consent of instructor required. Taught at Duke-Kunshan-University. Instructor: Bowsher. 3 units.

541K. Nuclear Medicine Physics. This course addresses the role of physics in nuclear medicine, particularly with regard to single-photon-emission and positron-emission imaging. Course topics include (i) relevant basic physics, such as radioactive decay and the interaction of radiation with matter, (ii) instrumentation methods for single-photon-emission and positron-emission imaging, (iii) tomographic acquisition and image reconstruction, and (iv) quantitative analysis of images. The course will be taught at Duke Kunshan University and covers the same topics as the Nuclear Medicine Physics course (MPH 541) taught at Duke University. Instructor consent required. Instructor: Bowsher. 3 units.

722K. Advanced Photon Beam Radiation Therapy. This course will cover the physics and clinical application of advanced external beam photon therapies with special emphasis on IMRT. Taught at Duke Kunshan University. Prerequisite: Medical Physics 520K. Instructor: Wu. 3 units.

723K. Advanced Brachtherapy / Special Topics and Procedures. Covers advanced treatment procedures including image-guided radiation therapy as well as its application in stereotactic radiation therapy and stereotactic radiosurgery. Instructor consent required. Open to graduate students at Duke Kunshan University. Instructor: Yin. Variable credit.

726K. Practicum on Monte Carlo Methods in Medical Physics. This course focuses on the fundamentals of Monte-Carlo simulations and provides hands-on experience with clinical Monte-Carlo codes used in medical dosimetry. The course will introduce software such as MCNP, EGS, FLUKA, GEANT and Penelope and companion data analysis software ROOT, PAW and CERNLIB. Students will study at least one major code and will perform two or more projects based on a clinically relevant task. Prerequisites: Calculus, modern physics, and programming. Knowledge of C, C++, or Fortran would be a plus. Consent of instructor required. Taught at Duke Kunshan University. Instructors: Gunasingha, H. Song, A. Kapadia. Variable credit.

728K. Clinical Practicum and Shadowing (RT). The course gives hands-on experience in practical aspects of medical physics as applied to radiation therapy. Special emphasis is given to the operation of various therapy units and dose measuring devices, techniques of measuring the characteristics of radiation beams, commissioning and quality assurance checks for radiation producing devices in the clinic. The course includes shadowing a clinician, technologist, or physicist, while performing their routine clinical tasks. The course has 3 components, each of which may be taken for 1 credit. Some components are offered in Summer Session II at Duke University, while other components are offered in Spring Semester at Duke Kunshan University. Instructor: Fang-Fang Yin. Variable credit.

731K. Advanced Medical Imaging Physics. The course includes advanced topics in diagnostic imaging including linear system theory, image quality metrology, digital radiography and mammography, new advances on three-dimensional imaging modalities, MRI, CT, ultrasound, and evaluation of diagnostic imaging methods. Prerequisite: Medical Physics 530K. Taught at Duke Kunshan University. Instructor: Dobbins. 3 units.

733K. Clinical Practicum and Shadowing (Diagnostic Imaging). Review and real-life exercises on principles of modern medical imaging systems with emphasis on the engineering and medical physics aspects of image acquisition, reconstruction and visualization, observations of imaging procedures in near clinical settings, and hands-on experience with the instruments. Modalities covered include ultrasound, X-ray, CT, and MRI. Offered at Duke Kunshan University. Prerequisite: Medical Physics 530K or equivalent. Instructor: Samei. 3 units.

734K. Advanced Topics of Non-ionizing-based Imaging Modalities. This course covers advanced topics in non-ionizing Imaging modalities such as Ultrasound and MR imaging, including speckle statistics, Doppler imaging, advanced MR pulse sequences,

MR angiography, flow and diffusion etc. Instruction will consist of didactic lectures accompanied by hands-on laboratory exercises (practicum). Offered at Duke Kunshan University. Instructor consent required. Instructor: Robertson. 3 units.

751-3K. Professional Development Skills for Medical Physicists. This seminar provides important skills for students' professional development through a series of presentations on relevant topics that include public speaking, effective scientific and professional communication, interviewing skills, entrepreneurship, etc. Designed for second year Medical Physics students. Taught at Duke Kunshan University. Instructor: Wilson. 1 unit.

751K. Seminars in Medical Physics. Medical physics is the application of the concepts and methods of physics and engineering to the diagnosis and treatment of human disease. This course consists of weekly lectures covering broad topics in medical physics including diagnostic imaging, radiation oncology, radiation safety, and nuclear medicine. Lectures will be given by invited speakers drawn from many university and medical center departments including Biomedical Engineering, radiology, physics, radiation safety, and radiation oncology. Prerequisites: background in engineering or physics. Instructor: Bowsher. 1 unit.

752K. Seminars in Medical Physics. Medical physics is the application of the concepts and methods of physics and engineering to the diagnosis and treatment of human disease. This course consists of weekly lectures covering broad topics in medical physics including diagnostic imaging, radiation oncology, radiation safety, and nuclear medicine. Lectures will be given by invited speakers drawn from many university and medical center departments including Biomedical Engineering, radiology, physics, radiation safety, and radiation oncology. Taught at Duke Kunshan University. Prerequisite: Background in engineering or physics. Instructor: Kapadia. 1 unit.

758K. Medical Physics Practicum and Shadowing. The course gives hands on experience in practical aspects of medical physics. Special emphasis is given to the operation of various therapy units and dose measuring devices, techniques of measuring the characteristics of radiation beams, commissioning and quality assurance checks for radiation producing devices in the clinic. Diagnostic Imaging, and Nuclear Medicine, and Health Physics equipment and procedures may be included. The course includes shadowing a clinician, technologist, or physicist, while performing their routine clinical tasks. Consent of instructor required. Taught at Duke Kunshan University. Instructor: Yin. Variable credit.

763K. Advanced Radiation Biology in Medical Physics. This course will teach students about cutting-edge topics in the field of radiobiology that have relevance to medical physicists. The teaching will be through the format of a Journal Club. Class and group participation is required. Students will select a topic from either the reviewed manuscripts or an approved subject of their own choosing. The student will write a detailed report on this subject. Grading will be based upon quality of manuscript review presentations and the detailed final written report. Instructor consent required. Taught in Durham. Instructor: Dewhirst, Palmer. 1 unit.

764K. Fundamentals of Radiomics, Genomics and Big Data Analytics. Radiomics refers to the extraction and analysis of large amounts of advanced quantitative imaging features with high throughput from medical images obtained with computed tomography, positron emission tomography or magnetic resonance imaging. Genomics refers to a branch of biotechnology concerned with applying the techniques of genetics and molecular biology to the genetic mapping and DNA sequencing of sets of genes or the complete genomes of selected organisms, with organizing of the results in databases, and with applications of the data (as in medicine or biology). This course introduces fundamentals of these concepts and their applications in big data analytics. Offered at Duke Kunshan University. Instructor consent is required. Instructor: Yin. Variable credit.

770K. Frontiers of Biomedical Science. A course covering frontier topics of biomedical science that are currently not within the domain of medical physics, but that medical physicists, nonetheless, need to have knowledge of. Topics include genomics, bioinformatics, proteomics, and others. Offered at Duke Kunshan University. Instructor: Bowsher. Variable credit.

790K. Independent Study in Medical Physics. Enables students to study medical physics topics of interest via an independent study format. Specific topic, learning objectives and study materials are developed by the student and the instructor. Offered at Duke Kunshan University. Instructor: Huang. 1 unit.

791K. Independent Study in Medical Physics. An independent research project with faculty advisor. Consent of instructor required. Instructor: Staff. Variable credit.

Medical Scientist Training Program

Christopher D. Kontos, MD, *Director*

A PhD is available in this program.

The Medical Scientist Training Program (MSTP), administered under the auspices of The Graduate School and the School of Medicine, is designed for students with strong backgrounds in science who are interested in careers in the medical sciences and academic medicine. The program combines graduate education in the trainee's chosen field of study with the clinical curriculum of the School of Medicine. Most trainees pursue a PhD in the biomedical sciences but others pursue degrees in medically relevant social sciences. Completion of the program typically requires seven to eight years of study and leads to both the MD and PhD. The combination of scientific and clinical training affords a remarkable range of career opportunities for program graduates, who generally follow one of two broad paths: Some pursue careers in teaching and research in one of the basic medical sciences; others enter residency programs and then go on to investigative and teaching careers in clinical medicine. Most graduates pursue some combination of research and clinical work.

Eligibility. Applicants must meet both The Graduate School PhD admission requirements and the School of Medicine MD admission requirements. Application and acceptance to the School of Medicine is requisite for admission to the MSTP. Most students apply for admission to the MSTP concurrent with application to first year of the MD program, but a few students are admitted each year after completing the second or third year of the School of Medicine. In addition to the minimum requirements for acceptance into The Graduate School and the School of Medicine, advanced coursework in science and mathematics and significant prior research experience are key elements in the selection of new students. Evidence of the potential for serious investigative work as a physician-scientist is

essential. Because a significant portion of the program's funding is provided by a National Institutes of Health training grant, program participants must be US citizens or official permanent residents of the United States.

The Training Program. Duke University School of Medicine's unique third-year research curriculum is well suited for dual-degree programs. The third year of medical school is essentially the first year of the PhD program, an arrangement that shortens the time-to-degree for the dual-degree student by a year. The typical student spends the first two years in medical school, followed by four to five years in a PhD program (which substitutes for the third medical school year) and, finally, returns to a fourth year of medical school. The coursework in the first medical school year provides a solid foundation in the basic medical sciences. The second year is devoted to a clinical sciences curriculum. Following completion of the second year, the trainee enters a graduate program to complete requirements for the PhD. A final academic year of elective clinical study completes the requirements for the MD degree.

The typical student follows the plan outlined above, but students whose research interests are well developed early in the first year may opt to begin the PhD at the beginning of their second year and then complete the clinical sciences curriculum after finishing the PhD. While this is not the typical sequence, considerable latitude is granted to students interested in early research experiences.

Financial Support. All students admitted to the program receive a full fellowship award: tuition, fees, health insurance, and a stipend to cover living expenses. The stipend for 2019-2020 is $31,693 for a twelve-month year. The award increases each year to match increases in fees, tuition, and living expenses. The program provides fellowship funds for the three medical school years and the first twenty-two months of enrollment in the PhD program; the PhD mentor provides financial support in the upper-level PhD years. Tuition for the third year of medical school is forgiven for MSTP students who 1) enter the program prior to the third year of medical school and 2) subsequently complete the PhD. Likewise, financial support for the fourth medical school year is contingent upon completion of the PhD, and, in order to qualify for this support in the last medical school year, the student must complete the PhD within seven years of the end of the second medical school year. Because MSTP fellowship support is intended to enable students to devote full-time to their work toward the two degrees, all years of fellowship support are contingent upon enrollment in either the School of Medicine or The Graduate School, satisfactory progress toward the two degrees, and no gainful employment.

Additional information may be obtained by contacting the program office directly: Medical Scientist Training Program, Box 102005, Duke University Medical Center, Durham, NC 27710; (919) 668-5528; MSTP@duke.edu.

Middle East Studies

Associate Professor McLarney, *Director*

A certificate is available in this program.

The Middle East studies certificate trains students for interdisciplinary research in Middle East studies and is designed to complement the disciplinary training in their home departments. The certificate is open to students in any department or professional school at Duke University who are engaged with the study of the Middle East. The certificate will be a joint offering of the Consortium in Middle East Studies through the Department of Asian & Middle Eastern Studies at Duke and the Department of Religious Studies at The University of North Carolina at Chapel Hill.

The objectives of this graduate certificate are to offer a coherent set of courses that introduce Middle East studies as an interdisciplinary field to MA, professional students, and PhD students; link coursework to research, doctoral exams, and thesis or dissertation writing, with an emphasis on the challenges of blending disciplinary and interdisciplinary training; and to provide training for classroom instruction in Middle East studies through coursework, faculty mentorship programs, and opportunities for teaching. The graduate certificate is built around an interdisciplinary core course and a research workshop that are both cotaught by faculty from two departments (one each from Duke and UNC).

Graduate Certificate Requirements

- Complete the Certificate Core Course: Asian & Middle Eastern Studies 620S (Critical Genealogies of the Middle East: An examination of the canon of Middle East scholarship)**.** This course provides an in-depth investigation into the various theoretical and textual traditions that inform interdisciplinary Middle East studies with a focus on history, cultural studies, religion, and social sciences. Interdisciplinary in scope, the course will maintain a disciplinary rigor so that students learn how knowledge is produced within the framework of specific disciplines. Foci include social history, literary theory, critical visual studies, and postcolonial theory. The course goals are
  - to acquaint students with the history and current state of Middle East studies;
  - to prepare students for undergraduate teaching in Middle East studies;
  - to build a cohort of graduate students with intellectual and personal ties across disciplines; and
  - to push students forward on their own research agendas.
- Complete three additional graduate courses on a topic related to the Middle East. One course must be outside the student's home department or school. Of these three courses one may be an advanced Middle East language (third-year and above in Arabic, Hebrew, Persian, Turkish, or Urdu). In order to count a course toward the certificate, students must demonstrate to the certificate program director that comparative and theoretical courses contain at least 50 percent Middle East content.
- Participate in a biweekly workshop organized each spring by the Consortium in Middle East Studies. This workshop is tailored to the interests of enrolled students who suggest readings for discussion and present their own work. There is no grade or credit associated with this workshop. To enroll, contact the Consortium in Middle East Studies prior to the beginning of the spring workshop. As an example, past workshops have allowed students and faculty the opportunity to present drafts of papers and thesis proposals and discussed the following subjects:
  - how to present papers at conferences;
  - how to craft literature reviews;
  - how to prepare and submit articles for publication;
  - how to prepare book proposals;
  - how to speak to the media; and

- how to write research and grant proposals.
- Submit to the Consortium in Middle East Studies a thesis, dissertation chapter, or a major seminar research paper on a topic related to Middle East studies. Students can meet this requirement through completion of one of the requirements for the student's primary degree (usually a master's thesis or PhD dissertation chapter). Students who are in programs that do not require a master's thesis must submit an equivalent research project (usually a major seminar paper) that is appropriate to their discipline. A member of the Faculty Steering Committee will read the written research work to judge whether it is suitable to complete the research requirement of the certificate, or, if appropriate, request that a Duke or UNC faculty member who specializes in the research area covered by the work make this judgment. It may be selected for posting online.
- Demonstrate relevant language skills, or international experience, or training. Language competency in a Middle Eastern language (Arabic, Modern Hebrew, Persian, Turkish, or Urdu) may be demonstrated by taking a placement test or an advanced language class or by using primary language texts in the major research project. International experience and training should include research, fieldwork, or study in a Middle Eastern country
- Evaluation. Students who have completed the program will fill out an exit survey and be interviewed by one of the program codirectors. This interview will provide us with an understanding of the extent to which the student has mastered some of the key issues in Middle Eastern studies and allow us to evaluate the extent to which the academic outcome goals of the program are being met. We will also track the future activities of students to determine the impact of this program on their professional development. The codirectors for the program will meet once a year to discuss the results of the exit surveys and interviews to determine if the program will need to be changed to better meet the needs of the students.

The Duke University Middle East Studies Center, together with UNC's Carolina Center for the Study of the Middle East and Muslim Civilizations, form the Duke-UNC Consortium in Middle East Studies. In addition to the graduate certificate, the Duke-UNC Consortium cosponsors many special events, conferences, and opportunities for students, scholars, and faculty to interact and collaborate. The interdisciplinary focus of the graduate certificate program is enhanced by the consortium's many activities, which offer graduate students a variety of intellectually challenging opportunities to enhance their academic training. In addition, the Duke-UNC Consortium awards several Foreign Language and Area Studies (FLAS) Fellowships each spring and been designated a National Resource Center for Middle East Studies by the US Department of Education.

For more information about the graduate certificate in Middle East studies and DUMESC's other activities, please go to DUMESC's website at https://middleeaststudies.duke.edu/ or contact the program coordinator, Box 90402, Duke University, Durham, NC 27708; (919) 668-1653; mideast@duke.edu.

Molecular Genetics and Microbiology

Professor Heitman, *Chair*; Associate Professor Tobin, *Director of Graduate Studies*; Professors Cullen, Heitman, Jinks-Roberson, Keene, Marchuk, Matsunami, Petes, and Valdivia; Associate Professors Chi, Coers, Dietrich, Luftig, McCusker, Rawls, Silver, Sullivan, and Tobin; Assistant Professors David, Heaton, Horner, Ko, Lowe, and Yan; Professors Emeriti Linney, Mitchell, Nevins, and Pickup

A PhD is available in this department.

The Department of Molecular Genetics and Microbiology offers a range of opportunities for training in the use of molecular and genetic tools to solve biological problems. Current research interests are focused in microbial pathogenesis, RNA biology, virology, and experimental genetics and genomics. Members of the department use a wide variety of experimental approaches (e.g., classical genetics, generation of transgenic animals, tissue culture models) and study a diversity of organisms (budding yeast, Cryptococcus, fruit flies, worms, zebrafish, and humans). The department is extremely interactive. In addition to coursework, students participate in a number of activities that enhance their training and facilitate interaction with each other, as well as with post-doctoral fellows and faculty. Visit https://mgm.duke.edu for more information.

Courses in Molecular Genetics and Microbiology (MGM)

520. Advanced Topics in Leveraging Fc-mediated Antibody Functions. Topics covered will include how the genetic and functional properties of the antibody Fc regions and their counterpart Fc-receptors can impact and be exploited to treat and prevent infections or cancer. The course will also cover design strategies to improve the Fc-mediated functions of monoclonal antibodies used for passive protection and treatment, as well as for vaccines to induce Fc-mediated antibody functions in active immunization strategies. The course is targeted for post-prelim students interested in state-of-the-art studies in immune responses to pathogens and malignancy. Instructor: Ferrari, Moody, Pollara. 1 unit.

522. Critical Readings in Genetics and Genomics. 3 units. C-L: University Program in Genetics 522

532. Human Genetics. Topics include segregation, genetic linkage, population genetics, multifactorial inheritance, biochemical genetics, cytogenetics, somatic cell genetics, neurogenetics, cancer genetics, clinical genetics, positional cloning, complex disease. Lectures plus weekly discussion of assigned papers from the research literature. Prerequisites: University Program in Genetics 778 or equivalent, and graduate status or consent of instructor. Instructors: Marchuk and staff. 3 units. C-L: University Program in Genetics 532

552. Virology. Molecular biology of mammalian viruses, with emphasis on mechanisms of replication, virus-host interactions, viral pathogenicity, and the relationship of virus infection to neoplasia. Instructor: Luftig and staff. 3 units.

582. Microbial Pathogenesis. Modern molecular genetic approaches to understanding the pathogenic bacteria and fungi. Underlying mechanisms of pathogenesis and host-parasite relationships that contribute to the infectious disease process. Instructor: Tobin and staff. 3 units.

593. Research Independent Study. Independent research in Molecular Genetics and Microbiology. Instructor: Staff. 3 units.

701. Foundations of Molecular Genetics and Microbiology. Foundations of MGM will provide first year MGM PhD students with exposure to the research interests in the department. MGM faculty will provide an overview of their research along with important

historical context. Instructor: Heaton and staff. 1 unit.

702. Papers and Grant Writing Workshop. Introduction to grant and fellowship writing; writing assignment of two proposal topics; evaluation and critique of proposal by fellow students. Instructor consent required. Instructor: Marchuk. 3 units. C-L: University Program in Genetics 702

720. Computational Tools in Next Generation Genomic Analysis. Covers biological data, DNA/RNA/protein, yeast, human—hands-on assignment based intensive, semester long, computational training—programming environment, hardware/software, Linux, client/server, user, root, /usr/local/bin, shell, and languages, virtual machines, cloud services, C, Perl, PHP, MySQL, HTML, make, command line tools—blast/fasta/EMBOSS/clustal/rsync/ssh and a dash of sed/awk/grep, genomic sequence, RNA-Seq, text and HTML output formats, prerequisite enthusiasm and consent of instructor. Instructor: Dietrich. 3 units.

732. Human Genetics. 3 units. C-L: see University Program in Genetics 732

790S. Topics in Molecular Genetics and Microbiology. Required course for all graduate students receiving their degree through MGM. Instructor: Tobin and staff. 1 unit.

793. Research for Graduate Students. Laboratory investigation for Graduate students. Various labs within the department of molecular genetics and microbiology. Credits to be arranged. Instructor consent is required. Instructor: Tobin. 2 units.

533. Essentials of Pharmacology and Toxicology. 4 units. C-L: see Pharmacology and Cancer Biology 533; also C-L: Neuroscience 533

551L. Biomedical Optical Spectroscopy and Tissue Optics (GE, IM). 4 units. C-L: see Biomedical Engineering 551L

691. Independent Study in Molecular Cancer Biology. Consent of instructor required. Instructor: Staff. 1 unit.

710. Papers and Grant Writing Workshop. 3 units. C-L: see Cell Biology 710; also C-L: Neurobiology 710, Pharmacology and Cancer Biology 710

730. Stem Cell Course. 3 units. C-L: see Cell Biology 730; also C-L: Pharmacology and Cancer Biology 730

733. Experimental Design and Biostatistics for Basic Biomedical Scientists. 2 units. C-L: see Pharmacology and Cancer Biology 733; also C-L: Neurobiology 733, Cell and Molecular Biology 733, Biomedical Engineering 733

761. Cellular Signaling Module I: GPCR Signaling and Disease. 1 unit. C-L: see Cell Biology 761; also C-L: Biochemistry 761, Pharmacology and Cancer Biology 761

762. Cellular Signaling Module II: Intracellular Signaling and Disease. 1 unit. C-L: see Cell Biology 762; also C-L: Biochemistry 762, Pharmacology and Cancer Biology 762

763. Cellular Signaling Module III: Growth Factor Pathway in Development and Disease. 1 unit. C-L: see Cell Biology 763; also C-L: Biochemistry 763, Pharmacology and Cancer Biology 763

780. Graduate Student Seminar. A presentation and discussion course in which program faculty and graduate students review recent progress in contemporary areas of Pharmacology and Cancer Biology. Provides an important avenue for evaluation and feedback for graduate student research and communication skills and is required for all students pursuing their PhD degree in Pharmacology and Molecular Cancer Biology. Instructor: Tsvetanova/Zhang. 2 units.

793. Research in Pharmacology. Variable credit. C-L: see Pharmacology and Cancer Biology 793

818. Molecular Mechanisms of Oncogenesis. This course is a lecture presentation and discussion course on the molecular mechanisms underlying cancer development in which students complete periodic tests, present a paper, and work in a group to write and defend a grant proposal. The objective of the course is to provide an opportunity for in-depth discussions of molecular mechanisms underlying the development of human cancers. The course is intended for second-year students. Instructor: Counter, Wood, and Yao. 3 units. C-L: Pharmacology and Cancer Biology 818

819. Cancer as a Disease. Instructor: Alvarez/Mathey-Prevot. 2 units.

Music

Professor of the Practice Bagg, *Chair*; Professor Todd, *Director of Graduate Studies*; Professors Brothers, Gilliam, Jaffe, Lindroth, Rupprecht, and Todd; Associate Professors Meintjes, Supko, and Waeber; Assistant Professors Giles and Stoia; Professors of the Practice Bagg and Parkins

A PhD is available in this program.

The Department of Music offers graduate programs leading to the PhD in composition, the PhD in ethnomusicology, and the PhD in musicology. It also offers the MA in performance practice as an alternative part of the PhD in musicology.

Applicants for admission to all degree programs will normally have a broad liberal arts background as well as demonstrable musical competence. Those applying to the composition program should submit samples of their compositions with their applications. For the musicology and ethnomusicology programs, applicants should include samples of their writing on musical topics. Upon acceptance to the university, by nomination of the graduate faculty in music, musicology students may also be admitted to the Program in Medieval and Renaissance Studies. For students pursuing the musicology PhD with emphasis in performance practice, the department encourages applications from advanced musicians who have demonstrated an ability to conduct research about the performance of music in historical contexts. Applicants in performance practice should submit a recording of their work in the field as well as a sample of their writing.

For the PhD in composition, seventeen courses (51 course credits) are required; up to four courses (12 course credits) may be accepted for transfer from another institution. Courses may be taken in other departments with permission of the director of graduate studies. Students are expected to pass a qualifying examination (in the fourth semester) and a preliminary examination (after completing

coursework, usually in the sixth semester); before taking the preliminary examination students are asked to submit a portfolio of compositions. Students in composition must also demonstrate knowledge of one foreign language. The dissertation requirements consist of a large-scale composition and an article of publishable quality.

For the PhD in musicology, seventeen courses (51 course credits) are required; up to four courses (12 course credits) may be accepted for transfer from another institution. Courses may be taken in other departments with permission of the director of graduate studies. Students are expected to pass a two-part qualifying examination (in the fourth and fifth semesters) and a preliminary examination (after completing coursework, usually in the sixth semester). In addition, students must demonstrate knowledge of two foreign languages. Within the framework of the musicology degree students may pursue projects in music theory or performance practice.

For the MA in performance practice, eleven courses (33 course credits) are required. Students are expected to pass a qualifying examination (usually in the second year) and to give a master's recital (usually toward the end of the first year). They also must demonstrate knowledge of one foreign language. The MA in performance practice is not a terminal degree; it is granted only to candidates matriculated into the PhD in musicology.

For the PhD in ethnomusicology, fifteen courses (45 course credits) are required, including three core courses. Of the twelve additional courses, at least four should be taken in the Duke Music Department and three in another single discipline. In order to advance to candidacy, students are expected to prepare a portfolio of their work, participate in a field specialization workshop (usually in the second year) and a prospectus workshop (after completing coursework, usually in the third year). Students must also demonstrate knowledge of one foreign language.

A more detailed description of each degree program is available upon request from the director of graduate studies.

Courses in Music (MUSIC)

501. Introduction to Musicology. Methods of research on music and its history, including studies of musical and literary sources, iconography, performance practice, ethnomusicology, and historical analysis, with special attention to the interrelationships of these approaches. Instructor: Rupprecht or staff. 3 units.

511-1. Collegium Musicum. An opportunity to study and perform vocal and instrumental music from the Middle Ages through the Baroque. Weekly rehearsals; one or two concerts per semester. Audition and consent of instructor required. Instructor: Staff. 1.5 units.

551. Music in the Middle Ages. Selected topics. Instructor: Brothers or Giles. 3 units. C-L: Medieval and Renaissance Studies 522

552. Topics in Renaissance Music. Selected topics. Instructor: Brothers, Giles, or staff. 3 units. C-L: Medieval and Renaissance Studies 523

553. Music in the Baroque Era. Selected topics. Instructor: Brothers, Giles, or staff. 3 units. C-L: Medieval and Renaissance Studies 524

554. Music in the Classic Era. Selected topics. Instructor: Todd. 3 units.

555. Music in the Nineteenth Century. Selected topics. Instructor: Todd. 3 units.

556. Music in the Twentieth Century. Selected topics. Instructor: Brothers, Rupprecht, Stoia, or Todd. 3 units.

560. Tonal Analysis. In-depth study of various methods for analyzing tonal music. Approach and content vary by instructor. Instructor: Stoia, Todd, or staff. 3 units.

561S. Analysis of Early Music. Selected areas of "pre-tonal" music and various analytical methodologies that have been developed to understand them. Content changes, from semester to semester and with different instructors. Possible areas covered include plainchant, trouvère monophony, Machaut, Fifteenth-century polyphony, modal music of the Renaissance, early seventeenth-century repertories. Instructors: Brothers, Giles, or staff. 3 units.

562. Analysis of Music After 1900. Introduction to analytic and theoretic methodologies for engaging the structures and rhetoric of a range of art-music styles since 1900. Readings in atonal and twelve-tone theories; hexatonic and octatonic pitch collections; neo-Riemannian transformations; voice leading, metric and rhythmic theories. Theory-based analysis of selected repertory. Instructor: Rupprecht or Staff. 3 units.

575S. Generative Media Authorship - Music, Text & Image. 3 units. C-L: see Visual Arts 575S; also C-L: Information Science + Studies 575S, Computational Media, Arts & Cultures 575S

590. Selected Topics in Analysis. An exploration of analytical approaches appropriate to a diversity of music, which may include settings of literary texts, pre-tonal music, and music in oral and vernacular traditions. Prerequisite: Music 560 or consent of instructor. Instructor: Rupprecht, Stoia, or staff. 3 units.

590S. Special Topics in Music. Opportunities to engage with a specific issue in music. Instructor: Staff. 3 units.

595. Language, Music and Dementia: Neuroscience Approaches. 3 units. C-L: see Linguistics 595; also C-L: Neuroscience 595

663. Theories and Notation of Contemporary Music. The diverse languages of contemporary music and their roots in the early twentieth century, with emphasis on the problems and continuity of musical language. Recent composers and their stylistic progenitors: for example, Ligeti, Bartók, and Berg; Carter, Schoenberg, Ives, and Copland; Crumb, Messiaen, and Webern; Cage, Varèse, Cowell, and Stockhausen. Instructor: Jaffe, Lindroth, Rupprecht, or Supko. 3 units.

690S-1. Composition Seminar: Selected Topics. Selected topics in composition. Instructor: Jaffe, Lindroth, or Supko. 3 units.

691S. Black Sonic Culture—Analog to Digital. 3 units. C-L: see African & African American Studies 622S; also C-L: English 691S, Literature 691S

697. Composition. Weekly independent study sessions at an advanced level with a member of the graduate faculty in composition, producing musical scores (or in some cases, audio documents) which accrue towards the production of a portfolio. Consent of instructor required. Instructor: Jaffe, Lindroth, or Supko. 3 units.

698. Composition. Continuation of Music 697. Weekly independent study sessions at an advanced level with a member of the graduate faculty in composition, producing musical scores (or in some cases, audio documents) which accrue towards the production of a portfolio. Consent of instructor required. Instructor: Jaffe, Lindroth, or Supko. 3 units.

699. Composition. Continuation of Music 698. Weekly independent study sessions at an advanced level with a member of the graduate faculty in composition, producing musical scores (or in some cases, audio documents) which accrue towards the production of a portfolio. Consent of instructor required. Instructor: Jaffe, Lindroth, or Supko. 3 units.

718S. Seminar in Performance Practice. A practical seminar in which participants will be expected to perform, to introduce the work to be played or sung, and to outline its interpretative problems. A list of the music concerned will be posted in advance, and all students will participate in the study (if not necessarily in the performance) of the works announced. It is expected that the seminar will cover most periods, from Gregorian chant to twentieth-century repertories. Consent of instructor required. Instructor: Staff. 3 units.

735. The History of Hip-Hop. 3 units. C-L: see African & African American Studies 735; also C-L: English 735, Visual and Media Studies 735

761. Theory and Practice of Tonal Music II. Study of four-part chorale-style writing, with an emphasis on correct voice leading, beginning with basic tonicization and modulation and moving through sequences and figuration to more complex chromaticism; three-part species counterpoint; analysis and study of form, with an emphasis on music of the Classical and early Romantic periods; composition of larger forms. Fluency assumed in harmonic syntax involving diatonic harmonies. Instructor consent required. Instructor: Stoia, Kelley, or Rupprecht. 3 units.

771S. Graduate Seminar: Theories of Corporeality. 3 units. C-L: see Dance 771S; also C-L: Gender, Sexuality, and Feminist Studies 771S

772S. Graduate Seminar in Critical Dance Studies. 3 units. C-L: see Dance 772S; also C-L: Gender, Sexuality, and Feminist Studies 772S

790S-1. Seminar in the History of Music. Selected topics. Instructor: Staff. 3 units.

790S-2. Studies in Ethnomusicology. A theoretical and methodological exploration of ethnomusicological approaches to the study of music and related expressive forms. Topics vary. Instructor: Meintjes. 3 units.

791. Independent Study. With the consent of a graduate faculty member and the approval of the director of graduate studies, the student will undertake a specialized research project of his/her own choosing. Instructor: Staff. 3 units.

792. Independent Study in Performance Practice and Interpretation. The exploration of significant interpretive and performance-practice issues as they affect a specific repertory. Weekly meetings with a member of the graduate faculty. Consent of instructor and director of graduate studies required. Instructor: Staff. 3 units.

797. Composition. Weekly independent studies at the doctoral level with a member of the graduate faculty in composition. Instructor: Jaffe, Lindroth, or Supko. 3 units.

798. Composition. Weekly independent studies at the doctoral level with a member of the graduate faculty in composition. Instructor: Jaffe, Lindroth, or Supko. 3 units.

799. Composition. Weekly independent studies at the doctoral level with a member of the graduate faculty in composition. Instructor: Jaffe, Lindroth, or Supko. 3 units.

Nanoscience

Professor Therien, *Director of Graduate Studies*

A certificate is available in this program.

The mission of the graduate Certificate Program in Nanoscience (CPN) is to educate students in nanoscience disciplines and applications. This graduate certificate program is designed to address the need for an interdisciplinary graduate education in nanoscience that extends beyond the traditional disciplines and skills that are taught within existing departments. In this program, graduate students are educated and mentored in classes, labs, and research projects by faculty from many disciplines. Current focus areas within nanoscience that are currently represented at Duke include (1) synthesis of nanostructured materials, (2) fundamental properties of nanostructured materials, (3) nanodevice fabrication and applications, and (4) advanced characterization of nanostructured materials and devices. The disciplines span the physical sciences, engineering, and the biological sciences that are relevant to nanoscience; the program includes faculty from departments within the Trinity College of Arts & Sciences, the Pratt School of Engineering, and the School of Medicine. Member departments include biology, biochemistry, biomedical engineering, cell biology, chemistry, civil and environmental engineering, computer science, electrical and computer engineering, mechanical engineering and materials science, and physics.

For additional information, contact Professor Michael Therien (michael.therien@duke.edu) or the assistant to director of graduate studies, Dr. Mei Lu (mei.lu@duke.edu).

Requirements

Participating departments include biochemistry, biology, biomedical engineering, cellular biology, chemistry, civil and environmental engineering, computer science, electrical and computer engineering, mechanical engineering and materials science, and physics. Students are admitted into existing departments or programs of Duke University, and receive their PhD within those degree-granting units (typically but not exclusively a participating department).

Certificate requirements include

- participation in the Nanoscience Seminar Series and
- three elective courses (listed below).

For more information, visit https://nano.duke.edu/.

Course in Nanoscience (NANOSCI)

511. Foundations of Nanoscale Science and Technology. This course is the introductory course for the Graduate Certificate Program in Nanoscience (GPNANO) and is designed to introduce students to the interdisciplinary aspects of nanoscience by integrating important components of the broad research field together. This integrated approach will cross the traditional disciplines of biology, chemistry, electrical & computer engineering, computer science, and physics. Fundamental properties of materials at the nanoscale, synthesis of nanoparticles, characterization tools, and self-assembly. Prerequisites: Physics 152L and Chemistry 101DL or instructor approval. Instructor: Staff. 3 units. C-L: Electrical and Computer Engineering 511, Chemistry 611

Elective Courses in Nanoscience (Three required for certificate)

Biomedical Engineering
522. Introduction to Bionanotechnology Engineering
525. Biomedical Materials and Artificial Organs
555. Advances in Photonics
567. Biosensors
590. Special Topics in Biomedical Engineering
Computational Biology and Bioinformatics
540. Statistical Methods for Computational Biology
Chemistry
521. Inorganic Chemistry
541. Quantum Chemistry
542. Quantum Mechanics
548. Solid-State and Materials Chemistry
590. Special Topics in Chemistry
601. Biosensors
630. Advances in Photonics
Computer Science
590. Nanoscale Assembly and Computing
624. Nanoscale and Molecular Scale Computing
663. Algorithms in Structural Biology and Biophysics
664. Computational Structural Biology
Electrical and Computer Engineering
512. Emerging Nanoelectronic Devices
521. Quantum Mechanics
523. Quantum Information Science
545. Foundations of Nanoelectronics & Nanophotonics
611. Nanoscale and Molecule Scale Computing
721. Nanotechnology Materials Lab
Mechanical Engineering and Materials Science
555-12. Advanced Topics in Mechanical Engineering (Topic: Thin-Film Photovoltaics)
711. Nanotechnology Materials Lab
Physics
509. Quantum Nanophysics
607. Introduction to Condensed Matter Physics
627. Quantum Information Science
764. Quantum Mechanics
810. Advanced Solid State Physics

Neurobiology

Professor Lisberger, *Chair*; Associate Professor Grandl, *Director of Graduate Studies*; Professors Brunel, Caron, Greenside, Grill, Groh, Huettel, Ji, La Spada, Liedtke, Lisberger, Matsunami, McNamara, Mooney, Nicolelis, Soderling, Song, Wang, and Woldorff; Associate Professors Adcock, Calakos, Dzirasa, Eroglu, Grandl, Jiang, Kuo, Silver, Sommer, West, R. Yang, and Yin; Assistant Professors Beck, Bohorquez, Field, Franks, Glickfeld, Gong, Heller, Hull, Kay, Meyer, Naumann, Tadross, Viventi, Volkan, Yan, and H. Yang

A PhD is available in this program.

At a time when many questions in biology have been eloquently answered, both scientists and the public correctly perceive that the brain remains, in fundamental ways, a profound mystery. During the last century tremendous advances have been made in understanding the structure, function, chemistry, and development of the brain. Nonetheless, in both biology and medicine, broad and important questions about this complex organ remain to be answered. These include how genetic instructions are linked to brain development, the basis of learning and memory, the nature of consciousness, and the etiology and proper treatment of neurological diseases such as epilepsy, neurodegenerative diseases such as Alzheimer's and Parkinson's, and neurodevelopmental disorders such as autism.

Neurobiologists approach the questions of how the brain works with techniques that are diverse, and generally reductionist. Pre-eminent are a host of sophisticated imaging and electrophysiological methods for detecting the activity of individual nerve cells or groups of nerve cells, extremely novel applications of the techniques of molecular biology and molecular genetics, and a wealth of anatomical methods for seeing the structure and connections of nerve cells. Noninvasive means of recording activity in the human nervous system—by functional nuclear magnetic resonance (fMRI), positron emission tomography (PET), or activity-related magnetic fields—also hold great promise for better understanding the brain. Still, progress in neurobiology—much as progress in any science—will depend on important insights arising from the imagination of neuroscientists who think deeply about these issues.

Neuroscience at Duke is pursued in a variety of departments and setting, all of which are possible sites for students who wish to be trained in this field. The Graduate Training Program has its home in the Department of Neurobiology at Duke University Medical Center, and includes forty-six training faculty with primary appointments in fifteen different departments in the School of Medicine, the Trinity College of Arts & Sciences, and the Pratt School of Engineering. A large and diverse body of students and other professionals are also engaged in neurobiological research.

Students in the graduate program take a core curriculum that covers the major subfields of contemporary neurobiology, but students are generally free to pursue—with the help of faculty advisors—a course of study tailored to their needs, backgrounds, and

individual interests. The core courses in the Department of Neurobiology are: Neurobiology 751 (Neuroscience Bootcamp), Neurobiology 790 (Student Seminar), Neurobiology 719 (Concepts in Neuroscience I), Neurobiology 720 (Concepts in Neuroscience II), Neurobiology 762 (Neurobiology of Disease), Neurobiology 710 (Scientific Writing), Neurobiology 735 (Quantitative Approaches to Neurobiology), Neurobiology 733 (Experimental Design and Biostatistics for Basic Biomedical Scientists), and Neurobiology 726 (Neurobiology Journal Club).

For additional information, visit https://www.neuro.duke.edu/ or email ladonna.huseman@neuro.duke.edu.

Courses in Neurobiology (NEUROBIO)

559. The Biological Basis of Music. Examine how and why we hear what we do, from intra-species communication to music. Consider the biological basis of music, in particular the relationship between music and speech. Comparison between the operating principles of the auditory system with what is presently known about vision. Limited inquiry into the neurobiology of aesthetics. Instructor: Purves. 3 units. C-L: Philosophy 559, Psychology 580

631. Contemporary Topics in Membrane Biology. 2 units. C-L: see Biochemistry 631; also C-L: Cell and Molecular Biology 631, Pharmacology and Cancer Biology 631

710. Papers and Grant Writing Workshop. 3 units. C-L: see Cell Biology 710; also C-L: Molecular Cancer Biology 710, Pharmacology and Cancer Biology 710

719. Concepts in Neuroscience I: Cellular and Molecular Neurobiology. The goal of this course is to introduce graduate students to the basic principles underlying cellular and molecular neurobiology. The first part of the course will cover the cellular mechanisms of neurophysiology, that is the generation and propagation of neuronal electrical signals. The second part will cover molecular mechanisms of synaptic signaling, plasticity, axon guidance, and neural regeneration. An interactive discussion-based format focused on key discoveries in these areas of research, including analysis of original papers, will allow students to learn how the brain encodes, transmits, and stores information as well as form neural circuits. Consent of instructor is required. Instructor: West and Kay. 5 units.

719A. Neuronal Excitability. The electric excitability of neurons is mediated by ion channels. First, we will give an overview of the human ion channel set and discuss the basic structure and functions of ion channels. We will show how the function of ion channels is measured and analyzed. We will analyze the 3D crystal structures of a few ion channels in greater detail. In the second week we will focus on the basic electrical properties of cell membranes, neuronal excitability, and action potentials. Instructor: Grandl. 1 unit.

719B. Cell Biology of the Neuron. How the brain is wired during development is a fundamental question of neurobiology. In this module we will discuss the molecular mechanisms that sculpt brain patterning and axon guidance, we will discuss the regulation of neurogenesis, we will cover how the synapse is formed, and we will talk about how sensory information guides the development of the brain in early postnatal life. Instructor consent required. Instructor: West. 1 unit.

719C. Synaptic Transmission. This module will cover the fundamentals of basic cell biology as well as focusing on cellular specializations that are exaggerated in neurons. Topics include polarized protein trafficking, organelle motility, cytoskeleton organization, synaptic scaffolds, intracellular signaling cascades and cell-to-cell communication, including communication between neurons and non-neuronal cells. We will cover genetic methods for the study of molecular function in neurons and finally we will have a class project to discuss how neurotrophic factors promote cell survival and the molecular mechanisms of neuronal death. Instructor consent required. Instructor: Hull, Franks. 1 unit.

719D. Neural Plasticity. Plasticity is one of the most unique features of the brain, mediating the ability of this organ to learn from its environment. In this module we will explore molecular and cellular mechanisms of the stimulus-inducible changes in synaptic strength (long-term depression and long-term potentiation; LTP and LTD) that are key models for learning and memory. We will review the signal transduction pathways that convert neuronal activity into changes in synaptic structure and function and we will explore the contexts in which synaptic and circuit plasticity contributes to changes in brain function and behavior. Instructor consent required. Instructor: Naumann, West. 1 unit.

719E. Neural Development. As the focal point of communication between neurons, the synapse is an essential adaptation of the nervous system that contains a wide variety of unique proteins and functional specializations. In this module, we will cover the structure and function of the synapse, from the dynamics of presynaptic vesicle release through the postsynaptic response to neurotransmitter, and the essential proteins and molecules that mediate these processes. Finally, we will discuss how these elements can be tailored to fit the needs of different circuits. Instructor consent required. Instructor: Kay. 1 unit.

720. Concepts in Neuroscience II: Principles of Organization of Neuronal Systems. The principles of organization of neurons into functional circuits will be examined through a series of 4 distinct modules, listed below. All four modules required for first-year neurobiology students. Instructor consent required. Prerequisite: Neurobiology 719. Instructor: Franks. 4 units.

720A. Circuits and Computation. In this module, we will explore computational approach to neuroscience and introduce the information theoretic tools upon which it is based. Emphasis will be placed on models of neural encoding and decoding, signal detection theory, decision theory, and model neural circuits that perform evidence integration, object tracking, and binary choice. Instructor: Wang/Glickfeld. 1 unit.

720B. Sensory Processing. A major function of the nervous system is to generate perceptions based on input from sensory organs. This module will explore how populations of neurons represent sensory information and perform computations on those signals. This question will be considered at a variety of levels of the visual and auditory pathways, and will span domains of inquiry from circuits to cognition. Instructor: Lisberger/Sommer. 1 unit.

720C. Sensory-Motor Integration. This module concerns how sensory and motor structures of the brain communicate with each other to support movements guided by sensory stimuli. Instructor: Groh. 1 unit.

720D. Learning and Memory. This module concerns the neural basis of learning and memory, with emphasis on bird song and decision making in drosophila. Instructor: Groh/Franks. 1 unit.

726S. Neurobiology Journal Club. Once a month, first and second year neurobiology graduate students meet to hold a student-run journal club to discuss the work of an invited seminar speaker from an outside institution. On the following Tuesday, the students attend the seminar, then have lunch with the speaker. Instructor: West. 1 unit.

730. Statistics for Neuroscience. Introduction to applied probability theory and statistical methods in commonly used neuroscience. Instructor consent required. Instructor: Beck. 1 unit.

733. Experimental Design and Biostatistics for Basic Biomedical Scientists. 2 units. C-L: see Pharmacology and Cancer Biology 733; also C-L: Cell and Molecular Biology 733, Biomedical Engineering 733, Molecular Cancer Biology 733

735. Quantitative Approaches in Neurobiology. Through lectures and hands-on problem solving, this course will provide students with a working, practicable background in coding in matlab, the fundamentals of statistics, and theoretical and computational neuroscience. The material will be oriented strongly towards the needs of working neurobiologists, and will require considerable independent work. Consent of instructor is required. Instructor: Lisberger. 3 units.

751. Neuroscience Bootcamp. 2 units. C-L: see Neuroscience 751

755. Neurotoxicology. 3 units. C-L: see Pharmacology and Cancer Biology 755

759S. Principles in Cognitive Neuroscience I. 3 units. C-L: see Psychology 759S; also C-L: Philosophy 753S

760S. Principles in Cognitive Neuroscience II. 3 units. C-L: see Psychology 760S; also C-L: Philosophy 754S

762. Neurobiology of Disease. Meeting 3x week—month of January—discuss given disease of the nervous system. One or two students working with a designated faculty member are responsible for an introduction (20-25 minutes) followed by a discussion of key primary papers on the subject. Two or three articles provided at least a week in advance provide a framework for discussion. Diseases to be covered currently include: ALS, Alzheimer's, CNS neoplasms, Epilepsy, multiple sclerosis, Parkinson's disease, retinitis pigmentosa, and stroke. will discuss key features of the disease, etiology and pathogenetic mechanisms of the disease, models available and the evidence establishing the validity of the models & therapies. Instructor: Staff. 2 units.

790S. Student Seminar (Topics). Prepare and present research papers to students and faculty on topics of broad interest in Neurobiology. Lead discussions and give feedback about the presentations. Required of all first- and second-year Neurobiology students. Instructor consent required. Instructor: Yang, Kay. 1 unit.

793. Research in Neurobiology. Guided independent study and research experience in neurobiology. Nature of topic to be decided by individual arrangement with faculty advisor. Prerequisite: consent of faculty advisor. Credit: 1-16. Staff. Variable credit.

795. Special Topics in Neuroscience. Neurobiology 795 will be a series of 2-week intensive mini-courses that cover a small area of the field of neuroscience intensively through critical reading of the literature and instructor guidance. Example topics would include: cerebellar learning; mechanisms of navigation; epigenetic control of neural function; the neuroscience of autism. Each mini-course will have a different faculty instructor selected from the Neurobiology Graduate Training Faculty. Students may enroll in Neuro 795 multiple times and will receive one credit for each mini-course they complete successfully. Variable credit.

859. Neuronal Cell Signaling and Related Topics. Using primary literature, this course will cover current topics in neuronal cell signaling, with special emphasis on related diseases as well as the biochemical, molecular, and cellular methods used in these studies. The format of the course will include both student-led presentations reviewing current knowledge on each topic and a journal club discussion of a research paper. The instructor will assist students in choosing the topics and will facilitate the discussion. At the end of the course each student will prepare a grant proposal outlining next steps for the topic researched. Students are expected to have a strong background in neuroscience, and permission of the instructor is required to register. Instructor: West. 2 units.

881. Functional Magnetic Resonance Imaging. 3 units. C-L: see Psychology 762

Nonlinear and Complex Systems

Professors Beale (Mathematics), Dowell (Mechanical Engineering and Materials Science), Greenside (Physics), Gauthier, Haff (Earth and Ocean Sciences), Hall (Mechanical Engineering and Materials Science), Henriquez (Biomedical Engineering and Nicholas School of the Environment), Kepler (Bioinformatics and Biostatistics), Katul (Nicholas School of the Environment), Krassowska, Neu (Biomedical Engineering), Krystal (psychiatry and behavioral sciences), Layton (Mathematics), Liu (Chemistry), Mattingly (Mathematics), McShea (Biology), Murray (Earth and Ocean Sciences), Nijhout (Biology), Rosenberg (Philosophy), Schaeffer (Mathematics), Socolar (Physics), Venakides (Mathematics), Virgin (Mechanical Engineering and Materials Science), and Witelski (Mathematics); Associate Professors Charonneau (Chemistry), Howle (Mechanical Engineering and Materials Science), Teitsworth (Physics), Wilson (Biology), and Wolf (Biomedical Engineering); Assistant Professor Sterrett (Philosophy); Professor Emeritus Palmer (Physics)

A certificate is available in this program.

The Center for Nonlinear and Complex Systems (CNCS) at Duke University is a well-established interdisciplinary program that links researchers in diverse scientific, mathematical, engineering social sciences and medical fields who have a common interest in all aspects of nonlinear dynamical phenomena, especially in complex systems. The activities of the CNCS include graduate and undergraduate training, and the fostering of interdisciplinary research. The center offers a certificate program for graduate students, provides a range of relevant courses, supports a regular seminar series and organizes scientific meetings, such as Dynamic Days as well as focused workshops. It helps foster links among researchers and students at Duke as well as on national and world scales.

The CNCS was officially established in the early '90s for the purpose of bringing together faculty at Duke whose research relies on the rapidly developing fields of nonlinear dynamics and complex systems. Anyone in the Duke community with interests in nonlinear dynamics and/or complex systems may choose to be affiliated with the CNCS. At present, members of the center include faculty, post-docs, and students from the departments of biology, biomedical engineering, cell biology, civil and environmental engineering, computer science, electrical and computer engineering, earth and ocean sciences, mathematics, mechanical engineering and materials science,

physics, neurobiology, psychiatry.

The CNCS graduate certificate program was created to respond to the need for a broad, interdisciplinary, and transferable set of skills. Certain basic concepts and techniques relevant to dynamical systems are now widely used in a many different disciplines. This program is intended to guide students toward this broad view by requiring the completion of a survey course, participation in seminars, and coursework.

Requirements

Students are admitted into existing Duke PhD departments associated with the center, and elect to begin their certificate program in the first or second year of graduate study. Students must complete the following:

- Survey course (Nonlinear and Complex System 501 (Topics in Nonlinear and Complex Systems).
- Four courses from an approved list.
- Dissertation on a topic in the domain of the center.
- Two center faculty members must be on the student's dissertation committee.

For more information, visit https://math.duke.edu/cncs/.

Courses in Nonlinear and Complex Systems (NCS)

501. Survey of Nonlinear and Complex Systems. Survey lectures by Duke experts active in CNCS research; regular attendance in the CNCS seminar series; and a weekly meeting to discuss the lectures and seminars. May be repeated once. Prerequisite: Physics 513. Instructor: Staff. 2 units. C-L: Physics 501

513. Nonlinear Dynamics. Introduction to the study of temporal patterns in nonequilibrium systems. Theoretical, computational, and experimental insights used to explain phase space, bifurcations, stability theory, universality, attractors, fractals, chaos, and time-series analysis. Each student carries out an individual research project on a topic in nonlinear dynamics and gives a formal presentation of the results. Prerequisite: Computer Science 101, Mathematics 216, and Physics 161D, 162D, or equivalent. Instructor: Staff. 3 units. C-L: Computer Science 524, Physics 513

A current list of approved courses is available on the CNCS website: https://math.duke.edu/cncs/.

Nursing

Professor Broome, *Dean of the School of Nursing*; Professor Docherty, *Program Director and Director of Graduate Studies*; Professors Bailey, Brandon, Cary, Chee, Cho, Crego, Corazzini, De Gagne, Docherty, Gonzalez-Guarda, Goode, Granger, Hendrix, Howard, Humphreys, Im, Kim, Knisely, Lipkus, McConnell, Noonan, Oermann, Oyesanya, Pan, Prvu Bettger, Randolph, Relf, Reuter-Rice, Richesson, Schneider, Shaw, Silva, Smith, Stevenson, Tanabe, Turner, Walker, Yang, and Yap

A PhD is available in this program.

The PhD Program in Nursing will prepare nurse scientists to conduct nursing research in the broad area of trajectories of chronic illness and care systems. Graduates will assume roles primarily in academic and research settings. The program's approach is to admit a small number of highly qualified applicants so that every student will work closely with one or more faculty members in a series of mentored experiences, supported by formal coursework, (a) to ensure socialization to the role of research scientist; (b) ensure significant knowledge and skill acquisition for launching a successful program of independent research post doctorate; and (c) to prepare for an entry level role in an academic setting.

The program requires a minimum of 47 course credits of graduate coursework (post-MSN) prior to a dissertation. Post-BSN students are required to take an additional three-credit advanced practice role course. Students will work on active research projects, and it is expected that most will graduate with a record of publication. Coursework is structured with a substantial core (33 course credits) of nursing science and research methods to be taken in the Duke University School of Nursing. This core will be expanded with 12 elected credits in statistics, research methods, and minor area courses (to be taken mainly outside of nursing in other Duke University departments. Additional requirements include a 1-credit research practicum, and a 1-credit teaching practicum. In addition, each student develops a scholarly portfolio. Each student completes a preliminary exam (admission to PhD candidacy) at the end of the second year. The final requirement is the presentation of a dissertation. Students will be expected to complete the program in three to five years.

A baccalaureate or master's degree in nursing from a program accredited by NLNAC or CCNE is required for admission to the PhD in nursing program.

For more information about the PhD in nursing program and curriculum details, consult the PhD in nursing program section of the Duke University School of Nursing website and the *PhD in Nursing Program Graduate Student Handbook* for 2019-2020. Prospective students may also contact the PhD Program Coordinator Revonda Huppert at (919) 668-4797 or revonda.huppert@duke.edu.

Courses in Nursing (NURSING)

901. Philosophy of Science and Theory Development. Focus is on the purposes of science, scientific process, and knowledge development as debated in current literature. Debates arising from philosophy and the history of science and nursing inform discussion about the nature of science and nursing's past, present and future directions in theory and knowledge development. Students will develop skills in concept and theory analysis related to trajectories of chronic illness and care systems. The student will apply knowledge gained to placing their area of scientific focus into a conceptual framework. Department consent required. 3 units.

902. Quantitative Research Designs. This course introduces students to a range of nonexperimental and experiment designs used in health care research. Topics include identifying researchable problems, formulating research questions/aims/hypothesis, conceptual and operational definitions of variables, sampling designs, ethical issues in human subjects research, data collection techniques, and critique of analytical methods. Students will apply knowledge by participating in class discussions, critiquing published research, and exploring possible designs for their research focus. 3 units.

903. The General Linear Models. Focus is on conceptual and methodological issues involved in the analysis of survey and clinical data using general linear models. Topics include analysis of variance, analysis of covariance, bivariate regression, and multiple

regression analyses. Emphasis is on the application of these statistical methods in the design and analysis of nursing and health care research. The student will apply concepts by analyzing archived public domain data using techniques and procedures in SAS. 3 units.

904. Statistical Analysis II: Categorical Data Analysis. Focus is on the most important and commonly used regression models for binary, ordinal, and count outcomes. Topics include: estimating and interpreting regression coefficients, assessing model fit, and significance testing using logistic, Poisson, and negative binomial models. Explore nonlinear regression models to analyze both epidemiologic (survey) and clinical data. Assignments will provide the student with hands-on data analytic experience (with relevant SAS procedures) and with a workbook of specific examples that can be applied to the student's subsequent research activities. Prerequisite: Nursing 903. Instructor consent required. 3 units.

905. Longitudinal Methods. Focus is on longitudinal research methods, including conceptualization, design, data management, and analysis. Assumptions and limitations of longitudinal statistics, particularly the general linear mixed model, generalized estimating equations, and survival modeling; relationship between design and analyses; and strategies to maintain scientific integrity are covered. Topics include estimating and interpreting coefficients in mixed models, assessing model fit, and significance testing using SAS procures. Assignments will provide the student with hands on data analytic experience (with relevant SAS procedures). Prerequisite: Nursing 903. Department consent required. 3 units.

906. Qualitative Research Methodology. Focus is on theoretical and methodological aspects of interpretive research design. Discusses interpretive approaches from a variety of disciplines and philosophical traditions, with emphasis on the application of research designs and data collection and analysis techniques to nursing studies. The relevance of these approaches to advancement of knowledge and practice in nursing and healthcare is explored. Department consent required. 3 units.

907. Overview of Chronic Illness & Care Systems. This doctoral seminar will provide an overview of science and research on the trajectories of chronic illness and care systems and their intersection. Fall topics will include an overview of the trajectories model, patterns of human responses to chronic illness, approaches to understanding trajectories and development, the care systems and their intersection through which individuals and groups interact to change illness trajectories. Department consent required. 3 units.

908. Context of Chronic Illness & Care Systems. This course focuses on the environmental and organizational context of chronic illness. Faculty and students will explore competing theoretical perspectives and consider how each would guide an empirical study in a specific research area. In addition, students will be introduced to School research faculty and the research going on in the school. The seminar also addresses scholarly skill development including research synthesis, authorship, academic integrity, grant writing, and human subjects; issues with vulnerable populations. Department consent required. 3 units.

909. Intervention Research Methods in Health Care. Focus is on an in-depth coverage of research designs that address causal relationships as well as critical elements in the design and implementation of intervention studies. Example of topics covered include development of research questions, hypotheses, sampling methods, research designs (quasi-experimental and experimental), reliability and validity (construct, internal and external validity), and intervention fidelity in research around trajectories of chronic illness and care systems. Department consent required. 3 units.

910. Doctoral Seminar in Nursing Science Dissertation. In this doctoral seminar, the student will develop and write the dissertation proposal. Topics for discussion will include theoretical, substantive, and methodological issues in planning longitudinal research, mentored research experiences, and mentored teaching experiences. Department consent required. 3 units.

911. Introductory Statistics. This course is designed to be an investigation into statistical elements and analyses commonly used in health and behavioral sciences. Focus is on gaining an understanding of statistical elements and tests involved in health science research. Topics will include measures of central tendency and variability, hypothesis testing, descriptive statistics, correlation, t-tests, ANOVA, simple and multiple linear regression, logistic regression, and non-parametric procedures in SAS. A SAS training course is offered as part of the course. The course will examine statistical test assumptions for parametric test involved in nursing research. The student will apply concepts by entering, analyzing, and interpreting data sets using SAS procedures. This course will also provide students with the ability to critically think about research methodology and testing used in nursing research. Instructor consent required. 3 units.

912. Quantitative Observational Research Techniques. This course explores quantitative techniques for behavioral observation research. Strategies for developing coding systems, determining reliability and validity, and analyzing data are included. Instructor consent required. 3 units.

913. Advanced Qualitative Data Analysis. This is an advanced graduate-level course focused on the theory, techniques, and issues of qualitative data analysis and interpretation. The course is designed for graduate students who are taking qualitative/interpretative approaches to their research i.e. using qualitative forms of data and/or qualitative (non-numeric, interpretive) forms of analysis. This course is ideal for students in the late data gathering and analysis phase of their research, although students at the proposal writing and pre-data collection stage will also benefit. The course aims to give students knowledge and experience in applied qualitative analysis practices, but also to enhance their ability to articulate and address the core theoretical and methodological issues of qualitative inquiry. 3 units.

914. Mixed Methods Research. Understand the modes of qualitative and quantitative inquiry and the subsequent techniques for collecting, analyzing and interpreting data. Develop necessary skills and knowledge to identify and use different types of research designs and methods. Interpret published empirical studies using mixed methods designs. Produce written work that integrates qualitative and quantitative methods. 3 units.

915. Measurement Theory and Practice. Instrumentation in chronic illness and care system research involves measurement of biological, psychological and/or sociological phenomena. An overview of the theories, principles and techniques that yield reliable and valid measurement of those phenomena. Opportunities will be provided to evaluate the psychometric properties of measures with an emphasis on those designed to measure change over time. Students will have opportunities to evaluate and critique existing measures and/or develop a new measure. Course is designed to aid the student in writing the measurement section of research proposals and reports. 3 units.

916. Statistical Modeling and Data Analysis. This is a seminar course with flexible topics to meet students' needs for their data-based research. The topics will be selected, through a needs assessment of students' common interests, from a list of advanced modeling and analytical techniques that are widely used in the health and behavioral sciences, but may vary from semester to semester. Starting with forming research questions, students in this seminar class work under instructor's guidance and supervision, apply specific modeling and analytical techniques to the research questions, carry out the analysis on existing real-world empirical data, and summarize the research findings. Instructor consent required. 3 units.

917. Understanding Individual Health Behavior Change. Understanding the theories that explain and predict why and when individuals modify and maintain health behavior change is critical to advancing clinical care and public health. This course will review main theories and constructs of individual health behavior change. This will include review of evidence to support their utility to explain and predict health behavior change, how to influence and integrate theoretical constructs into intervention designs, and assessments of key constructs. Prerequisite: Nursing 909. 3 units.

918. Leadership in Science: The Role of the Nurse Scientist. In this doctoral seminar PhD students examine their future role as a steward of the discipline and leader in the field. They will explore several evidence-based leadership frameworks to assess their own strengths and areas in which they think they should develop additional skills. Students will be encouraged to think beyond their PhD program and how they will utilize leadership strategies to become powerful contributors and influencers in the field. Open only to PhD students in first year of their full-time program. 1 unit.

919. Using Large Secondary Datasets in Health Related Studies: Research Design, Data Mgmt. and Analyses. This course provides students with expertise in locating, evaluating, obtaining and utilizing large secondary datasets, including electronic health data, useful for health care related studies. Confidentiality requirements, ethical issues and development of data use agreements to facilitate access while protecting privacy are reviewed. The student gains experience in hands on use of a variety of data sets to answer specific questions, to inform population health problem definition and to design research studies that incorporate strengths of chosen datasets while minimizing data limitations. Students gain beginning expertise in using a LINUX server with SAS original programming. Completion of a graduate statistics course and completion of a graduate research course. Others with strong quantitative backgrounds by permission of instructor. Laptop with access to School of Nursing network is required. Students will be required to meet with School of Nursing IT personnel to obtain assistance in accessing network through laptop prior to first day of course. 3 units.

920. Doctoral Mentored Teaching Practicum. This practice will focus in 4 areas: Enhance the professional development of PhD students to socialize and prepare them for faculty roles in schools of nursing. Provide a mechanism for self-evaluation, discussions with mentors about strengths/weaknesses related to teaching and learning in nursing education. Develop and improve teaching skills in preparing for faculty roles. Cultivate relationships between faculty and students who share pedagogical interests. Variable credit.

921. Integrated Research Practicum. Students engage in a research practicum with an experienced researcher. The purpose of the practicum is to develop research skills through participation in the activities of the mentor's program of research. Activities may include grant development, research team meetings, protocol implementation, data analysis and dissemination. Consent required. Instructor: Staff. Variable credit.

923. Health Information Technology for Population Health Research. This PhD elective course will provide an introduction to health information technology (HIT) for population health research at the local, national, and international levels. This course will examine contemporary HIT that has been adapted to population health research. This course will have a particular emphasis on quantitative and qualitative empirical methods using HIT. This course will also provide computer-based learning experiences of using contemporary software tools to handle data with various algorithms of machine learning. Another important feature of this course will be an intensive analysis of ethical and methodological issues in conducting population health research using HIT. Completion of 1st Year PhD Program or permission of the instructor. 3 units.

924. Theories and Research in Population Health. This course will appraise the theoretical bases and research methods used in population health research across the lifespan and its application to nursing science. The adequacy of existing knowledge in specific areas of population health will be investigated, and assumptions that underlie the knowledge will be made explicit. An evaluation of effects of knowledge on nursing practice and health policy will be performed. This course draws upon an interdisciplinary body of scientific literature to evaluate theoretical perspectives and evidence on the distribution, causes, and consequences of health issues for diverse populations, as well as inequities between and within specific populations. Completion of 1st Year PhD Program or permission of the instructor. 3 units.

969. Disparities in Health and Health Care in the United States. This course is a graduate level introduction to health and healthcare disparities that draws upon an interdisciplinary body of scientific literature to evaluate perspectives and evidence on the distribution, causes, and consequences of inequalities in the United States. This class will focus on multiple levels of analysis from individual to provider-patient interactions to health care systems. Disparities will be discussed relative to race/ethnicity, sexual orientation, gender, and disabilities. Students should seek to critically reflect on their personal and professional roles in eliminating health and healthcare disparities. Master's degree in nursing or related field required. 3 units.

Pathology

Professor Huang, *Chair*; Professor Abraham, *Director of Graduate Studies*; Professors Abraham, Alam, Alman, Bigner, Chao, Dewhirst, Everitt, Friedman, Gunn, Hale, Haystead, Hoffman, Howell, Huang, Klotman, Krauss, Lawson, Nair, Nicchitta, Ortel, Patz, Piantadosi, Pizzo, Proia, Sampson, Staats, Sunday, Wang, and Yan; Associate Professors Bachelder, Becher, Cunningham, Datto, Devi, He, Levinson, Lin, Liton, Lylery, Malek, Marks, Murphy, Sempowski, and Telen; Assistant Professors Baht, Chandramohan, Chen, Fecci, Filiano, Hu, Lee, Levinson, Lopez, Macias, and McNulty

A PhD is available in this program.

The PhD program in the Department of Pathology is designed to train students for research and teaching careers in molecular

medicine and experimental pathology. Coursework aims to provide a clear understanding of disease processes, while focusing on modern molecular approaches to understanding and treating human disease. Research in the department covers the broad areas of inflammation, infectious diseases and vaccine design, tumor biology, and vascular biology in a multidisciplinary fashion, involving both basic scientists and clinician researchers. Further information can be obtained from the director of graduate studies or from the departmental website at https://pathology.duke.edu/.

Courses in Pathology (PATHOL)

725. Introduction to Systemic Histology. This course takes an organ system approach to microscopic identification of a variety of cell types and tissues in histologic sections, with an emphasis on the histology of normal organs. A laptop computer is required for virtual microscopy; contact the instructor if you need specific information before registering. Instructors: Hale. 3 units.

735S. Animal Models in Translational Research. Working knowledge of the use of animal models in research, types of models and how to choose for translational relevance. Topics include the regulations governing the use of animals in research, principles of in vivo experimental design, as well as best practices for data collection, interpretation and reporting during animal study conduct. Students will be exposed to the principle elements that impart variability and bias in the generation of animal study data, and will learn best practices for the conduct of high quality animal studies that lead to reproducible data. Instructor: Everitt. 3 units.

750. General Pathology. This course presents broad concepts of disease and underlying molecular mechanisms, including identification of pathologic processes via both gross examination and virtual microscopy. A laptop computer is required for virtual microscopy. Prerequisite: Pathology 725. Instructor: Hale. 3 units.

785. Molecular Aspects of Disease. Background, investigative methods, and recent advances in understanding the molecular basis of selected diseases. In-depth focus on selected diseases whose defects are known at genetic or molecular levels. Prerequisites: introductory cell biology and biochemistry courses. Instructors: Bachelder, He, and staff. 3 units.

786. Translational Aspects of Pathobiology. Translational Research in Pathobiology is an integrated multidisciplinary course designed to provide students with the necessary tools to understand the principal components of the research processes involving patients or materials obtained from a human source. This course reflects the Department of Pathology's unique integration of traditional pathology research with experimental therapeutics in an environment that seeks to bridge the basic sciences and clinical medicine. Instructor: Devi. 3 units.

787D. Basic Biology of Cells as a Function of Age; Implication for Disease. The objective of this course is to review the fundamentals of cell biology as a function of age and their contribution to pathologies associated with age-related diseases. This course will cover a wide range of principles, from concepts and theories of aging, to experimental models, cell regulation and signaling, and impact of age-related cellular changes on metabolism and disease development. Instructor: Malek and Liton. 3 units.

793. Research Independent Study. Permission of department required. Instructor: Staff. 4 units.

855S. Graduate Seminar in Pathology. Graduate students in the Pathology program present their research in a formal presentation. Instructor: Abraham. 3 units.

Pharmacology and Cancer Biology

Professor McDonnell, *Chair*; Associate Professor MacAlpine, *Director of Graduate Studies*; Professors Abou-Donia, Arshavsky (Opthalmology), Blobe (Medicine), Casey, Counter, Haystead, Heitman (Molecular Genetics and Microbiology), Huang (Pathology), Kastan, Kirsch (Radiation Oncology), Kornbluth, Kuhn, Levin (Biological Psychiatry), Lew, Li (Dermatology), McDonnell, McNamara (neurobiology), Miller (Medicine), Muoio (Medicine), Newgard, Patierno (Medicine), Patz (Radiology), Pendergast, Ramanujam (Biomedical Engineering), Rao (Ophthalmology), Schwartz-Bloom, Slotkin, Sullenger (Surgery), Thiele, Wang, Yan (Pathology), and Yao; Associate Professors Armstrong (Medicine), Campbell (Medicine), Chi (Molecular Genetics and Microbiology), Floyd (Radiation Oncology), Fox, Hirschey (Medicine), Hong (Chemistry), Jordt (Anesthesiology), Kontos (Medicine), Kwatra (Anesthesiology), Linardic (Pediatrics), Locasale, MacAlpine, MacIver (Pediatrics), Nackley (Anesthesiology), Sipkins (Medicine), Spector (Medicine), VonDongen, Wechsler (Pediatrics), and Whorton; Assistant Professors Alvarez, Cartoni, Goetz, Herman (Medicine), Tsvetanova, and Wood; Research Professor Mathey-Prevot

A PhD is available in this department.

The Department of Pharmacology and Cancer Biology offers graduate work leading to the PhD in pharmacology.

Pharmacology is the science of drug action on biological systems. It encompasses the study of targets of drug action, the mechanisms by which drugs act, the therapeutic and toxic effects of drugs, as well as the development of new therapeutic agents. As the study of pharmacology is interdisciplinary, the graduate Program in Pharmacology is diverse and flexible. The focus of the graduate Program in Pharmacology is to prepare qualified individuals for a career in independent research. The department currently has twenty-five primary faculty and thirty-one secondary faculty with primary appointments in departments such as molecular genetics and microbiology, cell biology, cardiology, medicine, and neurobiology. The collaborative and collegial atmosphere between faculty and students provides a wide diversity of research opportunities.

Courses in Pharmacology and Cancer Biology (PHARM)

533. Essentials of Pharmacology and Toxicology. Drug absorption, distribution, excretion, and metabolism. Structure and activity relationships; drug and hormone receptors and target cell responses. Instructor consent required. Prerequisite: introductory biology; Chemistry 201DL; Mathematics 21 and 122. Instructor: Slotkin and staff. 4 units. C-L: Neuroscience 533, Molecular Cancer Biology 533

534. Interdisciplinary Approach to Pharmacology. Several model systems (cancer, immunological disorders, and infectious diseases) will be used to explore the molecular, biochemical, and physiological basis of drug action. Consent of instructor required. Instructors: Wang or Staff. 4 units.

554. Mammalian Toxicology. Principles of toxicology as related to humans. Emphasis on the molecular basis for toxicity of chemical and physical agents. Subjects include metabolism and toxicokinetics, toxicologic evaluation, toxic agents, target organs, toxic effects, environmental toxicity, management of poisoning, epidemiology, risk assessment, and regulatory toxicology, Prerequisite: introductory biology, and Chemistry 201DL, or consent of instructor. Instructor: Abou-Donia and staff. 4 units.

631. Contemporary Topics in Membrane Biology. 2 units. C-L: see Biochemistry 631; also C-L: Cell and Molecular Biology 631, Neurobiology 631

680. Molecular Cardiovascular Biology. 2 units. C-L: Cell Biology 680

693. Research Independent Study in Science Education. Individual research in a field of science education (with reference to pharmacology) at the precollege/college level, under the supervision of a faculty member, resulting in a substantive paper or written report containing significant analysis and interpretation of study results. Open to all qualified seniors and graduate students with consent of supervising instructor. Instructor: Sawyer. 3 units.

694. Research Independent Study in Science Education. Individual research in a field of science education (with reference to pharmacology) at the precollege/college level, under the supervision of a faculty member, resulting in a substantive paper or written report containing significant analysis and interpretation of study results. Open to all qualified seniors and graduate students with consent of supervising instructor. Instructor: Sawyer. 3 units.

04-G-B

710. Papers and Grant Writing Workshop. 3 units. C-L: see Cell Biology 710; also C-L: Neurobiology 710, Molecular Cancer Biology 710

730. Stem Cell Course. 3 units. C-L: see Cell Biology 730; also C-L: Molecular Cancer Biology 730

733. Experimental Design and Biostatistics for Basic Biomedical Scientists. The use and importance of statistical methods in laboratory science, with an emphasis on the nuts and bolts of experimental design, hypothesis testing, and statistical inference. Central tendency and dispersion, Gaussian and non-Gaussian distributions, parametric and nonparametric tests, uni- and multivariate designs, ANOVA and regression procedures. Ethical issues in data handling and presentation. Student presentations in addition to formal lectures. Intended for third-year graduate students. Instructor consent required. Instructor: Slotkin. 2 units. C-L: Neurobiology 733, Cell and Molecular Biology 733, Biomedical Engineering 733, Molecular Cancer Biology 733

755. Neurotoxicology. Adverse effects of drugs and toxicants on the central and peripheral nervous system; target sites and pathophysiological aspects of neurotoxicity; factors affecting neurotoxicity, screening and assessment of neurotoxicity in humans; experimental methodology for detection and screening of chemicals for neurotoxicity. Instructor: Abou-Donia and staff. 3 units. C-L: Neurobiology 755

761. Cellular Signaling Module I: GPCR Signaling and Disease. 1 unit. C-L: see Cell Biology 761; also C-L: Biochemistry 761, Molecular Cancer Biology 761

762. Cellular Signaling Module II: Intracellular Signaling and Disease. 1 unit. C-L: see Cell Biology 762; also C-L: Biochemistry 762, Molecular Cancer Biology 762

763. Cellular Signaling Module III: Growth Factor Pathway in Development and Disease. 1 unit. C-L: see Cell Biology 763; also C-L: Biochemistry 763, Molecular Cancer Biology 763

780. Graduate Student Seminar. A presentation and discussion course in which program faculty and graduate students review recent progress in contemporary areas of Pharmacology and Cancer Biology. Provides an important avenue for evaluation and feedback for graduate student research and communication skills and is required for all students pursuing their PhD degree in Pharmacology and Molecular Cancer Biology. Instructor: Tsvetanova/Zhang. 2 units.

793. Research in Pharmacology. Laboratory investigation in various areas of pharmacology. Credit to be arranged. Instructor: Staff. Variable credit. C-L: Molecular Cancer Biology 793

814. Integrated Case Studies in Toxicology. 1 unit. C-L: see Environment 814

815. Focused Topics in Toxicology. 1 unit. C-L: see Environment 815

818. Molecular Mechanisms of Oncogenesis. 3 units. C-L: see Molecular Cancer Biology 818

835. Innovations in Drug Development. Introduction to major issues in developing a drug to treat a disease in an interdisciplinary lecture-based and team-based learning environment. Translation of principles in biomedical sciences, biomedical engineering, and chemistry along with innovative approaches to develop a hypothetical drug for treating a disease of choice. Hypothetical development of model compounds, target analysis, and in vitro and in vivo models to test drug efficacy. Course requires one of the following (or equivalent): Pharmacology and Cancer Biology 533, Chemistry 518, or Biomedical Engineering 577. Instructor: Bloom. 4 units. C-L: Innovation and Entrepreneurship 835

847S. Seminar in Toxicology. A weekly research seminar throughout the year is required of participants in the Toxicology Program. Students, faculty, and invited speakers present their findings. Instructor: Meyer. 1 unit. C-L: Environment 847S

848S. Seminar in Toxicology. 1 unit. C-L: see Environment 848S

Philosophy

Professor Janiak, *Chair*; Professor Norman, *Director of Graduate Studies*; Professors Adler (Law, Economics, and Public Policy), Brading, Brandon, Farahany (Law and Bioethics and Science Policy), Ferejohn, Flanagan, Gillespie (Political Science), Hoover, Janiak, McShea (Biology), Moi (English), Neander, Norman, Purves (Neurobiology), Rosenberg, Sinnott-Armstrong, Sreenivasan, and Wong; Visiting Professor van Inwagen; Associate Professors De Brigard and Pavese; Professors Emeriti Golding and Sanford; Associate Research Professor Hawkins

A PhD is available in this department.

The Department of Philosophy offers graduate work leading to the MA and PhD in philosophy.

Seminar discussion complements formal instruction. Students may, after taking a balanced program, specialize in any of the following fields: the history of philosophy (from ancient to twentieth century analytic), epistemology, metaphysics, philosophy of language, philosophy of mind, the philosophical foundations of cognitive science, moral psychology, normative ethics, metaethics, political philosophy, Chinese philosophy, philosophy of science, philosophy of biology, philosophy of social science, philosophy of law, philosophy of mathematics, and philosophical logic.

Individual programs of study are developed for each student. Prior to being admitted to candidacy for the PhD, the student must successfully complete fifteen courses distributed among five subject areas and pass an exam on a future research statement as well as a preliminary examination on the dissertation proposal. In satisfying these requirements, students are expected to demonstrate both factual knowledge and critical understanding. Work in a minor or related field, not necessarily confined to any one department, is encouraged but not required.

If a student's dissertation is devoted to any considerable extent to an author, that student must be able to read the author's works in the original language/s. Reading knowledge is demonstrated by either (1) receiving at least a grade of B in French 2, German 2, Greek 2, Latin 2, or other language course that the director of graduate studies has approved in advance, or (2) passing a departmentally administered translation exam.

All philosophy graduate students at Duke are either in the PhD program or in a joint-degree program, such as the JD/MA or JD/PhD programs. A terminal degree of master of arts may be earned by a PhD student who decides not to continue with doctoral studies and who meets the requirements of The Graduate School for the MA. Such a student must pass an oral master's examination, which may be the defense of a master's thesis or an alternative academic exercise approved by the department. The JD/MA and JD/PhD are offered by the department in cooperation with the Duke Law School. JD/MA students must apply for admission to the Duke Law School, and JD/PhD students must apply for admission to both the Duke Law School and The Graduate School. Both kinds of students must combine relevant coursework in philosophy with full-time work toward a law degree.

For further information about the PhD Program in Philosophy, please see or write Wayne Norman, Director of Graduate Studies, Department of Philosophy, Box 90743, 201 West Duke Building, Duke University, Durham, NC 27708-0743; or email him at wayne.norman@duke.edu. For more information, visit https://philosophy.duke.edu/. To inquire about the JD/MA and JD/PhD programs, applicants should contact the Duke Law School directly at the following address: Associate Dean of Student Affairs, Duke Law School, Box 90376, Duke University, Durham, NC 27708, or by calling (919) 613-7020.

Courses in Philosophy (PHIL)

502S. Comparative Ethics. Chinese and Western ethics compared, including conceptions of the virtues, the good life, right action, and the person. Instructor permission required. Instructor: Wong. 3 units.

503S. Contemporary Ethical Theories. The nature and justification of basic ethical concepts in the light of the chief ethical theories of twentieth-century British and American philosophers. Consent of instructor required. Instructor: Flanagan, Sreenivasan, or Wong. 3 units. C-L: Political Science 582S

506S. Responsibility. The relationship between responsibility in the law and moral blameworthiness; excuses and defenses; the roles of such concepts as act, intention, motive, ignorance, and causation. Instructor: Staff. 3 units.

508S. Political Values. Analysis of the systematic justification of political principles and the political values in the administration of law. Instructor: Norman or Sreenivasan. 3 units.

510S. Adversarial Ethics. Course attempts to identify general principles for designing the rules & regulations for deliberately adversarial institutions (ie; markets, electoral systems/legislatures, criminal law, warfare, sports). Looks at the special virtues of sportsmanship, professionalism, business ethics, etc. people are expected to follow within these hyper-competitive contexts. By examining ways the criteria for being an ethical businessperson, lawyer, soldier, and so on may differ from the criteria for simply being an "ethical person", this course seeks to prepare students for future professional roles in these adversarial domains. No formal pre-requisites. Instructor: Norman. 3 units. C-L: Political Science 585S, Study of Ethics 510S

511S. Plato. Selected dialogues. Instructor: Ferejohn. 3 units. C-L: Classical Studies 572S

512S. Aristotle. Selected topics. Instructor: Ferejohn. 3 units. C-L: Classical Studies 573S

536S. Hegel's Political Philosophy. 3 units. C-L: see Political Science 676S; also C-L: German 575S

537S. Nietzsche's Political Philosophy. 3 units. C-L: see Political Science 577S; also C-L: German 576S

538S. Problems in the Philosophy and Policy of Genomics. An examination of normative, methodological, and metaphysical issues raised by molecular biology, and its relations to other components of biology, including human behavior. Instructor: Rosenberg. 3 units.

539S. Race Theory: Biological Classification and Moral Implications. Topics to include: Biological classification theory and its applications to humans; The fit, or lack thereof, of biological categories and folk classifications of race; The historical/political motivations behind human racial classifications; The role of race in moral interactions; and The role of race in the construction of personal identity. Instructor: Brandon. 3 units.

541S. Historical and Philosophical Perspectives on Science. An integrated introduction to the nature of science and scientific change, and its impact on society. Counts as elective for the Science & Society Certificate Program. Instructor: Brading, Janiak, or Rosenberg. 3 units. C-L: Literature 521S, Gender, Sexuality, and Feminist Studies 541S, History 577S

550SL. Digital Publishing: Concepts and Practice. 3 units. C-L: see Information Science + Studies 550SL

551S. Epistemology. Selected topics in the theory of knowledge; for example, conditions of knowledge, skepticism and certainty, perception, memory, knowledge of other minds, and knowledge of necessary truths. Instructor: Staff. 3 units.

552S. Metaphysics. Selected topics: substance, qualities and universals, identity, space, time, causation, and determinism. Instructor: Staff. 3 units.

555S. Topics in Philosophy of Mind. One or more topics such as mental causation, animal minds, artificial intelligence, and foundations of cognitive science. Includes relevant literature from fields outside philosophy (for example, psychology, neuroscience, ethology, computer science, cognitive science). Instructor: De Brigard or Neander. 3 units. C-L: Neuroscience 555S

559. The Biological Basis of Music. 3 units. C-L: see Neurobiology 559; also C-L: Psychology 580

566S. Topics in Early Modern Political Thought from Machiavelli to Mills. 3 units. C-L: see Political Science 579S

570. Body Works: Medicine, Technology, and the Body in Early Twenty-First Century America. 3 units. C-L: see Information Science + Studies 670; also C-L: Literature 623

571. Ancient Political Philosophy. 3 units. C-L: see Political Science 575S; also C-L: Classical Studies 571S

572. Frankfurt School Critical Theory. 3 units. C-L: see German 570; also C-L: Political Science 570

573S. Heidegger. 3 units. C-L: see Political Science 581S

584S. Modern Political Theory. 3 units. C-L: see Political Science 584S

590. Special Topics in Philosophy Lecture. Topics vary each semester. Instructor: Staff. 3 units.

590S. Special Fields of Philosophy Seminar (Topics). Instructor: Staff. 3 units.

618S. Medieval Philosophy. Study of Augustine against background of late ancient Roman philosophy, and Thomas Aquinas and others against background of medieval Muslim philosophy, in particular Avicenna and Averroes, and Neoplatonism. Instructor: Staff. 3 units. C-L: Medieval and Renaissance Studies 669S

625S. British Empiricism. A critical study of the writings of Locke, Berkeley, or Hume with special emphasis on problems in the theory of knowledge. Instructor: Janiak. 3 units.

627S. Continental Rationalism. A critical study of the writings of Descartes, Spinoza, or Leibniz with special emphasis on problems in the theory of knowledge and metaphysics. Instructor: Janiak. 3 units.

628S. Recent and Contemporary Philosophy. A critical study of some contemporary movements, with special emphasis on analytic philosophers. Instructor: Staff. 3 units. C-L: Linguistics 528S

629S. Topics in the History of Philosophy. Topics in one or more periods in the history of philosophy (for example, ancient, medieval, or modern) such as skepticism, mind-body relations, the nature of persons and personal identity, the relation between physics and metaphysics, causation and explanation. Instructor: Flanagan, Ferejohn, Janiak, or Rosenberg. 3 units.

631S. Kant's Critique of Pure Reason. Instructor: Janiak. 3 units.

633S. Methodology of the Empirical Sciences. Recent philosophical discussion of the concept of a scientific explanation, the nature of laws, theory and observation, probability and induction, and other topics. Consent of instructor required. Instructor: Brandon or Rosenberg. 3 units.

634S. Problems in the Philosophy of Biology. Selected topics, with emphasis on evolutionary biology: the structure of evolutionary theory, adaptation, teleological or teleonomic explanations in biology, reductionism and organicism, the units of selection, and sociobiology. Consent of instructor required. Instructor: Brandon, Neander, or Rosenberg. 3 units. C-L: Biology 555S

640S. Philosophical Psychology. A study of recent work on the nature of the self and the nature and function of consciousness. Work from philosophy, psychology, cognitive neuroscience, and evolutionary biology will be discussed. Instructor: Flanagan or Neander. 3 units.

650S. Topics in Formal Philosophy. Topics selected from formal logic, philosophy of mathematics, philosophy of logic, or philosophy of language. Instructor: Staff. 3 units.

678S. Pragmatism. A study of the philosophical school of American Pragmatism. Involves close reading, discussion, and analysis of the major pragmatist philosophers of the late 19th and early 20th centuries, including Peirce, James, and Dewey, as well as more recent pragmatists, such as Rorty. Topics include pragmatic analyses of belief, action, will, and experience and their applications to human inquiry, scientific method, ethics, and political philosophy. Instructor: Hoover. 3 units.

681S. Wittgensteinian Perspectives on Literary Theory. 3 units. C-L: see Literature 681S; also C-L: English 582S

692S. Bioethics. Course offers a graduate-level intro to bioethics. Topics include the history of bioethics; research ethics; limit setting in health care; and reproductive ethics. Course primarily intended for seniors and graduate students. Instructor: Hawkins or Sreenivasan. 3 units.

01-G-B

701S. Seminar in Special Fields of Philosophy. Instructor: Staff. 3 units.

702S. ProSeminar in Metaphysics and Epistemology. Close study of texts which drove the development of analytic philosophy &

informed current research. Covers texts any analytic philosopher needs to be familiar with. Discussion-based classroom sessions focus on one or two key texts with corresponding reading questions and assigned weekly 2-3 page philosophical essay. Instructor: Staff. 3 units.

703S. Proseminar in Ethics. Foundational course for first and second year PhD students only. Complements the pro seminar in metaphysics and epistemology. Pro seminars aim to build cohort cohesion among entering PhD students/equip them with PhD level skills in textual analysis and philosophical writing. Seminar examines classic or important contemporary articles in ethics or political philosophy, as selected by instructors. Instructor: Staff. 3 units.

711. Philosophy and Medicine. The scope of medicine as a philosophical problem, the concept of health, and investigation of ethical issues arising in medical contexts. Consent of instructor required. Instructor: Staff. 3 units.

717S. The Evolution of Bioethics in the 20th Century. This course will address important themes in Bioethics and how they evolved through the 20th Century. Issues will include the ethical conduct of human subjects research (including study of misadventures like the Tuskegee syphilis project); contemporary thought regarding end-of-life decisions; the effect of advancing technology on ethical reasoning regarding pregnancy (prenatal genetic testing, the changing limits to viability of newborns, and attitudes toward abortion); research in children; and the issues of public health like quarantine and the right to refuse vaccination. Instructors: McKinney, Sreenivasan, Baker, Humphreys, Lyerly. 3 units.

753S. Principles in Cognitive Neuroscience I. 3 units. C-L: see Psychology 759S; also C-L: Neurobiology 759S

754S. Principles in Cognitive Neuroscience II. 3 units. C-L: see Psychology 760S; also C-L: Neurobiology 760S

785S. Philosophy of Biology. Interdisciplinary discussion group focused on topics in the philosophy of biology. No formal prerequisites, though a background in philosophy or biology is desirable. This course is repeatable over multiple semesters. Instructor: Staff. 0.5 units.

790. Philosophy Special Topics. Instructor: Staff. 3 units.

790S. Seminar in Special Fields of Philosophy. Instructor: Staff. 3 units.

795S. Seminar in Teaching Philosophy. Source of pedagogical instruction for graduate students assigned as teaching assistants or course instructors in philosophy courses. Faculty advice about syllabi preparation, discussion of problems that can arise in the college classroom, etc. Course is repeatable across multiple semesters. Instructor: Staff. 0.5 units.

796S. Work in Progress Seminar. For students enrolled in the doctoral program in philosophy. Practice interviews (including filming when possible), mock job talks, etc. Course is repeatable across multiple semesters. Instructor: Staff. 0.5 units.

797S. Dissertation Seminar. Seminar required in the spring semester for grad students going on the job market the following fall. Each student presents material from their dissertation, for discussion with the other graduate students in the seminar and the faculty instructor. Vital part of students preparation for the job market. Note: student must have passed doctoral qualifying examination. Course is repeatable across multiple semesters. Instructor: Staff. 0.5 units.

798S. Philosophical Interlocution. For Philosophy Doctoral Students only: required for all students in residence. Frequently includes meetings with Colloquia speakers to discuss background or related topics. Course is repeatable across multiple semesters. Instructor: Staff. 0.5 units.

863S. Eastern & Western Conceptions of Human Nature, Ethics, & Politics. Course deals with differences of value by understanding a variety of traditions: explores conceptions of human nature & how these connect with views about the good human life, duties, responsibilities, rights, & proper forms of political governance. International team leads discussions from comparative & cross-cultural perspectives. Critically examines Western sources, Chinese/Korean sources, Hindu, Buddhist, & Jain sources- analyzing how these ideas shape contemporary Western/East Asian/South Asian culture. All in context of contemporary scientific sources on human nature from psychology, anthropology, & primatology. Instructor: Flanagan or Wong. 3 units.

947S. Philosophy and Literature. Looks at what defines subject matter/boundaries/methodologies/products of analytic philosophical discourse & literature (mostly novels & plays). Central question: Are there ways of treating philosophical problems in ethics, epistemology, & metaphysics that are well-suited to expression in literature than in standard analytic philosophical discourse? Discusses advantages/disadvantages of different idioms, disciplines for addressing phil problems; what lit can teach about phil problems relating to mind/morals/meaning of life. Prior to seminar students study A. J. Ayer's Language, Truth and Logic, (seminar's exemplar for analytic philosophy). Approved course for PAL Certificate. Instructor: Flanagan. 3 units. C-L: Literature 882S

950S. Neurophilosophy. Status of such concepts of the 'self,' 'person,' 'free will' in the age of mind science. Conflict between scientific and humanistic images of persons. Varieties of naturalism, neurophilosophy, and neurophenomenology Explanation, prediction, correlations, identitites, reduction, levels, laws, functions, and mechanisms in mind science. The logical relations between neurobiology, cognitive, and affective neuroscience, cognitive science, psychology, and social science(s). Instructors: Flanagan or De Brigard. 3 units. C-L: Psychology 950S

951S. Free Will and Moral Responsibility in light of Philosophy & Neuroscience. Discusses selection of recent work on issues like: What is free will? Is it compatible with determinism? With Indeterminism? With external sources for our actions? Does free will require reasons-responsiveness? Second-order endorsement? Do our (mental) wills really cause our (physical) actions? How is free will related to moral responsibility? Is anyone ever fully morally responsible? Why does it matter? Do people who lack moral responsibility ever deserve to be punished? Students encouraged to develop their own views. Instructor: Sinnott-Armstrong. 3 units.
Philosophy, Arts, and Literature

Professor Moi, *Director of Graduate Studies*

A certificate is available in this program.

Requirements

This certificate does not originate in an existing department with a clearly defined body of knowledge to be mastered by all. It is an attempt to meld different disciplines by working on similar or connected questions.

- Five graduate-level courses approved by the steering committee, taken two per semester. Each course must satisfy at least one of the following criteria:
  - engages a specific art form in relation to a key philosophical or aesthetic concept;
  - explores the nature of an art form and connects it to key philosophical or aesthetic concepts;
  - examines the connection between philosophy and at least one other art form**;**
  - focuses on at least one writer/artist and connects them with philosophically informed reflection on the dynamics of form, meaning and/or performance;
- focuses on at least one key work or number of works, connecting then with philosophically informed reflections on creativity, the nature of specific art forms, questions of historicity and creativity, ethics and aesthetics;
- present a research paper at a workshop at Duke after completion of at least four of the graduate level courses required; or interdisciplinary experience. Students must take courses in a minimum of three different departments.

For more information, visit https://dukepal.org/certificate/.

Philosophy of Biology

Professor Brandon, *Director of Graduate Studies*

A certificate is available in this program.

The Duke Center for the Philosophy of Biology offers a formal interdisciplinary graduate certificate in the philosophy of biology. The program draws upon coursework and faculty from the Duke departments of biology and philosophy, as well as from those at The University of North Carolina at Chapel Hill and North Carolina State University. It is designed to enable students with substantial backgrounds in one of the two disciplines to learn about the major issues that animate research and scholarship on the intersections between biology and philosophy. The philosophy classes enable students to acquire experience in methods of philosophical analysis and to explore the broader philosophical background of problems in the philosophy of biology. The biology classes provide exposure to theoretical questions in biology that raise conceptual issues, to experimental methods and quantitative modeling with substantive and often unarticulated philosophical implications. Students generally apply to the program in their first or second years of doctoral study.

The interdisciplinary certificate will require at least two graduate-level seminars in the philosophy department in philosophy of biology, at least two graduate-level courses in evolutionary and/or developmental biology in the biology department; a directed reading class supervised by a faculty member in the Center for the Philosophy of Biology, which eventuates in a capstone research paper; and regular participation in the philosophy of biology seminar over a two-year period. The certificate will have as prerequisites prior enrollment in at least one 100-level class in the philosophy of science or the philosophy of biology, and at least two courses in biology at the 100 level.

Requirements

Draws resources from Duke philosophy and biology departments, as well as from The University of North Carolina at Chapel Hill and North Carolina State University. Students enter the certificate program during their first or second year of graduate work. Certificate prerequisites are

- prior enrollment in a minimum of one 100-level course in the philosophy of science, or philosophy of biology; and
- prior enrollment in at least two 100-level courses in biology;

Additional requirements

- two graduate-level seminars in philosophy of biology (philosophy department);
- two graduate-level courses in evolutionary and/or developmental biology (biology department);
- directed reading class supervised by a faculty member in the center;
- Capstone research paper; and
- regular seminar participation over a two-year period (philosophy of biology).

For more information, visit https://philosophy.duke.edu/graduate/certificates.

Photonics

Professor Wax, *Director of Graduate Studies*

A certificate is available in this program.

The purpose of the graduate Certificate Program in Photonics is to broaden the scope of the typical disciplinary graduate student education program. Students are encouraged to develop interdisciplinary and transferable sets of skills in their coursework and research activities. The program is designed to accommodate both master's of science and PhD students who have been admitted to one of the participating departments. The certificate program helps to guide students toward this broad view by requiring the completing of an introductory course in photonics; three courses from the approved course listing; one formal presentation in the Fitzpatrick Institute Seminar Series; attend at least four Fitzpatrick Institute Seminars a year (as documented by the student's advisor); and if the student is pursuing a PhD, one member of the FIP should be on the PhD dissertation committee. For more information about the program, contact Adam Wax, Box 90281, Duke University Fitzpatrick Center, Durham, NC 27708; (919) 660-5143.

Requirements

- For PhD candidate, one member of the FIP must be on the PhD dissertation committee.
- Certificate accommodates both terminal MS and PhD students who have been admitted to one of the participating departments (biomedical engineering, electrical and computer engineering, computer science, mathematics, chemistry, physics).
- Four photonics courses from the approved course listing, of which one course must be a qualified "Introductory Survey Course"

(See the certificate course list at https://fitzpatrick.duke.edu/education/certificate).
- One research presentation for the Fitzpatrick Institute Student Groups. The director of graduate studies will maintain list of approved student seminar series.
- Attend one semester of Optics and Photonics Seminar Series (Biomedical Engineering 609/ Electrical and Computer Engineering 549/ Physics 549).

For more information, visit https://fitzpatrick.duke.edu/education/certificate.

Physics

Professor Bass, *Chair*; Professor Scholberg, *Associate Chair for Teaching*; Associate Professor Teitsworth, *Director of Graduate Studies*; Professors Aspinwall, Baranger, Bass, Beratan, Bray, Brunel, Calderbank, Chandrasekharan, Chang, Curtarolo, Dobbins, Driehuys, Edwards, Finkelstein, Gao, Greenside, Howell, Johnson, Kim, Kotwal, Kruse, Liu, Mehen, Mueller, Oh, Petters, Plesser, Rubinstein, Samei, Schmidt, Scholberg, Smith, Socolar, Springer, Walter, Warren, Wax, Wu, and Yang; Associate Professors Arce, Barbeau, Charbonneau, Delaire, Lu, Mikkelsen, and Teitsworth; Assistant Professors Barthel, Haravifard, Kapadia, Marvian, Scolnic, Troxel, and Vossen; Lecturers Brown and Roy; Professors Emeriti Evans, Goshaw, Palmer, Roberson, Robinson, Thomas, Tornow, and Weller; Adjunct Professors Ahmed, Champagne, Everitt, Fischer, and Gauthier

A PhD is available in this department.

The Department of Physics offers graduate work for students wishing to earn the PhD in physics.

In addition to a balanced program of core graduate courses, the department offers specialized courses and seminars in several fields in which research is being done by faculty and staff. With the help of faculty advisors, students select a course program to fit their individual backgrounds and goals, often including work in a related field. Students are encouraged to begin research work early in their careers, normally not later than the end of their first year in the program. Active areas of research include experimental studies in astrophysics, atomic physics, accelerator physics, biophysics, condensed matter, high energy, nonlinear, nuclear, optics and quantum information physics, as well as theoretical work in condensed matter, nonlinear, nuclear and particle physics, astrophysics, cosmology, and string theory. In addition, the physics department is a major participant in the university-wide Center for Nonlinear and Complex Systems and the Center for Theoretical and Mathematical Science.

Courses in Physics (PHYSICS)

501. Survey of Nonlinear and Complex Systems. Survey lectures by Duke experts active in CNCS research; regular attendance in the CNCS seminar series; and a weekly meeting to discuss the lectures and seminars. May be repeated once. Prerequisite: Physics 513. Instructor: Staff. 2 units. C-L: Nonlinear and Complex Systems 501

505. Introduction to Nuclear and Particle Physics. Introductory survey course on nuclear and particle physics. Phenomenology and experimental foundations of nuclear and particle physics; fundamental forces and particles, composites. Interaction of particles with matter and detectors. SU(2), SU(3), models of mesons and baryons. Weak interactions and neutrino physics. Lepton-nucleon scattering, form factors and structure functions. QCD, gluon field and color. W and Z fields, electro-weak unification, the CKM matrix, Nucleon-nucleon interactions, properties of nuclei, single and collective particle models. Electromagnetic and hadronic interactions with nuclei. Nuclear reactions and nuclear structure, nuclear astrophysics. Relativistic heavy ion collisions. Prerequisite: for undergraduates, Physics 464, 465; for graduate students, Physics 764, which may be taken concurrently. Instructor: Oh. 3 units.

509. Quantum Nanophysics. Quantum phenomena in nanostructures, emphasizing interference, dimensionality, and electron interactions. Uses current research topics to introduce fundamental building blocks of the subject, thereby providing in addition a background in solid-state physics. Topics covered may include: graphene, carbon nanotubes, and topological insulators; scanning tunneling microscopy; quantum point contacts and quantum dots; spintronics, single electronics, and molecular electronics; superconducting qubits; giant and colossal magnetoresistance; quantum Hall effect. Emphasis placed on phenomena observed in the last two decades. Prerequisite: Physics 464 or instructor consent. Instructor: Baranger. 3 units.

513. Nonlinear Dynamics. Introduction to the study of temporal patterns in nonequilibrium systems. Theoretical, computational, and experimental insights used to explain phase space, bifurcations, stability theory, universality, attractors, fractals, chaos, and time-series analysis. Each student carries out an individual research project on a topic in nonlinear dynamics and gives a formal presentation of the results. Prerequisite: Computer Science 101, Mathematics 216, and Physics 161D, 162D, or equivalent. Instructor: Staff. 3 units. C-L: Computer Science 524, Nonlinear and Complex Systems 513

516. Quantum Materials: Introduction to Solid State Physics. Microscopic structure of solids, liquids, liquid crystals, polymers, and spin systems; elastic scattering and long-range order; topological defects; electronic structure of crystals (metals and semiconductors); phonons and inelastic scattering; magnetism; superconductivity. Recommended prerequisite: Physics 464, 465, and 563. Instructor: Baranger. 3 units.

522. Special and General Relativity. Review of special relativity; ideas of general relativity; mathematics of curved space-time; formation of a geometric theory of gravity; Einstein field equation applied to problems such as the cosmological red-shift and blackholes. Prerequisite: Physics 361 and Mathematics 216 or equivalents. Instructor: Plesser. 3 units.

549. Optics and Photonics Seminar Series. 1 unit. C-L: see Electrical and Computer Engineering 549; also C-L: Biomedical Engineering 609

555. Introduction to Cosmology. Cosmology is the study of the origin, structure and evolution of the Universe itself. The goal of this course is to provide an advanced undergraduate or introductory graduate description of the “standard” big bang theory of the Universe, the Lambda-Cold Dark Matter model, that includes recent experimental developments. Topics include: the observational and theoretical basis for the model; spacetime and the Friedmann-Lemaitre-Robertson-Walker metric; big bang cosmology and the Universe’s contents and dynamics; the cosmic microwave background; formation of galaxies, large-scale structure, and gravitational lensing; dark matter and dark energy; current and future observational experiments. Recommended prerequisite: Physics 361 and

Mathematics 216 or Physics 264L. Instructor: Troxel. 3 units.

556. Stellar Astrophysics. This course surveys the key physics of stellar structure, interiors, and evolution. The focus is on the essential concepts for understanding dynamical processes in stars, the relevant equations and their approximate solutions. Topics include: timescales, scaling relations, equations of state, radiative transfer, convection, nuclear reactions and rates, white dwarfs, neutron stars, and supernovae. We will aim throughout the course to impart a better physical and intuitive understanding of the essential meaning of the equations, processes, and principles that govern stars of all sort, and of their universality. The intended audience is graduate students and upper-level undergraduates. Prerequisite: Physics 305. Instructor: Scolnic. 3 units.

562. Fundamentals of Electromagnetism. Electrostatics, Laplace's equation, multipole expansion, dielectrics, magnetostatics, magnetization, Maxwell equations, gauge transformations, electromagnetic waves, Fresnel equations, and waveguides. Prerequisite: Physics 362 or equivalent and 560. Instructor: Staff. 3 units.

563. Introduction to Statistical Mechanics. Fundamentals of kinetic theory, thermodynamics and statistical mechanics with applications to physics and chemistry. Undergraduate enrollment requires consent of director of undergraduate studies. Prerequisite: Physics 464. Instructor: Finkelstein. 3 units.

566. Computational Physics. Introduction to numerical algorithms and programming methodologies that are useful for studying a broad variety of physics problems via simulation. Applications include projectile motion, oscillatory dynamics, chaos, electric fields, wave propagation, diffusion, phase transitions, and quantum mechanics. Prerequisites: Physics 264L and 363. Experience with a programming language is desirable, but can be acquired while taking the course. Instructor: Walter. 3 units.

567. Theoretical Neuroscience. Introductory course on theoretical neuroscience. Neuronal biophysics: ions, membranes, channels. Single neuron models: Hodgkin-Huxley, 2D reductions, phase plane analysis. Leaky integrate-and-fire model, response to stochastic inputs. Models of synapses and synaptic plasticity. Models of networks at various scales. Network dynamics: rate models, networks of spiking neurons. Coding and decoding by single neurons and populations of neurons. Unsupervised learning, supervised learning, reinforcement learning. Adequate for any graduate student in physics or other quantitative fields (mathematics, statistics, engineering, computer science) and undergraduate majors in such fields. Instructor: Brunel. 3 units. C-L: Neuroscience 567

590. Selected Topics in Theoretical Physics. Topics vary as indicated on Physics Department Web site. Consent of Instructor required. Instructor: Staff. 3 units.

603. Representation Theory. 3 units. C-L: see Mathematics 603

621. Advanced Optics. This course presents a rigorous treatment of topics in Photonics and Optics targeted at students with an existing photonics or optics background. Topics will include, Optical Sources, Statistical Optics and Coherence Theory, Detection of Radiation; Nonlinear Optics; Waveguides and Optical Fibers; Modern Optical Modulators; Ultrafast lasers and Applications. These topics will be considered individually and then from a system level perspective. Prerequisite: Electrical and Computer Engineering 340L or equivalent. Instructor: Adam Wax. 3 units. C-L: Electrical and Computer Engineering 541, Biomedical Engineering 552

622. General Relativity. This course introduces the concepts and techniques of Einstein's general theory of relativity. The mathematics of Riemannian (Minkowskian) geometry will be presented in a self-contained way. The principle of equivalence and its implications will be discussed. Einstein's equations will be presented, as well as some important solutions including black holes and cosmological solutions. Advanced topics will be pursued subject to time limitations and instructor and student preferences. Prerequisite: A familiarity with the special theory and facility with multivariate calculus. Instructor: Aspinwall. 3 units. C-L: Mathematics 527

627. Quantum Information Science. 3 units. C-L: see Electrical and Computer Engineering 523

655. Astrophysics. An introductory survey of astrophysics with an emphasis on topics of current interest. Introduction to General Relativity, Stellar and Galactic Evolution, Standard Cosmology, Big-Bang Nucleosynthesis, Early Universe, Neutrino Astrophysics, Supernovae and Cosmic Rays, Special Topics. Prerequisites: Physics 361, 362, 363, 464; Physics 465 is recommended. Instructor: Staff. 3 units.

671. Quantum Optics. The linear and nonlinear interaction of electromagnetic radiation and matter. Topics include lasers, second-harmonic generation, atomic coherence, slow and fast light, squeezing of the electromagnetic field, and cooling and trapping of atoms. Prerequisite: Physics 465 and 560. Instructor: Staff. 3 units.

01-G-B

715. Advanced Quantum Mechanics I. Third semester of graduate quantum mechanics sequence. Angular momentum and symmetries in quantum mechanics from group theory viewpoint; formal scattering theory; many body quantum mechanics; identical particles; path integral applications; quantization of electromagnetic field; relativistic treatment of spin-1/2 particles. Prerequisite: Physics 464 and Physics 465 or equivalent. Instructor: Springer. 3 units.

719. Advanced Electrodynamics. Lienard-Wiechart potentials, scattering theory, radiation theory, MHD and plasmas. Prerequisite: Physics 562. Instructor: Staff. 3 units.

721. Introduction to Accelerator Physics. Aspects of modern accelerator physics; operation of a variety of accelerators from electron microscopes to large ring machines; phenomena responsible for stability and instability of particle beams. Prerequisite: Physics 561, 562 or equivalents. Instructor: Staff. 3 units.

732. Advanced Quantum Optics. Advanced theory of light-matter interactions. Density matrix and semiclassical Bloch-Maxwell equations, three level laser and nonlinear spectroscopic methods. Superradiance in extended media. Electromagnetic field quantization and radiative damping, master equation approach. Noise and fluctuations, first and second order coherence for classical and quantum fields. Dressed state picture of laser cooling. Prerequisite: Physics 715 Instructor: Staff. 3 units.

745. Accelerator Physics for USPAS. Introduction to the physics of modern particle accelerators, their design and critical

engineering concepts. Topics might include beam dynamics, experimental beam physics, plasma acceleration, the designs of storage ring, cyclotrons, superconducting linacs, induction accelerators, and FELs. May also include critical engineering topics such as vibration control, cryogenics, vacuum systems, and large-scale metrology. .01 Fundamentals of Accelerator Physics .02 Accelerator Physics .03 Experimental Beam Physics .04 Special Topics in Accelerator Physics Lectures by USPAS instructors. Instructor consent required. Instructor: Staff. 3 units.

752S. Seminar Techniques. Discussion of ways of presenting seminars and participating in follow-on question periods. Each student is required to present at least one seminar on an appropriate research topic. Instructor: Staff. 1 unit.

760. Mathematical Methods of Physics. Includes topics in probability theory, complex analysis, asymptotic expansions, group theory, Fourier analysis, Green functions, ordinary and partial differential equations; and use of Mathematica. Instructor: Arce. 3 units.

761. Classical Mechanics. Lagrangian and Hamiltonian formalisms for describing the dynamics of classical systems including point particles, rigid bodies, and continuous media; principle of least action; symmetries, conservation laws, and Noether's theorem; small oscillations about stable equilibria; canonical transformations and canonical perturbation theory; Euler and Navier-Stokes equations for describing fluid motion including laminar and turbulent flows; dynamical properties of elastic solids; additional possible topics include wave propagation on strings and membranes, driven dissipative systems, and nonlinear dynamical systems. Instructor: Barbeau. 3 units.

762. Electrodynamics. Maxwell's equations, special relativity, covariant formulation of electrodynamics, conservation laws, electrostatics, magnetostatics, boundary conditions, electromagnetic induction, electromagnetic waves, and elementary radiation theory. Instructor: Mehen. 3 units.

763. Statistical Mechanics. Canonical and grand canonical ensembles, quantum statistics, ideal Bose and Fermi systems, classical non-ideal gases, virial expansion, phase transitions, fluctuations, transport coefficients, non-equilibrium processes. Instructor: Chandrasekharan. 3 units.

764. Quantum Mechanics. Angular momentum and symmetries in quantum mechanics from group theory viewpoint; time-independent and time-dependent perturbation theory; path integral formulation; scattering theory; identical particles; applications. Instructor: Baranger. 3 units.

765. Advanced Quantum Mechanics. Concepts of quantum fields and canonical quantization; non-relativistic quantum mechanics in Fock space; Hamiltonians for relativistic particles; Dirac Hamiltonian and spin-half particles; Hamiltonians for lattice vibrations, phonons, and scalar particles; electromagnetic field quantization; gauge symmetry and the Hamiltonian for photons; global symmetries and spontaneous symmetry breaking; interactions of atoms with the electromagnetic field; density matrix; the path integral formulation; entanglement; interacting bosons and superfluidity; interacting fermions and superconductivity; additional possible topics include coherent state path integral methods for bosons and fermions. Instructor: Barthel, Chandrasekharan. 3 units.

766S. Physics Research Seminar. Series of weekly presentations on research projects under investigation in the department. Credit/No credit grading only. Instructor: Warren. 1 unit.

771. Mini-Course on Current Research in Physics. One-third semester mini-course covering selected topics of current research in Physics. Topics course. Instructor: Staff. 1 unit.

772. Mini-Course on Methods for Physics Research. One-third semester mini-course covering selected experimental, computational, and/or theoretical methods used in physics research. Topics course. Instructor: Staff. 1 unit.

781. Quantum Field Theory. Classical field theory, symmetries and conservation laws, representations of the Lorentz Group, canonical quantization, Feynman diagrams and perturbation theory, elementary quantum electrodynamics, radiative corrections, renormalization. Prerequisite: Physics 464, 465 and 715. Instructor: Chandrasekharan. 3 units.

782. Advanced Quantum Field Theory. Study of a variety of topics in quantum field theory, selected from nonabelian gauge theory, anomalies, instantons, super-symmetry, topological defects, large-N techniques, spontaneous symmetry breaking, effective potentials, and finite temperature methods. Prerequisite: Physics 781. Instructor: Mehen. 3 units.

804. Advanced Topics in Statistical Mechanics. This course will vary from year to year. Possible topics include Fermi liquids, systems of bosons, many-body theory, nonequilibrium statistical mechanics. Prerequisite: Physics 763 and 816. Instructor: Staff. 3 units.

805. Electromagnetic and Weak Interactions in Nuclear Physics. Elcectromagnetic interaction, Compton scattering, electron scattering, parity-violating electron scattering, weak interaction, neutrino physics, fundamental symmetry studies using ultra-cold neutrons, neutron beta decay, neutron electric dipole moment, CP-violations, Standard Model tests at low energies. Prerequisites: Physics 464, 465, 505 and 715. Instructor: Staff. 3 units.

806. Radiation Detection. Introduction to detection of charged particles, photons and neutrons. Emphasis on active detector techniques: ionization detectors, scintillators and semiconductors; some passive methods mentioned. Quick review of radiation interaction with matter, followed by general detector characteristics, practical measurement techniques, signal processing and brief overview of radiation protection. Prerequisite: Core courses in graduate physics program. Instructor: Staff. 3 units.

808. Introduction to High-Energy Physics. An overview of elementary particles and forces studied by experiments carried out at the frontier of high-energy physics. Discussion of basic symmetry principles and conservation laws of nature and review of their experimental tests. Development of the quark model of hadrons and comparisons with observed particle spectra. Review of the Standard Model by comparing predictions to current experimental measurements. Instructor: Staff. 3 units.

810. Advanced Solid-State Physics. Advanced energy band theory; Fermi liquid theory; many-body Green functions and diagrammatic techniques; interacting electron gas; superconductivity; applications. Prerequisite: Physics 607 or equivalent. Instructor: Staff. 3 units.

813. Advanced Topics in Nonlinear and Complex Systems. Survey of current research topics that may include: advanced signal analysis (wavelets, Karhunen-Loeve decomposition, multifractals), bifurcation theory (amplitude and phase equations, symmetry breaking), spatio-temporal chaos, granular flows, broken ergodicity, complexity theory of dynamical systems, and adaptive systems (genetic algorithms, neural networks, artificial life). Emphasis on quantitative comparisons between theory, simulations, and experiments. Not open to students who have taken Computer Science 313. Prerequisite: Computer Science 524 or Physics 513; recommended: Physics 560, 563, or equivalent. Instructor: Staff. 3 units. C-L: Computer Science 724

814. Introduction to Fluid Mechanics. Fundamentals of fluid dynamics. Ideal fluids, viscous fluids, turbulence, boundary layers, heat conduction, relativistic fluids. Prerequisite: Physics 560 and 231. Instructor: Staff. 3 units.

816. Advanced Quantum Mechanics II. Quantum physics of systems of many identical particles, symmetrization, anti-symmetrization, scattering theory, Born approximation, WKB approximation, partial wave expansion, optical theorem, quantization of continuous systems, one-dimensional string, electromagnetic field, spontaneous emission, second quantization. Prerequisite: Physics 715. Instructor: Staff. 3 units.

846. Topics in Theoretical Physics. Topics vary; check Physics Department Web site. Consent of instructor required. Instructor: Staff. 3 units.

861S. Physics of Free-Electron Lasers. Seminar course on the basic physical mechanisms and effects responsible for emission and amplification of radiation by electron beams moving through transverse fields. Prerequisite: Physics 719 and 816. Instructor: Staff. 3 units.

995. Graduate Training Internship. Designed to allow graduate student in Physics to engage in internship lab work and doctoral study with external agencies and institutions for credit, when determined necessary for degree completion. Laboratory work and analysis can be conducted at external institution with permission of immediate faculty supervisor. Permission of instructor required. Instructor: Staff. 1 unit.

Political Science

Professor Vanberg, *Chair*; Associate Professor Leventoglu, *Associate Chair and Director of Graduate Studies (Master's)*; Professor Beardsley, *Director of Graduate Studies (PhD)*; Professors Beardsley, Beramendi, de Marchi, Feaver, Gillespie, Grieco, Hillygus, Kitschelt, Knight, Kuran, Malesky, Manion, McClain, McCubbins, Munger, Niou, Price, Remmer, Rohde, Siegel, Vanberg, and Wibbels; Associate Professors Beardsley, Haynie, Johnston, Kirshner, Leventoglu, Stegmueller, and White; Assistant Professors Fresh, Jardina, Rousseliere, and Schubiger; Associate Professor of the Practice Maghraoui; Professors Emeriti Fish, Grant, Holsti, Hough, Horowitz (law), Johns, McKean, Paletz, Spragens, and Ward; Research Professors Emeriti Brennan, Keech, and Soskice; *Secondary Appointments*: Professors Hacohen (History), Jentleson (Public Policy), Kelley (Public Policy), Krishna (Public Policy), Rosenberg (Philosophy), N. Siegel (Law), and Vaisey (Sociology); Associate Professors Atkins (Classical Studies), Bermeo (Public Policy), Carnes (Public Policy), Goss (Public Policy), Hacohen (History), and Mullin (Environment); Assistant Professors Barnes (Public Policy), Johnson (Public Policy), and Rose (Public Policy); Adjunct Professors Lawrence, Liu (Asian & Middle Eastern Studies), MacKuen, and Stimson; Associate Professor of the Practice Charney (Public Policy); Professor Emeritus Mickiewicz (Public Policy)

A master's degree and a PhD are available in this department.

The Department of Political Science offers graduate work leading to the MA and PhD in political science.

Instruction is designed to prepare the student primarily for teaching and research. Instruction is currently offered in the following fields: political economy; behavior and identity; security, peace, and conflict; political methodology; normative political theory and political philosophy; and political institutions.

The candidate for the degree of doctor of philosophy in political science must demonstrate competence in at least two general fields of the discipline by taking four courses in each field. The candidate must also fulfill a methodology requirement, consisting of four courses; pass a qualifying exam in the major field; pass a preliminary exam, consisting of the defense of an article-length research paper; and write a satisfactory dissertation.

The terminal degree of master of arts is awarded following successful completion of: (1) eight one-semester courses of 3 course credits each, at least half of which must be in political science; (2) six course credits of ungraded research (thesis option) or two additional courses of 3 course credits each (non-thesis option); 3) complete and defend a thesis or a non-thesis portfolio of two research papers completed during the students' coursework. In addition, candidates for the degree must demonstrate competence in one foreign language or in statistics.

These requirements for the degree apply both to students enrolled in the terminal program and to students originally enrolled in the PhD program who decide to end their involvement in the PhD program with a terminal degree.

Further details on the graduate Program in Political Science, the departmental facilities, the staff, and available financial aid may be obtained from the director of graduate studies, Department of Political Science.

Related Coursework in the Duke University School of Law

Students at the Duke School of Law earning a MA degree in political science along with the JD degree may take four courses (12 course credits) in political science as part of their required 84 course credits for the JD. To be eligible to receive the MA, they must complete four additional courses in political science, for a total of eight, and complete and defend a thesis or choose the non-thesis option. The courses chosen must be approved by the director of graduate studies. Further details on the Program in Political Science may be obtained from the director of graduate studies, Department of Political Science.

Courses in Political Science (POLSCI)

501S. Politics and Media in the United States. The impact of the media of communication and new technologies on American political behavior, government, politics, issues and controversies. Development of critical interpretive skills and arguments as students

write research papers assessing the media's political influence and effects. Instructor: Staff. 3 units.

502S. Understanding Ethical Crisis in Organizations. 3 units. C-L: see Study of Ethics 562S; also C-L: Sociology 542S, Public Policy 558S

503S. Crisis, Choice, and Change in Advanced Democratic States. Contributions of Marx, Weber, and Durkheim toward analysis of modern democracies. Examination of selected contemporary studies using these three perspectives to highlight processes of change and crisis. Unsettling effects of markets upon political systems, consequences of bureaucratic regulation, and transformation of sources of solidarity and integration in modern politics. Instructor: Kitschelt. 3 units.

504S. Comparative Ethnic Politics. Why and when ethnicity becomes a salient cleavage for political mobilization and the conditions under which ethnic collective action may take violent or non-violent forms. Approaches to the study of social identities; types of ethnic collective action, including non-violent (electoral participation and social protest) and violent ones (riots, rebellions, civil war, and terrorism); and main normative debates in favor and against ethno-cultural group rights. Comparisons include Latin America, Africa, Europe, and South Asia. Instructor: Staff. 3 units.

505S. Race in Comparative Perspective. Comparative study of the way race is socially constructed in the United States, several European, Latin American, and other countries. The real effects of this social construction on the social and political lives of communities of color in these countries. Instructor: McClain. 3 units. C-L: International Comparative Studies 505S

507S. Religion and Comparative Politics. The relationship between states, societies, and religious institutions in contemporary world politics. Theories that emphasize the explanatory role of religious ideas, religious market structures, and different socio-economic and political conditions. Major focus on Christianity (Catholicism, Protestantism and Evangelicalism) mostly in Latin America, Western and Central Europe, and the United States. Attention also to Islam and Hinduism in Africa, the Middle East, and India. Instructor: Staff. 3 units.

508S. Public Opinion and Behavior. Several facets of the political behavior of mass actors in American politics. Likely topics include the factors that cause the type and amount of individual participation, mobilization by elites, ideology and information, partisanship, partisan stability and change, socialization, macro-level change, negative advertising, economic voting, issue evolution, and the effects of institutional changes (especially election rules) on voter turnout. Consent of Instructor required. Instructor: Aldrich or Hillygus. 3 units.

509S. Political Participation: Comparative Perspectives. The study of political participation through development of an understanding of relevant research methods. The effects of political culture on political participation. Popular participation and mobilization systems in liberal democracies and developing countries. Instructor: Staff. 3 units. C-L: International Comparative Studies 511S

515S. Post War Europe, 1945-1968: Politics, Society, and Culture. 3 units. C-L: see History 537S; also C-L: International Comparative Studies 537S

516S. Rule of Law. An investigation, employing both historical and conceptual analysis, of the idea of the rule of law. Several classic and contemporary texts will be considered. Topics include: the nature of law; the relationship between law and morality; the relationship between the rule of law and politics; the role, if any, of the rule of law in facilitating social and economic development; and the ways in which the rule of law might be institutionalized in modern society. Permission of instructor required. Instructor: Knight. 3 units.

517S. Democratic Institutions. How constitution makers choose basic rules of the democratic game, such as the relations between legislatures and executives, the role of parties, electoral system, prerogatives of constitutional courts, and other important elements of democratic institutional design; the impact of such arrangements on various groups within the state, and the overall performance of democracies; durability of arrangements, the structuring of power relations among parties, and whether democratic institutions affect economic and social policy outcomes. Instructor: Kitschelt. 3 units.

518. The Politics of Health Care. 3 units. C-L: see Public Policy 635

519. The American Party System. Role of political parties and the party system in the origin and perpetuation of democratic politics. Critical evaluation of different theories and models of the origins, structures, and activities of American political parties and their contribution to maintenance of a democratic society. Development of original research or critical evaluation of research findings using an extensive array of evidence, including statistical estimation and formal modeling. Instructor: Aldrich. 3 units.

520S. Congressional Policy-Making. Lawmaking and oversight of the executive branch by the U.S. Congress. Committee, party, executive, and interest group roles. Instructor: Rohde. 3 units.

521S. Gender, Identity, and Public Policy. 3 units. C-L: see Public Policy 530S; also C-L: Gender, Sexuality, and Feminist Studies 515S

522S. Comparative Party Politics. The concepts, models, and theories employed in the study of political parties in various competitive democracies. Focus on advanced industrial democracies where there is a rich empirically oriented literature on this topic. The resurgence of democracy in developing areas and the role of party competition and democracies in these regions of the world. Instructor: Kitschelt. 3 units.

525S. Race and American Politics. A broad overview of the salience of race in the American political fabric and how it structures racial attitudes on a number of political and policy dimensions. Instructor: McClain. 3 units. C-L: African & African American Studies 544S, Public Policy 526S

526S. Markets and Democracy in Latin America. Explores the interaction between markets and democracy in Latin America in relationship to broader theoretical and substantive debates in the field of comparative politics. Addresses competing theoretical perspectives on the interaction between markets and democratic institutions; focuses upon issues of regime change and consolidation with emphasis on the political economy of democratic transitions and institutional change; and examines the politics of market-oriented

reform in the new international context of regional development with emphasis on policy formation in Latin America. Instructor: Staff. 3 units.

527S. Global Africa. 3 units. C-L: see Cultural Anthropology 561S; also C-L: African & African American Studies 510S, History 561S, International Comparative Studies 510S

528S. Peace and Conflict Processes. Understanding the causes of armed conflict, as well as strategies to prevent, manage and resolve it. Course readings from the academic literature. Writing developed in a multi-part assessment of an ongoing conflict that includes simulation of a peace process and a final research paper. Prerequisite: Political Science 160S. Instructor: Beardsley. 3 units.

536S. Choosing in Groups: Social Choice and Collective Action. Survey of problems of social choice and collective action in politics and economics. Representing preferences, indifference, geometric representation of trade-offs. Consideration of Arrow Problem and Olson Problem of Collective Action. Instructor consent required. Prerequisite: Political Science 342 or equivalent. Instructor: Munger. 3 units.

542S. The Global Cold War. 3 units. C-L: see Public Policy 556S; also C-L: History 556S

543. Counterterrorism Law and Policy. 3 units. C-L: see Public Policy 504

544. 9/11: Causes, Response & Strategy. 3 units. C-L: see Public Policy 561; also C-L: International Comparative Studies 561

545S. International Environmental Regimes. Law, politics, and institutional design of international regimes created among nations to cope with environmental problems. Includes study of particular conventions and treaties (for example, acid rain, ozone, carbon reduction, biodiversity, Antarctica, regional seas, ocean dumping), and the environmental implications of international trade rules and regimes (for example, GATT). Instructor: Staff. 3 units. C-L: Public Policy 581S, International Comparative Studies 521S

546S. Assisting Development. 3 units. C-L: see Public Policy 515S; also C-L: International Comparative Studies 514S

547. Politics of United States Foreign Policy. 3 units. C-L: see Public Policy 506; also C-L: International Comparative Studies 506

549S. Collective Action, Property Rights, and the Environment. The rational choice tradition (public goods, collective action, game theory, property rights, new institutionalism) as applied to environmental problems, resource exploitation, environmental justice, and the design of an environmentally sound society. Instructor: Staff. 3 units. C-L: Environment 544S

550S. Predicting Politics: Counter Insurgency, Elections, and Stability. Learn modes of predicting political events and outcomes. Survey of ways that are used to predict US National Presidential and Congressional elections, as well as polls. During election years, will focus on active campaigns. Second half of course devoted to prediction of conflict outbreaks around the world. Students will develop their own data, models, and forecasts for political processes. Pre-requisites: 300 level course in the subfield as well as all general requirements in the major: Political Science 102, 175, and Statistics 101. Instructor: Staff. 3 units.

551S. Voting Behavior. A research-centered seminar focusing on models of voting behavior. Voting behavior includes individual voting by citizens in democracies but also voting by politicians in a variety of contexts (e.g., national legislatures or the United Nations). Methods employed will range from applied statistics to game theory to more recent innovations in the areas of computational social science and machine learning. Students will produce a journal length article. Instructor: Demarchi. 3 units.

555S. The Politics of Market Competition in a Global Economy. Course examines history and contemporary political, economic, and legal aspects of industrial policy and its development in East Asia. Explores evolution of economic competition or business-state relations thought and practice in East Asia over the past century, the recent rapid spread of innovative policies, as well as domestic and international conflicts and cooperation over competition policy. Students will write original research papers on a related topic of their own choosing. Instructor: Staff. 3 units. C-L: Study of Ethics 555S, Public Policy 555S

561S. Problems in International Security. States attempt to secure their population and territory. Such security measures sometimes bring states into conflict with each other. Course explores how states search for security, cooperate with one another, and engage in interstate violence. Instructor: Staff. 3 units.

562S. American Grand Strategy. Study of policy that nations adopt to marshal their political, economic, military, technological, and diplomatic resources to achieve their national goals in the international environment they face, drawing on political science, history, public policy, law and political economy and other disciplines to achieve these ends. Course examines the history, current reality, and future prospects of American grand strategy. Consent of instructor required. Instructor: Feaver or Miles. 3 units. C-L: History 567S, Public Policy 501S

570. Frankfurt School Critical Theory. 3 units. C-L: see German 570; also C-L: Philosophy 572

573S. Intellectual History and Political Theory. 3 units. C-L: see History 541S

574S. Dissent, Disobedience and Revolution. Examines boundaries of democratic practice - including hate speech, protest, and secession. Key topics in democratic theory will be addressed including scholarly debates over free speech, civil disobedience, and justified revolution. Readings include works by Mill, Locke, Waldron, Buchanan, Cristiano, Elster. Instructor: Kirshner. 3 units.

575S. Ancient Political Philosophy. Intensive analysis of the political philosophy of Plato, Aristotle, and other ancient theorists. Research paper required. Instructor: Gillespie or staff. 3 units. C-L: Classical Studies 571S, Philosophy 571

576. Politics and Philosophy of Self and Other. Epistemological, ontological, ethical, and political dimensions of relations between self and other. Theorists may include Husserl, Merleau-Ponty, Levinas, Derrida, Adorno, Gadamer, Sartre, Foucault, and Bakhtin. Instructor: Staff. 3 units.

577S. Nietzsche's Political Philosophy. Study of the thinker who has, in different incarnations, been characterized as the prophet of nihilism, the destroyer of values, the father of fascism, and the spiritual source of postmodernism. An examination of his philosophy as a whole in order to come to terms with its significance for his thinking about politics. Instructor: Gillespie. 3 units. C-L: German 576S, Philosophy 537S

578S. Contemporary Theories of Democracy. Seminar has three aims: (a) to introduce students to some important topics and approaches in contemporary democratic theory; (b) to investigate the ways in which these issues are related to broader discussions about the strengths and weaknesses of democracy and the rule of law; (c) to familiarize students with a range of strategies for justifying or criticizing political arrangements or policies. Topics include social justice, individual rights and community, representation, deliberation, the relationship between democratic decision-making and markets and the normative implications of moral, religious and ideological pluralism. Instructor: Knight. 3 units. C-L: Study of Ethics 578S

579S. Topics in Early Modern Political Thought from Machiavelli to Mills. Topics vary from semester to semester. Topics course. Instructor: Staff. 3 units. C-L: Philosophy 566S

580S. Social Theory and Social Practice. Comparison and critique of answers given by philosophers and social theorists to the questions: what can we know about society and what is the practical utility of that knowledge? Theorists and topics include Aristotle, early modernity's "new science of politics," Marxist praxis, Weber's "wertfrei" science, Mill's logic of the "moral sciences," Comte's sociology, Mannheim's sociology of knowledge, behaviorism and its critics, and the vocation of social science. Instructor: Staff. 3 units.

581S. Heidegger. An examination of the philosophy of Martin Heidegger from its phenomenological beginnings to its postmodernist conclusions with particular attention to its meaning for questions of identity, history, nihilism, technology, and politics. Instructor: Gillespie. 3 units. C-L: Philosophy 573S

582S. Contemporary Ethical Theories. 3 units. C-L: see Philosophy 503S

583S. Thucydides and the Realist Tradition. Focus on Thucydides as a foundational text in the international relations tradition of realism. Issues include human nature; the relationship between self-interest and moral norms; conceptions of power; and motivations of justice. Readings will include Thucydides' History, selections from Hobbes' Leviathan, evidence from the post-Napoleonic and post-World War I periods, and modern interpretive studies. Instructor: Staff. 3 units.

584S. Modern Political Theory. A historical survey and philosophical analysis of political theory from the beginning of the seventeenth to the middle of the nineteenth century. The rise of liberalism, the Age of Enlightenment, the romantic and conservative reaction, idealism, and utilitarianism. Instructor: Staff. 3 units. C-L: Philosophy 584S

585S. Adversarial Ethics. 3 units. C-L: see Philosophy 510S; also C-L: Study of Ethics 510S

586S. Political Thought in the United States. American political thought and practice through the Civil War period. A critical analysis of the writing of our founders and their European antecedents. Focus on the philosophical and political debates and the underlying ethical and political issues found in the debates over the Constitution, slavery, and the Union. Instructor: Gillespie or staff. 3 units.

587S. Free Speech, Hate Speech, and Civil Disobedience. What justifies free speech? When can it be limited legitimately? What justifies civil disobedience? Is violent resistance ever justified? Answering these questions will constitute the key work of this course. Students will debate these questions by confronting key works in political philosophy and by thinking through how these theoretical questions come up in debates over: the regulation of pornography and hate speech, the ridiculing of religious figures, and the use of violence to protest unjust policies. Readings include works: Mill, Locke, King, Langton, Waldron, Shelby and Rawls. Instructor: Kirshner. 3 units.

588S. Toleration, Freedom of Conscience, and Religious Liberty. 3 units. C-L: see Classical Studies 564S; also C-L: Religion 564S, History 564S

589S. The Black Radical Tradition: COVID-19, #JusticeForGeorgeFloyd, and the Movement for Black Lives. 3 units. C-L: see African & African American Studies 503S; also C-L: Religion 503S, Cultural Anthropology 503S, International Comparative Studies 504S

590-1. Intermediate Topics in Political Theory. Intermediate topics in political theory. Instructor: Staff. 3 units.

590-2. Intermediate Topics in Political Institutions. Intermediate topics in political institutions. Instructor: Staff. 3 units.

590-3. Intermediate Topics in Security, Peace, and Conflict. Intermediate topics in security, peace, and conflict. Instructor: Staff. 3 units.

590-4. Intermediate Topics in Behavior and Identities. Intermediate topics in behavior and identities. Instructor: Staff. 3 units.

590-5. Intermediate Topics in Political Methodology. Intermediate topics in political methodology. Instructor: Staff. 3 units.

590-6. Intermediate Topics in Political Economy. Intermediate topics in political economy. Instructor: Staff. 3 units.

590S-2. Intermediate Topics in Political Institutions. Intermediate topics in political institutions taught in seminar format. Instructor: Staff. 3 units.

590S-3. Intermediate Topics in Security, Peace and Conflict. Intermediate topics in security, peace, and conflict taught in seminar format. Instructor: Staff. 3 units.

590S-4. Intermediate Topics in Behavior and Identities. Intermediate topics in behavior and identities taught in seminar format. Instructor: Staff. 3 units.

590S-5. Intermediate Topics in Political Methodology. Intermediate topics in political methodology taught in seminar format. Instructor: Staff. 3 units.

590S-6. Intermediate Topics in Political Economy. Intermediate topics in political economy taught in seminar format. Instructor: Staff. 3 units.

610S. Political Persuasion. Course will examine political persuasion and democratic decision-making, with particular attention paid to US presidential campaigns. Explores what techniques political elites use to attempt to influence mass opinions and behaviors;

who is likely to be influenced by such appeals; and the role of the mass media. Readings drawn from political communication, political psychology, and political behavior. Instructor: Hillygus. 3 units.

616S. Persistence and Change in Political Institutions. Persistence and Change in Political Institutions. International and domestic institutions in world politics; focus on causes and mechanisms of institutional persistence and change in comparative perspective. Examines, for instance, evolution of political-economic institutions under the impact of globalization. Instructor: Staff. 3 units.

617S. The Regulatory Process. 3 units. C-L: see Public Policy 609S

618S. Politics of Institutional Change. Research seminar focusing on the political economy of institutional change with emphasis on less industrialized and emerging market nations. Open to undergraduates with permission of the instructor. Instructor: Staff. 3 units.

619. Media and Social Change. 3 units. C-L: see Policy Journalism and Media Studies 676; also C-L: Public Policy 676, Russian 516

630. Probability and Basic Regression. Offers an introduction to empirical methods used in contemporary research in political science. Course develops an applied understanding of the linear regression model in the context of political science research questions. Students will be able to evaluate and interpret allied aggression results as well as develop their own simple models. Required of all incoming graduate students. Open only to Political Science graduate students. Instructor: Staff. 3 units.

631L. Introduction to Deductive & Analytical Approaches to Political Phenomena. Introduction to deductive and analytical approaches currently used to study political phenomena, with focus on fundamentals of non-cooperative game theory. Students will become good consumers of applied game theoretic research as well as be able to develop some simple game theoretic models of political phenomena. Required of all incoming graduate students. Instructor: Leventoglu or Niou. 3 units.

632. Computational Political Economy. Introduction to the field of computational modeling. Emphasis on conducting formal replicable investigations of political phenomena with clearly defined assumptions and hypotheses. Study of current literature in cognitive psychology, political psychology, and experimental economics. Instructor: de Marchi. 3 units.

633S. Positive Political Theory. Introduction to generating hypotheses and building theory in political science. Focus on general principles of deductive and computational modeling, how theoretical models connect to empirical tests, and several of the main schools of theoretical modeling in political science including game theory and social choice. Course is expected to be taken simultaneously with Political Science 748. Open only to Political Science graduate students. Instructor: Staff. 3 units.

634. Social Networks and Political Interdependence. Theory of and empirical support for importance of networks and interdependent behavior in political and social processes. Methodology covered includes tools for empirical analysis of relational data as well as game theoretic and computational/behavioral modeling approaches to analyzing role of network structure. Substantive ties to literatures in political science, economics, and sociology. Instructor: Siegel. 3 units.

642S. Global Inequality Research Seminar. 3 units. C-L: see Public Policy 645S; also C-L: African & African American Studies 642S, Economics 541S, Sociology 642S, Human Rights Program-Franklin Humanities Institute 642S

644S. The Political Economy of Inequality. Study of the concept and measurement of inequality; evolution of inequality across concepts, space, time (developed and developing world); what explains this evolution; and political consequences of inequality. Instructor: Beramendi. 3 units.

645S. Political Economy of Growth, Stabilization and Distribution. Examines why some nations are rich and others poor; whether financial crises are inevitable; whether economic growth reduces poverty, increases inequality, or both. Addresses extent to which answers to these questions are under human control. Instructor: Staff. 3 units. C-L: Economics 548S

646S. The Politics of European Integration. Politics and institutions of the European Union (EU) and the historical process that led to it. Theoretical perspectives discussed include classics of integration theory (neofunctionalism, intergovernmentalism) but also theories of state formation, delegation, and distributional politics (EU comparatively as instance of common political phenomena). Social constructivist, gender, and Marxist theories also considered. Research papers on process of European integration or contemporary EU politics. Instructor: Staff. 3 units.

647S. International Democratization. 3 units. C-L: see Public Policy 513S

650S. Political Economy of International Relations. Provides an intensive investigation of the major political-economic actors and their interactions in the modern world economy: states, multinational enterprises, and international institutions. Serves as capstone experience for undergraduate students who are pursuing Political Economy or Security, Peace and Conflict as concentrations in political science, or who are pursuing a certificate in Markets and Management. Designed to help graduate students prepare for the qualifying exam in Security, Peace and Conflict and in Political Economy, and to provide them with an opportunity to conduct sustained research in these two fields. Instructor: Grieco. 3 units.

651S. Theories of International Political Economy. Advanced discussion of core issues and the research frontier in IPE (trade, finance, economic development, globalization). Focus on theoretical debates over the source of preferences, the role of power and institutions, conflict and cooperation in the world economy. Instructor: Staff. 3 units. C-L: Public Policy 651S

652S. Repression and State Violence. This course engages with research on state-sanctioned violence against individuals and groups. Topics covered include the relationship between repression, state violence, and political order; the perceived (il)legitimacy of different types of state violence; logics and effects of state-sanctioned violence against different segments of civilian populations in times of war and peace; patterns of human rights violations around the globe; repression in democratic and autocratic regimes; mass killings; disappearances; police violence; mass incarceration; the war on drugs; the implications of new information and communication technologies for repressive practices and surveillance. Instructor: Schubiger. 3 units.

658S. Political Economy of Terrorism. Seminar in the formal, quantitative study of subnational terrorism. Addresses historical terror examples, aggregate and individual determinants of terrorism, mobilization and terror networks, methods of terror and counter-

terror and their consequences, organization of and competition between terror groups. Focuses on unsolved problems and opportunities for research. Instructor: Siegel. 3 units.

659S. Civil Wars. In-depth examination of internal armed conflict. Exploration of micro and macro level approaches to causes of civil wars; types of civil wars; ethnicity and conflict; warfare; repertoires and dynamics of violence in conflict; armed group organizations and their tactics; relationship between armed groups and the state; duration and termination of internal conflicts; consequences of conflict and processes of transitional justice after conflict termination. Overview of both classical and more recent works on these topics. Instructor: Staff. 3 units.

660S. Theories of International Conflict. Social science literature review of the causes of international conflict emphasizing the theories concerning the causes of war. Objectives of course: to identify the strengths and weaknesses of the literature concerning the causes of war; to define specific questions and issues which must be addressed by future research; and to develop concrete research strategies for investigating these questions. Instructor: Staff. 3 units.

661S. Courts, Wars, Legacies of Wars. The impact of international wars, international policing, and domestic wars relating to national security on the United States courts of the Fourth Circuit (Maryland, Virginia, West Virginia, North and South Carolina), and the role played by these courts in the Mid-Atlantic South from the American Founding into the Cold War Era. The American Constitution, laws, and treaties of the United States, and principles of admiralty and international law which figure in assigned published and unpublished judicial decisions of the region's United States district and old circuit courts and of the post-1891 Fourth Circuit Court of Appeals. Research paper required. Also taught as Law 548S. Instructor: Staff. 3 units. C-L: History 562S

662S. Problems in International Politics. The development and critical analysis of various models in political science and economics that focus on the relationship between international economics and international security. Various models of the impact of political-military dynamics on international economic relationships, and the impact of international economics on the likelihood of war and peace among nations. Attention to the interplay between economics and security in a key region of the world—East Asia. Prerequisite: one course in international relations, foreign policy, or diplomatic history. Instructor: Staff. 3 units.

663S. Energy and U.S. National Security. 3 units. C-L: see Public Policy 583S; also C-L: Environment 583S

663SK. Energy and National Security. 3 units. C-L: see Public Policy 583SK; also C-L: Environment 583SK

664S. Leaders, Nations, and War. The interaction between state structures and the international system, with a focus on the rise and development of European nations. Topics include war and its effects on national political institutions, nationalism, and state formation; war and national revolution; imperialism and decolonization; and economic dependency and national autonomy. Research paper required. Prerequisite: Political Science 160. Instructor: Grieco. 3 units. C-L: International Comparative Studies 664S

665S. Theory and Practice of National Security. In-depth look at the theoretical and empirical literature explaining how states seek to guarantee their national security. Topics include: grand strategy, nuclear deterrence and warfighting, coercive diplomacy, military intervention, decisions for war, and civil-military relations. Special attention paid to U.S. national security during and after the Cold War. Consent of instructor required. Instructor: Feaver. 3 units.

667S. American Civil-Military Relations. Theory and practice of relations between the military, society, and the state in the US. Special attention paid to how civil-military relations play out in the use of force. Other topics include: public opinion, casualty sensitivity, and the role of the military in partisan politics. Consent of instructor required. Instructor: Feaver. 3 units. C-L: Public Policy 667S

668S. Theory and Practice of International Security. Analysis and criticism of the recent theoretical, empirical, statistical, and case study literature on international security. This course highlights and examines potentially promising areas of current and future research. No prerequisite, but Political Science 160 recommended. Instructor: Staff. 3 units.

670S. Contemporary United States Foreign Policy. 3 units. C-L: see Public Policy 502S

675S. Economy, Society, and Morality in Eighteenth-Century Thought. Explorations of eighteenth-century topics with a modern counterpart, chiefly (a) self-interest, liberal society, and economic incentive; and (b) the passions, sociality, civic virtue, common moral sensibilities, and the formation of taste and opinion. Original texts: for example, Bacon, Newton, Shaftesbury, Mandeville, Hutcheson, Hume, Smith, Hogarth, Burke, Cato's Letters, Federalist Papers, Jane Austen. Stress on integrating economic and political science perspectives. Open only to seniors majoring in either political science or economics. Not open to students who have had Economics 312. Prerequisite: Economics 205D and Economics 210D. Instructor: De Marchi and staff. 3 units. C-L: Economics 547S

676S. Hegel's Political Philosophy. Within context of Hegel's total philosophy, an examination of his understanding of phenomenology and the phenomenological basis of political institutions and his understanding of Greek and Christian political life. Selections from *Phenomenology*, *Philosophy of History*, and *Philosophy of Right*. Research paper required. Instructor: Gillespie. 3 units. C-L: Philosophy 536S, German 575S

677S. Contemporary Continental Political Thought. Exploration and assessment of the major theories (critical theory, hermeneutics, post-structuralism) and thinkers (Adorno, Habermas, Gadamer, Foucault, Derrida) of European political thought from World War II to the present. Themes addressed include alienation, power, liberation, social construction of identity. Research paper required. Instructor: Staff. 3 units.

678S. Democracy and Constitutionalism. Study of the essential questions of constitutional democracy and constitutional law: what makes democracy valuable and how constitutions work and are interpreted. Class will provide a strong foundation in both constitutional and political theory. Readings include works by Hamilton, Dahl, Ely, Dworkin, and Ackerman. Instructor: Kirshner. 3 units.

679S. The Past and Future of Capitalist Democracy I. Intensive examination of theories of capitalism and democracy. Will study whether democracy and capitalism conflict; whether either is viable and self-correcting in the long term; competing theories of freedom, equality, and progress; relevance of ecological limits, sustainability, and resilience; alternative perspectives, including socialism and

traditional conservatism. Attention to current debates, such as Piketty and inequality, climate change; major engagement with founding theorists of these issues, including Adam Smith, J.S. Mill, Marx, Schumpeter, with constant attention to contemporary relevance. Available for single semester but Intended as first half of yearlong course. Instructor: Purdy. 3 units.

680S. The Past and Future of Capitalist Democracy II. Continuation of POLSCI 679S The Past and Future of Capitalist Democracy I. Intensive engagement with core texts and arguments concerning the relationship between markets and democracy, economics and politics: special attention to equality and inequality, ecological limits, and the challenges of the post-2008 crisis period. Readings include F. Hayek, K. Polanyi, J. Dewey, W. Lippmann, F. Hirsch, F. Fukuyama, T. Piketty. Instructor: Purdy. 3 units.

681S. Law and Philosophy. Seminar will engage in an investigation of the concept of law. Employ both historical and conceptual analyses of several texts, both classic and contemporary. Topics include: the nature and legitimacy of law; the relationship between law and morality; the relationship between law and politics and the concept of the rule of law. Instructor: Knight. 3 units.

682S. Legal Analysis for Development Governance. 3 units. C-L: see Public Policy 647S

683S. Theology and Political Philosophy. Course will examine the transformation of theology and political philosophy in the period between Aquinas and Dante until Montaigne and Bacon. Understanding the changes in thinking about God, man, and the natural world during this period is essential to understanding modernity. While a knowledge of Christianity is essential in this enterprise, we obviously cannot cover all of the earlier Christian material in even the most rudimentary way in the course of the semester, we will look at some that is essential. Instructor: Gillespie. 3 units.

684S. Republicanism. Study of the republican political theory and its historical tradition. Emphasis on key concepts of this tradition, including freedom as non-domination, virtue, the mixed constitution and the common good. Study and comparison of the Roman Republic, English, American, Italian and French republican trends. Readings include Cicero, Machiavelli, Milton, Montesquieu, Rousseau, Arendt and contemporary neo-republican scholarship. Instructor: Rousseliere. 3 units.

685S. Social Contract Theory. Course investigates the use of social contract as a device to legitimize specific forms of social and political organization. Explores the origins of the social contract tradition, its most influential iterations in early modern philosophy and its revival in contemporary philosophy. Will study the role of social contract theory in the rise of liberalism, the question of the legitimacy of the state and the right to resistance. Course will also ask about the limits and exclusions intrinsic to the social contract as it has developed historically. Instructor: Rousseliere. 3 units.

686S. Injustice, Domination and Exploitation. What is injustice? Why is it wrong if one group dominates another? How does exploitation work? Is imperialism wrong, necessarily? Recent years have witnessed a surge of theoretical and philosophical inquiry into the nature and forms of injustice including misogyny, racism and economic exploitation. Will read and discuss works by a diverse range of authors like Tommie Shelby, Kate Manne and Miranda Fricker. Will encounter classic works on the nature of justice by authors like John Rawls. Course has no prerequisites, but previous course work in political theory, philosophy and related subjects may be helpful. Instructor: Kirshner. 3 units.

690-1. Advanced Topics in Political Theory. Advanced topics in political theory. Instructor: Staff. 3 units.

690-2. Advanced Topics in Political Institutions. Advanced topics in political institutions. Instructor: Staff. 3 units.

690-3. Advanced Topics in Security, Peace and Conflict. Advanced topics in security, peace and conflict. Instructor: Staff. 3 units.

690-4. Advanced Topics in Political Behavior and Identities. Advanced topics in political behavior and identities. Instructor: Staff. 3 units.

690-5. Advanced Topics in Political Methodology. Advanced topics in political methodology. Instructor: Staff. 3 units.

690-6. Advanced Topics in Political Economy. Advanced topics in political economy. Instructor: Staff. 3 units.

690S-1. Advanced Topics in Political Theory. Advanced topics in political theory. Same as Political Science 690-1 except in seminar format. Instructor: Staff. 3 units.

690S-2. Advanced Topics in Political Institutions. Advanced topics in political institutions. Same as Political Science 690-2 except in seminar format. Instructor: Staff. 3 units.

690S-3. Advanced Topics in Security, Peace and Conflict. Advanced topics in security, peace and conflict. Same as Political Science 690-3 except in seminar format. Instructor: Staff. 3 units.

690S-4. Advanced Topics in Political Behavior and Identities. Advanced topics in political behavior and identities. Same as Political Science 690-4 except in seminar format. Instructor: Staff. 3 units.

690S-5. Advanced Topics in Political Methodology. Advanced topics in political methodology. Same as Political Science 690-5 except in seminar format. Instructor: Staff. Variable credit.

690S-6. Advanced Topics in Political Economy. Advanced topics in political economy. Same as Political Science 690-6 except in seminar format. Instructor: Staff. 3 units.

01-G-B

701. Core in Political Behavior and Identity. Formation of public opinion in terms of preferences and demands mass publics might direct toward political authorities; the cognitive attribution of causal agency to politicians and collective entities in the political process, as well as the assessment of results of that process; the collectivities that actors identify with as members or the boundaries they draw between their own and other actors' collective memberships/identities, including their affective bases; and the attribution of value and "legitimacy" to political institutions, processes, and entire regimes. Major methods of research to which students are exposed are surveys, experimentation, and qualitative research. Instructor: Staff. 3 units.

702. Political Psychology (A). Examination of the human political situation through the study of actual problems and solutions at the level of: (1) the individual, (2) political discourse among government officials, (3) public discourse in the media. Instructor: Staff. 3 units. C-L: Psychology 717

703S. Racial and Ethnic Minorities in American Politics. Graduate-level course on politics of the United States' four principal racial minority groups Blacks, Latinos, American Indians, and Asian Americans. Importance of race and ethnicity in American politics is also explored. Instructor: McClain. 3 units. C-L: African & African American Studies 740S, Public Policy 845S

704. Survey Methodology Practicum. Course will serve as an introduction to methodologies for measuring public opinion, with a primary focus on survey research methods including survey experiments. Instructor: Hillygus. 3 units.

705S. Political Economy of Macroeconomics. Study of models of unemployment, inflation, growth, monetary, fiscal, exchange rate, incomes policies and distribution. Also examination of financial crises, political explanations of differences in macro management, financial regulation, and relation to varieties of capitalism. Designed for political science and public policy students without a strong economics background to learn in simple form the "new" macroeconomic models which guide central bank and government policy-making. Instructor: Staff. 3 units. C-L: Public Policy 681S

706S. Political Judgment and Decision Making. Course explores how people in democratic societies make politically-relevant judgments and how they choose among political alternatives. Topics include: heuristics and biases, impression formation and candidate assessment, forecasting and risk assessment, judgments of fact and misinformation, moral judgment, decision making under risk and uncertainty, compensatory and non-compensatory decision rules, and spatial, heuristic, and expressive voting models. Instructor: Johnston. 3 units.

707A. Marine Policy (A). 3 units. C-L: see Environment 786A; also C-L: Public Policy 849A

708. Democracy and the Rule of Law. Course provides an overview of the normative and positive issues associated with modern democracies and their legal systems. Instructor: Knight and McCubbins. 2 units.

709S. Research Seminar on the Politics of Behavior, Identities, and Institutions. Conduct original research on political behavior, identities and politics, or political institutions. Students will work collectively on how to implement original research from the development of new ideas and problems to solve, through the process of applying for grants and other forms of support, to the actual conduct of designing a research project and implementing it. Develop skills in presenting research to research panels, groups of scholars, and public. Instructor: Aldrich. 3 units.

710. Civic Engagement in a Changing Media Environment. Course will examine both old and new forms of civic engagement. Examine the causes and consequences of different types of civic engagement; impact of online engagement; research challenges and opportunities in studying these topics, and the best way to measure civic engagement. Instructor: Hillygus. 3 units.

711S. Politics, Groups, and Identities. Course offers an introduction to the concepts of groups and identities and their study in political psychology, sociology, and social psychology. Consider how theories from these different disciplines apply to different identities, including racial, ethnic, national and religious identities. Explore how groups and identities develop, and consider how they have been instrumental in politics not only at the individual level, but also how they have been implicated in social movements. Examines how identities are a lens through which individuals view the social and political world and how groups and identities foster conflict or cooperation. Instructor: Jardina. 3 units.

712S. Values and Ideology. Examines the political preferences of the public through in-depth examination of the concepts of "values" and "ideology". Topics include: structure of mass belief systems; core human values and core political values, their nature and origins, and their use in political judgment; nature and meaning of ideological self-identifications; origins of mass ideology in biological and psychological processes; ideology and its dynamics over time at the aggregate level; and relationship of ideology to institutional legitimacy. Instructor: Johnston. 3 units.

713. Workshop in Political Behavior and Identities. Research workshop in political behavior and identities. Instructor: Staff. 1 unit.

714. Workshop in Political Behavior and Identities II. Research workshop in political behavior and identities. Students must complete Political Science 769 before taking this course. Instructor: Staff. 1 unit.

715. Core in Political Institutions. Studies the formal and informal rules, practices, and regularities at both the domestic and international level that guide and constrain political choices and activities. It is concerned with the emergence, dynamics, and consequences of institutions in both authoritarian and non-authoritarian regimes. Focus includes constitutional design and how the organization of legislatures, parties, judiciaries, markets and other social structures shape relationships between individuals and states, and in turn, the factors shaping the emergence and evolution of those institutions. Instructor: Staff. 3 units.

716. The New Institutionalism in Political Science (C-E). Survey of recent developments in information economics, theory of the firm, the property rights paradigm, and contract theory. Emphasis on using these techniques to answer classic questions in political science. Instructor: Staff. 3 units.

717S. Seminar in Political Institutions. Survey, analysis, and critique of the literature. Instructor: Rohde. 3 units.

718. Core Course in American Politics (BI, PI). Introduction to fundamental research and theoretic statements in American politics. Instructor: Aldrich. 3 units.

719S. Comparative Constitutional Design. Consideration of configurations of political institutions apt for democratizing countries, especially those divided by ethnic or religious affiliations. Begins with theories of constitutional and legal change and of efficacy of constitutions as instruments of conflict management, as well as alternative approaches. Specific issues include: electoral systems; federalism and regional devolution; the presidential-parliamentary debate; costs and benefits of judicial review; the special issue of Islam and the state. Extensive discussion of the overarching question of adoptability and emphasis on the relations between processes of constitutional change and the content of the institutions adopted. Instructor: Knight. 2 units. C-L: Law 717

720S. Capitalism. 3 units. C-L: see Cultural Anthropology 716S; also C-L: Sociology 716S

721. Authoritarian Institutions. Course will survey the exciting new work on the variation, causes, and effects of institutional configurations in authoritarian regimes. Coverage of different regimes types including analysis of particular institutions: party systems and structure; parliaments; elections and electoral systems; local governments and modes of decentralization; and courts and judicial independence. Instructor: Malesky. 3 units.

722. Election Law. 3 units. C-L: see Law 311

724. Empirical and Theoretical Approaches to Security, Peace and Conflict. Course provides a survey of the extant, state-of-the-art models in the broad area of Security, Peace and Conflict. Each topic will survey the theoretical and empirical evidence that is marshaled in the literature. Topics include: Strategic Dependencies; Rational Choice; Bargaining: Escalation; Deterrence; Arms Races; Alliances; Mediation; Domestic Politics; Civil Wars; Sanctions; International Institutions; Trade; and other topics. Instructor: Leventoglu. 3 units.

725S. Research on Chinese Politics: Forefront and Foundations. Systematic study of new, cutting-edge scholarship on contemporary Chinese politics: research questions, methods, contributions to substantive knowledge. Assessment of how and how much cumulativeness achieved; consideration of fit into broader literature on authoritarianism; scrutiny into relevance of dominant concepts, questions, methods from previous decades. Topics include political selection, representation and responsiveness, elite politics, decentralization, information management. Graduate status, familiarity with multivariate statistical methods required. Foundation in more sophisticated statistical methods and prior knowledge about China helpful but not required. Instructor: Manion. 3 units.

726S. Informal Institutions. Institutions are enduring systems of social constraint on behavior, which promote realization of order in society. This graduate seminar investigates emergence, maintenance, and change in informal political institutions—those not reflected in formal authoritative rules of governance, but which nonetheless organize political action. Its focus is both theoretical and on different sorts of institutions in a variety of empirical settings. It is a point of departure for developing research on this topic, applicable to any particular empirical political science field. Reserved for graduate students, open to undergraduate students by instructor permission. Instructor consent required. Instructor: Manion. 3 units.

727S. Monitoring, Evaluation, and Learning for Development (MELD) Seminar. This seminar is focused on the real world of international development monitoring, evaluation, and learning (MEL). This is an applied course that covers the landscape of international development funding and research organizations. In addition to the actors involved in international development MEL, this seminar covers "getting the work" (responding to a solicitation for MEL activities), as well as "doing the work" (design and implementation of selected international development MEL projects). Because the topics covered are very broad, this seminar provides a high-level overview of the international development MEL landscape, and does not focus on the details of specific evaluation methods. Instructor: Wibbels, Field, Andrzejewski. 3 units. C-L: Economics 747S

728. Workshop in Political Institutions I. Research workshop in political institutions. Content of the course continues in Political Science 722. Instructor: Staff. 1 unit.

729. Workshop in Political Institutions II. Research workshop in political institutions. Students must complete Political Science 719 before taking this course. Instructor: Staff. 1 unit.

730. Formal Modeling in Political Science (C-E). Introduction to formal analysis of recent work in political science. Focus on a number of important theorems and their proofs drawn from such areas as bargaining, deterrence, public goods, collective choice, electoral politics, and new institutionalism. Students will in the process be expected to begin work on formal proofs of their own. Prerequisite: one course in game theory. Instructor: Niou. 3 units.

731. Scope and Methods in Political Science (C-E). Designed to explore philosophical assumptions in political science, theory, and matters of evidence and judgment, the course is meant to be an introduction to variations in research design, empirical methods, and the execution of research. Instructor: Staff. 3 units.

731S. Formal Modeling In Political Science (C-E). Emphasis on use of formal analysis in various subfields in political science. Students expected to (i) derive/prove the results from the readings, (ii) analyze the contribution of readings and (iii) find ways to improve the line of research. Students expected to have taken a course in game theory, Political Science 243S or equivalent. Instructor: Leventoglu. 3 units.

732. Developing a Clear Thesis Project. This class has two goals: First, to take your nascent prelim papers/dissertation idea and turn it into a very clear project; second, to use some readings and discussion on key topics in research design to service the development of your project. Thus, the class will be highly participatory and rely on many presentations by you. Each student presents three papers of increasing length on their research topic. These presentations start early in the semester, so you need to enter the class with a moderately clear research question. This is not a class for students in search of an idea and who want to investigate a broad array of potential methodologies to inform their future research. Instructor: Staff. 3 units.

733. Advanced Regression. Theory and practice of likelihood inference for social science models, spanning binary, nominal, ordinal, count, and continuous random variables. Estimation, interpretation, and presentation of results will also be emphasized. Content may vary by year. Instructor: Staff. 3 units.

743. Workshop in Political Methodology I. Research workshop in political methodology. Content of the course continues in Political Science 775. Instructor: Staff. 1 unit.

744. Workshop in Political Methodology II. Research workshop in political methodology. Students must complete Political Science 776 before taking this course. Instructor: Staff. 1 unit.

745. Core in Political Economy (PE). Survey of techniques and substantive work in the field. Political economy uses the tools of modern economics and game theory to address questions of fundamental importance at the national and international level. Analyze the aggregate impact of trade, policies of redistribution, regulations, and assignment of property rights. Study of the "micro," including

incentives and individual choice, and the "macro," representing the conflict of social interests and aggregate consequences of individual choices. Instructor: Staff. 3 units.

746S. Seminar on Political Economy: Micro Level. Survey of recent work in political science and economics on the organization of institutions: political, sociological, and economic. Focus upon the ways in which rational choice theory is applied to areas outside of economics. Instructor: Staff. 3 units.

747S. Seminar in Political Economy: Macro Level (C-E). Survey and analysis of recent work in political science, economics, and sociology on the relationships between states and markets. Special emphasis on the ways states influence market outcomes and the ways the organization of power in markets influences state behavior, especially in democratic systems. Instructor: Staff. 3 units.

748. Causal Inference. Theory and practice of causal inference in the social sciences, introduces basic concepts, such as counterfactuals and identification. Introduces the formal frameworks of potential outcomes and graphical models (DAGs). Covers experiments (in the lab and the field), and various regression-based approaches. Department consent required. Open only to Political Science graduate students. Instructor: Fresh. 3 units.

749S. Advanced Game Theory. Course has two primary aims: 1) better understanding of the technical modeling literature and 2) enhanced ability to write models. Will be exposed to array of different theoretical modeling choices, from signaling and bargaining games to agency problems to behavioral models and computational methods. Instructor: Siegel. 3 units.

750S. Political Economy of Development. Course provides an overview of advanced contemporary research on the political economy of development. Students will work through growth models and attempt to map them onto broader debates in the political economy of development - debates surrounding the impact of institutions, historical legacies, inequality, natural resources, trade, ethnic heterogeneity, foreign aid and the like on prospects for economic development. Extensive use of field and natural-experiments to identify the key instruments of development. Instructor: Wibbels. 3 units.

751S. Empirical Investigation of Governance. Explore the cutting edge experimental research on the determinants of good governance, and the impact of governance on critical economic, development, and policy outcomes. Themes will include: accountability, mechanisms, participatory institutions, transparency reforms, control of corruption, economic regulation, and bureaucratic efficiency. Instructor: Malesky. 3 units.

752. What Machiavelli Really Says. 3 units. C-L: see Italian 743; also C-L: Literature 743, History 743

758. Workshop in Political Economy I. Research workshop in political economy. Content of the workshop continues in Political Science 759. Instructor: Staff. 1 unit.

759. Workshop in Political Economy II. Research workshop in political economy. Students must complete Political Science 784 before taking this course. Instructor: Staff. 1 unit.

760S. Core in Security, Peace and Conflict (SP). Critical survey of theories and research in security and conflict at the international, transnational, and subnational levels. Emphasis will be placed on the interrelation between theory and research. Instructor: Staff. 3 units.

761. Islam and the State: Political Economy of Governance in the Middle East. Introduction to political history of Middle East from the advent of Islam to modern era. Examine institutions responsible for characteristics of political development in the region; consider selected cases relating to mechanisms of political development, including democratization; investigate religion's role in shaping the region's political trajectory; identify social forces, especially economic, driving contemporary rediscovery and reinterpretation of Islam's political organization and requirements, by both Islamists and secular political actors. Instructor: Kuran. 1 unit.

762. The Political Economy of Institutions. 3 units. C-L: see Economics 751

763S. Foundational Scholarship in International Relations. Seminar producing firm grounding for graduate students in several key research programs in the field of International Relations. Examination of foundational books and, in some instances, articles, and follow-on works, representing core elements in International Relations, including international structuralism (realist and liberal), the impact of domestic institutions and world politics, the role individual group psychology in foreign policy, and recent IR work employing constructivist international theory. Students will write essays on each research tradition with the goal of identifying plausible questions they could pursue in larger research papers. Instructor: Grieco. 3 units.

764S. Political Economy of Corruption and Good Governance. Seminar focuses on corruption—the abuse of public power for private gain—as a generic research question and practical policy problem. Reviews the theoretical and empirical analyses by economists, political scientists, and policy analysts that attempt to sort out systematically corruption's underlying causes, global distribution, and consequences for growth, investment, government expenditure, income distribution, and regime support. Examines what the literature implies about the desirability and prospects for success and prescriptions, if any, for hurrying good governance along. Open only to graduate students in political science. Instructor: Manion. 3 units.

773. Workshop in Security, Peace, and Conflict I. Research workshop in security, peace and conflict. Content of the course continues in Political Science 745. Instructor: Staff. 1 unit.

774. Workshop in Security, Peace, and Conflict II. Research workshop in security, peace and conflict. Students must complete Political Science 744 before taking this course. Instructor: Staff. 1 unit.

788. Workshop in Normative Political Theory and Political Philosophy. Research workshop in normative political theory and political philosophy. Instructor: Staff. 1 unit.

789. Workshop in Normative Political Theory and Political Philosophy II. Research workshop in normative political theory and political philosophy. Students must complete Political Science 701 before taking this course. Instructor: Staff. 1 unit.

790S. Seminar for Teaching Politics Certificate Program. This course focuses on the problems and special techniques of teaching courses in political science. It meets as a weekly seminar, and brings in faculty from the department to add their perspectives on syllabus design, the large lecture, leading discussions, teaching writing through long papers and short memos, guarding against plagiarism, and other topics. Instructor: Munger. 1 unit.

791S. Thesis Writing in Political Science. Provides an overview of the major sections of a research paper, including the introductory frame, literature review, theoretical argument, research design, discussion of the results, and conclusion. Students will read model examples, discuss best practices, practice writing each type of section, and receive feedback from the instructor. Required for MA students on the thesis track, and counts as three of the six ungraded credits needed for completion of the thesis track. Elective for PhD students. Instructor: Staff. 3 units.

796S. Research Seminar in Political Science I. Consideration of various elements involved in the conduct of research, including identifying topics for study, theory construction and application, gathering and marshaling evidence, and framing and presenting analysis. Ideas will be applied in collaborative research. Content of the course continues in Political Science 395B. Instructor: Rohde. 3 units.

797S. Research Seminar in Political Science II. Consideration of various elements involved in the conduct of research, including identifying topics for study, theory construction and application, gathering and marshaling evidence, and framing and presenting analysis. Ideas will be applied in collaborative research. Students must complete POLSCI 395A before taking this course. Consent of instructor required. Instructor: Rohde. 3 units.

798. Individual Research (A,B,C,D). Students will conduct research designed to evaluate hypotheses of their choice. Reports on the research must be presented in appropriate professional style. Instructor consent required. Instructor: Staff. 3 units.

890-1. Political Theory. Political Theory. 3 units.

890-2. Political Institutions. Political Institutions. 3 units.

890-3. Security, Peace and Conflict. Security, Peace and Conflict. 3 units.

890-4. Political Behavior and Identities. 3 units.

890-5. Political Methodology. Topics on political methodology. Instructor: Staff. 3 units.

890-6. Political Economy. Topics on Political Economy. Instructor: Staff. 3 units.

899. Internship. Open to students engaging in practical or governmental work (part-time or full-time) experience during the summer or a regular semester. A faculty member in the department will supervise a program of study related to the work experience, including a substantive paper on a political science-related topic, maintaining significant analysis and interpretation. Consent of director of graduate studies required. Instructor: Beardsley. 2 units.

03-G-K

663SK. Energy and National Security. 3 units. C-L: see Public Policy 583SK; also C-L: Environment 583SK

Population Health Sciences

Professor Curtis, *Chair*; Professor Bosworth, *Vice Chair of Education*; Associate Professor Skinner, *Director of Graduate Studies*; Professors Bosworth, Curtis, Maciejewski, and Reeve; Associate Professors Dupre, Hammill, Skinner, Wang, and Zullig; Assistant Professors Coles, King, McKethan, O'Brien, Raman, and Smith

A master's degree is available in this department.

The Department of Population Health Sciences offers a master of science in population health sciences, which provides a solid methodological and analytical foundation across broad population health sciences concepts, including basic study design, determinants of health, health disparities, implementation and evaluation, and policies and systems. The program consists of coursework, collaborative research projects, and hands-on experience. Students take advanced classes in applied analytics methods, foundational courses in population health sciences, research methods, and study design along with four electives. Real-world experience comes from a year-long capstone project during which students complete an internship and write a master's paper. The program requires professional development seminars on topics including leadership and professional adaptability, networking and communication techniques, having a professional presence, and US employer expectations. Broadly, it is expected that students entering the MS Program in Population Health Sciences should have a background or strong interest in the social sciences, quantitative sciences, and health care.

Degree Requirements for the Master of Science

Coursework includes 40 units over four semesters, including required Graduate School training in Academic Integrity and Responsible Conduct of Research (AIRCR).

Course requirements include:

- 4 courses in applied analytic methods (2 core courses with accompanying programming labs and 2 electives)
- 2 foundational courses in population health sciences
- 2 courses in population health sciences research methods and study design
- 2 seminar courses in professional development
- 2 general electives (either DPHS electives or other Duke courses, with approval from the director of graduate studies)

Courses in Population Health Sciences (POPHS)

701. Applied Analytic Methods for Population Health Sciences I. This is an introductory course in statistical analysis and inference methods useful for Population Health Sciences. Topics include descriptive statistics, analysis of contingency tables, one-

and two-way analysis of variance, simple linear regression, measures of uncertainty, and hypothesis testing. Both parametric and nonparametric techniques are explored. Core concepts are taught through team-based case studies and analysis of research datasets taken from the population health sciences literature and demonstrated in concert with Population Health Sciences 703. Computational exercises will primarily use the SAS Statistical Computing Platform. Instructor: O'Brien, Hammill. 3 units.

702. Applied Analytic Methods for Population Health Sciences II. This course is the second course in a two-course sequence that provides students a foundation in methods for analyzing clinical, health and economic outcomes often encountered in population health studies. Through course readings, in-class discussions, and data analysis, students will develop research skills and competencies related to understanding, conducting and interpreting regression analyses. Prerequisite: Population Health Sciences 701 and 703. Department consent required. Instructor: Maciejewski, Smith. 3 units.

703. Introduction to Statistical Programming for Population Health Sciences I. Introduction to statistical software packages (i.e., SAS Software System, R Statistical Computing Platform) to provide an introduction to the core ideas of programming including data preparation, input/output, debugging, and strategies for program design. Students will learn to write code to perform descriptive, statistical, and graphical analyses, and write maintainable code, to test for correctness and to apply basic principles of reproducibility. Programming techniques and their applications will be closely connected with the methods and examples presented in the concurrent course Population Health Sciences 701. This course assumes minimal programming knowledge. Instructor: Coles. 1 unit.

704. Introduction to Statistical Programming for Population Health Sciences II. Students will build on programming learned in Population Health Sciences 703 using the SAS Software System and R Statistical Computing Platform. Students will continue to learn to write code to perform descriptive, statistical, and graphical analyses; write maintainable code to test for correctness and to apply basic principles of reproducibility. Programming techniques and their applications will be closely connected with the methods and examples presented in the concurrent course Population Health Sciences 702. Prerequisite: Population Health Sciences 703. Instructor: Coles. 1 unit.

705. Topics in Population Health Sciences I. This course is designed to introduce students to the transdisciplinary field of population health sciences and provide students with a greater understanding of the general theories, concepts, and measures often used in population health sciences. Instructor: Dupre. 3 units.

706. Topics in Population Health Sciences II. This course introduces the key components of the US health-care system—the organization, financing, and delivery of services; the role of prevention and other non-medical factors in population health outcomes; key management and policy issues in contemporary US health care. These components are one of the foundations from which we can understand contemporary challenges and questions to address within population health. Topics include the overall structure of the US health-care system, financing (insurance and payment models), health system and providers, the Affordable Care Act, mental health, health economics, and quality of care. Prerequisite: Population Health Sciences 705. Instructor: Bosworth, Wang. 3 units.

707. Population Health Sciences Research Design and Study Methods I. This is the first in a two-course sequence that gives students a strong foundation in population health research methods. The course introduces critical concepts in research methods, including varying types of validity, reliability, and causal inference. Topics include sampling and interpretation of probability and nonprobability sampling; an introduction to measurement theory; threats to internal validity; experimental designs; and quasi-experimental designs. Instructor: King. 3 units.

708. Population Health Sciences Research Design and Study Methods II. This is the second in a two-course sequence where students establish a strong foundation in population health research methodology, including randomized and non-randomized study design. Prerequisite: Population Health Sciences 707. Instructor: Curtis, Raman. 3 units.

709. Population Health Sciences Professional Development I. This multi-semester course gives students a holistic view of their career choices and how to develop the tools they'll need to succeed professionally. The fall semester focuses on creating a strong professional presence, proper networking techniques, American employer expectations, creating and maintaining a professional digital presence, and learning how to conduct and succeed at informational interviews. Instructor: McKethan, Skinner. 1 unit.

710. Population Health Sciences Professional Development II. This is the second of two-semester course sequence, continuing Population Health Sciences 709, and teaches project and team management. Prerequisite: Population Health Sciences 709. Instructor: Skinner. 1 unit.

711. Pragmatic Health Policy Analysis. Course provides a general (and highly accelerated) overview of the local and national policy-making process and the substance of major public policy challenges (with a focus on US domestic health and welfare policy). It exposes students to the conceptual and analytical perspectives necessary for understanding and influencing the policy-making process. This course will illuminate policy, technical, and normative challenges in areas such as health care, human services, and public health. Students will be able to evaluate challenges facing policy-makers and address key technical, political, and resource constraints to adopting evidence-based policies. Instructor: McKethan, Sandoe. 3 units.

713. Population Health Implementation Science. This course introduces key concepts and definitions, theoretical frameworks, and methods considerations for translating evidence-based policies, practices, and interventions into healthcare contexts. The course also examines the methods for conducting and evaluating rigorous research on implementation. Instructor: Zullig. 3 units.

715L. Fundamentals of Conducting Qualitative Research. This introductory course prepares students for implementing and analyzing qualitative research studies. Students will gain competency in coordinating qualitative studies, conducting qualitative interviews, managing study data, and conduct qualitative analysis. Instructor: Corneli, Perry. 3 units.

751. Population Health Capstone. The first of the two-semester capstone sequence, in this course students will develop an interdisciplinary project to identify, analyze, and implement tangible solutions for a specific Population Health issue. Guided by a faculty advisor, each student will complete the course through independent study. Open only to students in the Population Health Sciences Program. Instructor: Skinner. 3 units.

Psychology

Professor Huettel, *Chair*; Professor Marsh, *Associate Chair*; Associate Professor Yin, *Director of Graduate Studies*; Associate Professor Zucker, *Associate Director of Graduate Studies*; Professors Asher, Bennett, Bilbo, Cabeza, Caspi, Cooper, Groh, Hariri, Hoyle, Huettel, LaBar, Marsh, Meck, Moffitt, Putallaz, Rubin, Strauman, Tomasello, and C. Williams; Associate Professors Day, Egner, Shah, and Yin; Assistant Professors Bergelson, Gaither, Gaffrey, McHenry, Overrath, Puffer, Samanez-Larkin, and Seli; Research Professors Mazuka and Rabiner; Associate Professors of the Practice Hard and Wilbourn; Assistant Professors of the Practice Newpher and Ng; Lecturers Murphy and Vieth; Lecturing Fellow Batson; *Medical School Faculty*: Bonner, Compton, Curry, Keefe, Rosenthal, Smoski, Williams, and Zucker; Professors Emeriti Coie, Costanzo, Eckerman, C. Erickson, R. Erickson, Hall, Kremen, Lockhead, Roth, Thompson, and M. Wallach; *Secondary Appointments*: Adcock, Appelbaum, Bettman, Brownell, Chartrand, Costello, Dawson, De Brigard, DeBellis, Dodge, Ehrensaft, Fairbank, Fitzsimons, Fitzsimons, Gassman-Pines, George, Gibson-Davis, Gold, Goldston, Kay, R. Keefe, Kollins, Larrick, Levin, Linville, Lisanby Madden, Mauro, Meade, Nicolelis, Nowicki, Payne, Pearson, Purves, Rezvani,Sherwood, Siegler, Smith-Lovin, Sommer, Suarez, Swartzwelder, Weinfurt, Welsh-Bohmer, White, and Woldorff

A PhD is available in this department.

The Department of Psychology offers graduate training leading to the PhD in psychology. This unique program merges social sciences and natural sciences in the study of brain, behavior, and cognition in humans and animals. Program tracks are offered in clinical psychology, cognition/cognitive neuroscience, developmental psychology, social psychology, and systems and integrative neuroscience.

Courses in Psychology (PSY)

500S. The Cinematic Depiction of Psychopathology. Critically explore depictions of mental illness in modern cinema and television, and the extent to which they capture our emerging understanding of dysfunction in core neural circuits supporting normal behavior. Prerequisite: Psychology/Neuroscience 277. Instructor consent required. Instructor: Hariri. 3 units. C-L: Neuroscience 500S

510S. Developmental Psychopathology. Examines emotional and behavioral disorders in childhood and adolescence from a developmental perspective. Issues addressed include biological, cognitive, familial, and social aspects of the disorders and relevant risk and protective factors. Open only to graduate students and advanced undergraduate students. Instructor: Staff. 3 units.

561S. Evolution, Cognition, and Society. 3 units. C-L: see Evolutionary Anthropology 561S

575. Brain and Language. 3 units. C-L: see Linguistics 510; also C-L: Neuroscience 510

580. The Biological Basis of Music. 3 units. C-L: see Neurobiology 559; also C-L: Philosophy 559

590. Special Topics in Psychology. Advanced topics vary by semester and section from the areas of Psychology: Abnormal/Health, Biological, Cognitive, Developmental or Social. Consent of instructor and/or specific prerequisites may be required for specific offerings. Open to Undergraduate and Graduate/Professional students. Instructor: Staff. 3 units.

601S. Psychology Teaching Seminar. Exploration of issues relevant to teaching in psychology and related disciplines. Focus on a variety of pedagogical issues: course development, teaching strategies, preparation of materials, evaluation, classroom management. Strong emphasis also on ethical issues bearing on pedagogy. Open to undergraduates serving, or scheduled to serve, as teaching assistants in psychology, as well as to graduate students. Instructor consent required. Instructor: Hard, G. Samanez-Larkin, or staff. 3 units.

603S. Teachers as Scientists: Psychological Research in the Classroom. How can psychology help us understand and improve education? In this course, students will develop skills as both critical consumers and producers of empirical research on teaching and learning. Students will develop original, testable hypotheses in the domain of teaching and learning and design ethical studies to test those hypotheses. This is a course for undergraduate and graduate students who are interested in teaching, education more generally, and/or in the application of psychology to real-world problems. Undergraduate students must have fulfilled P&N major requirements in methods and statistics. Prerequisite: For undergraduates, any one of the following statistics courses: Psychology 201L, Statistical Science 101, 102, 104, 111, 250 or Mathematics 342, and any one of the following methods courses: Psychology 202 or 301, 302L, 303L, 304, 305, 306, 308L, 309, 309K, 310, 313. No prerequisites for students with graduate standing. Instructor: Hard. 3 units.

605S. Obesity and Eating Disorders. A review of obesity and of the major clinical eating disorders (including binge eating disorder, bulimia nervosa and anorexia nervosa) and their pathophysiology, and their treatments. Prerequisite: Introductory Biology. Instructor: Staff. 3 units.

607S. Personality, Stress, and Disease. The role of psychosocial factors in the development and course of physical disease. Both epidemiological and laboratory-based research considered. Become familiar with major behavioral medicine research studies that have made significant contributions to our understanding of the role of psychosocial factors in medical illness and develop skills necessary for critical evaluation of research on psychosocial factors and disease. Appropriate for students with interests in medical careers or in health psychology. Instructor: R. Williams. 3 units.

609S. Psychosocial Determinants of Health. Provides an in-depth understanding of psychosocial determinants of health. Emphasis on the ways psychological factors interact with social, cultural, economic, and environmental contexts of health. Topics include impact of social integration, socioeconomic position, discrimination, health behaviors, and affective states on health outcomes. Students will gain competency through lectures, discussions, written work, and oral presentations. Prerequisite: Psychology 104 or 105, Research Methods. Open to juniors, seniors and graduate students. Instructor: Staff. 3 units.

610S. The Psychology of Mindfulness Meditation: Theory, Research, and Practice. Mindfulness meditation in relation to psychological and physical health. Traditional Buddhist teachings and contemporary Western perspectives on mindfulness. Survey of empirical research, including controlled trials and studies of basic mechanisms and processes through self-report, psychophysiological, and neuroimaging methods. Use of mindfulness practices in behavioral and other psychotherapies. Includes experiential learning through meditation practices in class and for homework assignments, as well as lecture and discussion. Readings mostly original

journal articles and book chapters. Prerequisites: Psychology 102, 105, or 106 desirable. Open to graduate and advanced undergraduate students. Instructor: Smoski or staff. 3 units.

611. Global Mental Health. 3 units. C-L: see Global Health 660; also C-L: Cultural Anthropology 611, Human Rights Program-Franklin Humanities Institute 660

613S. Clinical Interventions: Treating Emotion Dysregulation and Impulsivity Using DBT. Introduction to the basic principles, strategies and methods of an empirically-based clinical intervention, Dialectical Behavior Therapy (DBT), a cognitive behavioral based treatment for individuals with severe emotional dysregulation and impulsivity. Seminar includes didactics, discussion, video demonstrations, skills practice, and role-plays, as well as experiential homework assignments in order to further understanding of the theoretical underpinnings of DBT, biopsychosocial model of psychopathology, case formulation, and skills needed for conducting both individual DBT therapy and the DBT skills training group (e.g., mindfulness. emotion regulation). Prerequisites: Psychology 105. Instructor: S. Samanez-Larkin. 3 units.

625S. Motives, Goals, and Social Behavior. Covers a variety of topics involving the motivations underlying a variety of social behaviors (such as interpersonal relationships, stereotyping, and achievement) and the social and psychological processes involved when people try to regulate their own motives, thoughts, emotions, and behavior. Reading and discussion of literature on current theory and research on motivation, goal-directed behavior, and self-regulation. Instructor: Shah. 3 units.

627S. Stereotypes and Stigma. Experimental research in stereotyping and stigma; readings from psychology, public health, and sociological perspectives on issues related to ethnicity, gender, and social class. Instructor consent required. Instructor: Staff. 3 units.

654S. Psychology of Aging. An interdisciplinary approach to the study of aging. Psychological development in middle adulthood and old age as linked to disciplines such as Public Policy, Sociology, Geriatric Medicine & Psychiatry. Age-related changes in well-being, cognition, personality, and social relationships. Real-life issues that will affect most people in the future (e.g., successful retirement, decreasing one's risk of dementia). Open to undergraduate and graduate students. Prerequisites: none. Instructor: Staff. 3 units.

668S. Everyday Cognition. Key cognitive processes (e.g., attention, memory, comprehension, problem solving) and how they work in everyday settings. Cognition in classrooms, courtrooms, hospitals, grocery stores, kitchens, jobs, sports, and dance. Focus on Medical Cognition, Courtroom Cognition, and Memory for Movement. For each setting--successful vs. mediocre performance, types of errors, and applications. Visits by experts (e.g., pharmacists, doctors, judges, lawyers, chefs, choreographers) to discuss the cognitive processes essential for their jobs. Instructor: Day. 3 units.

670S. Language, Brain, and Human Behavior. 3 units. C-L: see Linguistics 502S

671S. Nature and Treatment of Eating Disorders Across the Lifespan. Study of atypical and typical development of conscious somatic sensation, i.e. how individuals sense and understand body signals and how extremes of sensitivity may form part of the core phenomenology of disorders such as anorexia nervosa, pediatric obesity, and autism spectrum disorders Study of detailed narratives of patients have served as a springboard for novel hypotheses about human function. Readings alternate between primary journal articles to patient memoirs and narratives. Students interview patients struggling with eating disorders, children who binge eat, and children with high functioning autism, among other clinical conditions. Juniors, Seniors and Graduate students. Instructor: Zucker. 3 units.

681S. Genetics and Environment in Abnormal Behavior. Introduces students to an emerging topic in behavioral science: the interaction between genes and environments. Evaluates research showing that genes influence susceptibility to the environmental causes of abnormal behavior, and research showing that genes' connections to behaviors depend on environmental experiences. Readings are primary journal articles. Topics include the design and analysis of genetic research into mental disorders, and ethical issues stemming from genetic research into human behavior. Prior coursework in statistics/research methods, genetics, and/or abnormal psychology is desirable. Consent of instructor required. Instructors: Caspi and Moffitt. 3 units.

684S. Hormones, Brain, and Cognition. Current research on how hormones modify and modulate cognitive processes across the lifespan. Consent of instructor required. One course. Instructor: C. Williams. 3 units. C-L: Neuroscience 584S

685S. Biological Pathways to Psychopathology. Introduces students to emerging methodologies for understanding the biological pathways of psychopathology. Evaluates research showing that the integration of psychology, neuroimaging, pharmacology and genetics can illuminate specific biological pathways that help shape risk for and emergence of psychopathology. Readings are primary journal articles. Topics include the design and analysis of multimodal research (fMRI, PET, pharmacology, molecular genetics) examining the biological underpinnings of behavioral traits relevant to psychopathology. Prerequisite: Psychology 277/Neuroscience 277 or Instructor consent required. Instructor: Hariri. 3 units. C-L: Neuroscience 685S

686S. Principles of Neuroimmunology. Bidirectional communication between the brain and immune system, in disease and during normal function/homeostasis. Historical foundations of the field in disorders such as multiple sclerosis and HIV; the anatomy of CNS-immune connections; blood-brain-barrier function and dysfunction; leukocyte trafficking, surveillance, and infiltration of the CNS; cellular players including peripheral vs. CNS-resident immune cells and antigen presentation; neuroinflammation and neurodegenerative disease; recent literature highlighting the critical role of immune molecules in neural development and lifelong plasticity. Instructor consent required for undergraduates. Instructor: Bilbo. 3 units. C-L: Neuroscience 686S

690S. Special Topics in Psychology. Topics vary by semester and section from the different areas of Psychology: Abnormal, Biological, Cognitive, Developmental or Social. Consent of instructor and/or specific prerequisites may be required for specific offerings. Open to Undergraduate as well as Graduate/Professional students. Instructor: Staff. 3 units.

705. Adult Psychopathology. Examination of current diagnostic and theoretical approaches to adult psychopathology and personality disorders and the implications of diagnostic and theoretical systems for assessment and treatment. Instructor: Strauman. 3 units.

707. Models of Intervention and Prevention. Review of empirically-supported treatments for adult disorders. Therapeutic relationship issues and communication style; strategies commonly used across disorders in empirically-supported treatment and

prevention programs; their application to specific disorders; development of theoretically integrative treatments. Course balances discussion of theory and research findings with practical and ethical issues in treatment delivery, illustrated by case transcripts and videotapes. Instructor: Robins. 3 units.

710. Diversity and Mental Health: Issues in Theory, Treatment, and Research. Discussions of theoretical, research, and clinical issues in multicultural psychology. Increase multicultural awareness and skills to conduct research and clinical practice. Consent of instructor required. Instructor: Staff. 3 units.

711S. Social Behavior and Personality. Broad examination of current theory and research on the interpersonal, personological, and social cognitive influences on social interaction/behavior. Emphasis on: nature of social influence, function/construction of the self, relationship formation/maintenance, aggression, altruism, personality-based mediators and moderators of social behavior, and application of social psychological theory/research to real-world issues. Methodologies discussed include experimental, quasi-experimental, narrative, and observational models. Instructor: Hoyle. 3 units.

713S. Motivation Science in Social Psychology. This graduate level course will explore the reemerging focus in social psychology on motivation and its role in determining the nature and consequences of self and social-regulation. Specifically, this seminar will focus on research and theorizing on the differing motivations underlying social behavior (such as the motivations characterizing stereotyping and prejudice a well as achievement behavior and interpersonal relationships). Students will be expected to read research articles and chapters from the leading social psychology outlets to actively discuss the merits and limitations of these research traditions. Students will also be expected to actively participate in weekly discussions and to present a grant proposal for a research study inspired by the weekly reading assignments and classroom discussion. Because this is an advanced graduate seminar, registration requires instructor approval. Instructor: Staff. 3 units.

714S. Self-Regulation. Examines psychological models of human self-regulation. Includes coverage of relevant dimensions of temperament and personality, executive functioning, emotion, and behavior. Conscious and nonconscious processes at play in goal pursuit are considered. Topics include self-awareness, self-monitoring, self-control, impulsivity, and regulatory style. The role of self-regulation in adjustment and well-being is explored. Discussion-oriented class meetings are based on readings from scholarly books and journals. Prior advanced coursework in psychology required; personality, social, cognitive, and/or abnormal psychology is desirable. Instructor: Hoyle. 3 units.

715. Seminar in Consumer Behavior. 3 units. C-L: see Business Administration 962

716. Behavioral Decision Theory. 3 units. C-L: see Business Administration 925

717. Political Psychology (A). 3 units. C-L: see Political Science 702

718S. Research Design. Methodology principles of research design in psychology. Experimental, quasi-experimental and correlational research. Permission of instructor required. Instructor: STAFF. 3 units.

719. Behavioral Research Methods. 3 units. C-L: see Business Administration 967

720. Applied Multivariate Statistics. Applications of multivariate statistics in psychology and related disciplines. Topics include: MANOVA, factor analysis, principal components analysis, cluster analysis, multidimensional scaling, multiple logistic regression, and various approaches to longitudinal data analysis. Covers issues in applied data analysis such as a priori and post-hoc power analyses, transformation of data, and graphical/written/oral presentation of results. Data analyzed using the SAS statistical software package, as well as other specialty programs. Mandatory weekly lab sessions. Consent of instructor required. Instructor: Staff. 3 units.

721. Social Development. Analysis of children's social development from multiple theoretical perspectives including biological, social cognitive, social learning, and ecological perspectives. Includes socialization in the contexts of families, peers, schools, and neighborhoods and the role of media. Implications for prevention/intervention programs and social policy are discussed. Permission of the instructor required. Instructor: Asher. 3 units.

722. Advanced Cognitive Development. Advanced level introduction to critical issues in the study of cognitive development from birth to adolescence. Emphasis on both theoretical accounts of cognitive development and recent research that informs these explanations. Permission only. Instructor: Staff. 3 units.

725. Seminar in Contemporary Psychotherapy. An intensive seminar providing training in a contemporary empirically supported psychotherapy. Includes readings and discussion of the strategies and techniques of the selected treatment modality, examination of the empirical support for the treatment, and where possible, supervised practicum experience providing the treatment to appropriate patient populations. Instructor: Strauman. 3 units.

727S. Theories of Developmental Psychology. Examine worldviews and assumptions that underlie theories in developmental psychology; discuss the philosophical and historical foundations for key ideas and theories in the study and understanding of human development, take on the perspectives of key historical figures in developmental psychology; understand how change and development have been conceptualized over the history of the field; debate ongoing controversies in the field such as nature-nurture, continuity-discontinuity, universal-culturally specific development; explore the link among theoretical perspectives, research methodologies and data interpretation. Permission of instructor required. Instructor: Staff. 3 units.

729S. Foundations of Cognitive Development. Introduction to main theories and concepts of cognitive development as it is studied from psychological and neuroscience perspectives. Instructors: Brannon. 3 units.

730S. Foundations of Cognitive Psychology. Current concepts and controversies in the way people and other animals perceive, think, and remember. Instructor consent required. Instructor: Marsh. 3 units.

733. Cognition and Teaching. An examination of key phenomena and concepts in cognitive psychology (especially in areas of perception, attention, memory, comprehension, mental representation, and problem solving) and their implications for the teaching-learning process at the college level. Instructor: Day. 3 units.

735. Personality Assessment. A course for clinical graduate students on assessment of persons through a variety of methods, including personological, clinical and semi-structured interviews, analysis of narrative material, and psychological tests. Introduction to self-report, observer-report, and projective methods. Consent of insructor. Instructor: Curry. 3 units.

737S. Language Development. Introduces research on a fundamentally unique human ability: learning language. Covers how young children first learn about their native language, including (1) how children figure out what sounds their language includes; (2) how infants learn words and their meanings and (3) what kind of processes help babies figure out the grammar of their particular native language. Since young children understand more than they can say, the course also covers the methods available for figuring out what kids know, based on experimental and observational data. Students will discuss and present recent research articles and new study ideas. Open to graduate students with relevant background. Instructor consent required. Instructor: Bergelson. 3 units.

738S. Children's Peer Relations. Examination of the empirical literature with emphasis on the functions that peers serve for children, the developmental course of these relationships, the clinical ramifications and possible explanations for inadequate peer relations (including an examination of the family's role), and interventions used to improve children's relationships with their peers. Regular opportunities to analyze, critique, and synthesize primary research literature. Instructor: Asher. 3 units.

739. Ethical Issues in Research and Clinical Practice. Topics including ethical issues in teaching, research, and clinical practice. Instructor: Bonner. 3 units.

743. Clinical Practicum. Intensive experience and supervision in clinical intervention processes. Student training in psychotherapy strategies and techniques and in clinical consultation skills is conducted in clinical settings. 0 to 6 units. Instructor: Staff. Variable credit.

744. Clinical Practicum. Intensive experience and supervision in clinical intervention processes. Student training in psychotherapy strategies and techniques and in clinical consultation skills is conducted in clinical settings. 0 to 6 units. Instructor: Staff. Variable credit.

745S. Teaching Practicum. Experience based on teaching assistantship for fall semester. Instructor: Bonner. 3 units.

746S. Teaching Practicum. Experience based on teaching assistantship for spring semester. Instructor: Bonner. 3 units.

748. Child/Adolescent Psychotherapy. Introduction to psychodynamic and cognitive-behavioral approaches to clinical problems of children and adolescents, with an emphasis on empirically-supported interventions. Instructor: Curry. 3 units.

749. Practicum in Psychological Research. Instructor: Staff. 3 units.

750. Practicum in Psychological Research. Instructor: Staff. 3 units.

752. Child Assessment. Interview methods; intelligence and achievement testing; personality and developmental batteries; peer, teacher, and parental instruments; and observational techniques. Instructor: Staff. 3 units.

753S. Mind Wandering and Inattention. Introduction to theoretical and practical aspects of research in cognitive science. Classes and readings will focus on popular topics in the domain of mind wandering and inattention, with an emphasis on the research process. This course will focus on critically evaluating primary-source material, and on honing presentation and writing skills. Instructor: Seli. 3 units.

754S. Cognitive Assessment. This course enables students to master a key professional skill of the clinical psychologist that is used in internship, clinical practice, and academic research. Theory topics include psychometric measurement, the science of test construction, the politics and history of mental testing, and the misuses of mental testing. Students learn to evaluate and critique tests. Students learn to administer, score and interpret eh WPPSI, WISC, WAIS, and selected tests of academic achievement and neuropsychological brain functions. Students learn to write a formal report of assessment findings, to give oral consultations to patients, parents and referring physicians, to understand the legal aspects of assessment practice, and to appropriately apply test for diagnosis and treatment planning. Instructor: Moffitt. 3 units.

755. Research Practicum. Students will be involved in a research apprenticeship to a faculty member for hands-on experience with research efforts. Instructor: Staff. 3 units.

756. Research Practicum. Students will be involved in a research apprenticeship to a faculty member for hands-on experience with research efforts. Instructor: Staff. 3 units.

757S. Cognitive Neuroscience Colloquia. Graduate students (2nd year and higher) and other research trainees (e.g. postdocs) in cognitive neurosciences will each take a turn at presenting a research topic (e.g. a research update, a practice talk, an experimental proposal, presentation of a scientific article) in a forum aimed at helping junior researchers develop and hone their presentation skills. Consent of instructor required. Instructor: Woldroff and staff. 1 unit.

758S. Cognitive Neuroscience Colloquia. Graduate students (2nd year and higher) and other research trainees (e.g. postdocs) in cognitive neurosciences will each take a turn at presenting a research topic (e.g. a research update, a practice talk, an experimental proposal, presentation of a scientific article) in a forum aimed at helping junior researchers develop and hone their presentation skills. Consent of instructor required. Instructor: Woldroff and staff. 1 unit.

759S. Principles in Cognitive Neuroscience I. Introduction to the cognitive neuroscience of emotion, social cognition, executive function, development, and consciousness. Topics also include cognitive disorders, and computer modeling. Highlights current theories, methodological advances, and controversies. Students evaluate and synthesize findings across a variety of research techniques. Consent of instructor required. Instructor: Cabeza, Labar, Purves, or Woldorff. 3 units. C-L: Neurobiology 759S, Philosophy 753S

760S. Principles in Cognitive Neuroscience II. Introduction to the cognitive neuroscience of emotion, social cognition, executive function, development, and consciousness. Topics also include cognitive disorders, and computer modeling. Highlights current theories, methodological advances, and controversies. Students evaluate and synthesize findings across a variety of research techniques. Consent

of instructor required. Instructor: Cabeza, Labar, Purves, or Woldorff. 3 units. C-L: Neurobiology 760S, Philosophy 754S

762. Functional Magnetic Resonance Imaging. This course will cover the complete fMRI analysis pipeline, from the scanner to constructing brain maps. Students will be trained on basic principles of fMRI, artifact detection, preprocessing, and task-fMRI signal estimation. This course will also cover recent advancements in resting-state fMRI, connectivity/graph-theoretic/independent-component analyses, and machine learning. The course will consist of lectures, review of key research papers and integrated laboratory sessions. The laboratory sessions will include hands-on analysis of fMRI data sets. Students will gain experience both in the theoretical principles of fMRI analysis and in the practical aspects of implementing them. Instructor: Michael. 3 units. C-L: Neurobiology 881

763S. Psychology and Neuroscience First Year Seminar I. Introduction to graduate school and academia, talk preparation and practice, grant writing, career paths, ethics. This is a two semester class with 1.5 credits each semester. Instructor: Marsh. 1.5 units.

764S. Psychology and Neuroscience First Year Seminar II. Introduction to graduate school and academia, talk preparation and practice, grant writing, career paths, ethics. This is a two semester class with 1.5 credits each semester. Instructor: Marsh. 1.5 units.

765S. Psychology and Neuroscience Grant Writing. Editing and submission of NSF application; peer review of other students' grant submissions. Prerequisite: Psychology 763S or equivalent. Instructor permission required. Instructor: Hoyle. 1 unit.

766. Applied Analysis of Variance. Application of analysis of variance typical in psychology and related disciplines. Introduction to the general linear model. Foundations of experimental design, probability, inference. Topics include: one factor ANOVA, factorial ANOVA with two- and three-way interactions, trend analysis, within-subjects designs, analysis of covariance, effect size and power estimation. Equips students to apply, interpret, and report results of ANOVA. Training in the use of SAS statistical computing system. Mandatory weekly lab sessions. Assumes undergraduate statistics course; understanding of basic statistical concepts. Consent of instructor required. Instructor: Staff. 3 units.

767. Applied Correlation and Regression Analysis. Applications of correlation and regression analysis typical in psychology and related disciplines. Correlation topics include: computing, testing, and comparing zero-order, partial, and semi-partial correlation coefficients. Regression topics include: logic of model comparison, hierarchical analysis, effect and dummy coding, interaction effects, curvilinear effects, diagnostics, and power estimation. Equips students to apply, interpret, and report results of correlation and multiple regression analyses. Training in the use of the SAS statistical computing system. Mandatory weekly lab sessions. Assumes prior graduate training in general linear model. Consent of instructor required. Instructor: Staff. 3 units.

768. Applied Structural Equation Modeling. Applications of structural equation modeling typical in psychology and related disciplines. Topics include: notation, path diagrams, specification and identification, estimation, modification, power estimation, measurement models, multivariate regression models, panel models, growth models. Emphasis on model comparisons, limits on causal inference. Equips students to apply, interpret, and reports results of structural equation modeling analyses. Training in the use of relevant software. Mandatory weekly lab sessions. Consent of instructor required. Instructor: Staff. 3 units.

769S. Research Synthesis and Meta-Analysis (G). 3 units. C-L: see Education 794S

770. Applied Multilevel Modeling. Applications of multilevel modeling typical in psychology and related disciplines. Estimation and interpretation of models for multilevel data structures, including data generated by clustered and longitudinal designs. Examination of conceptual, substantive, and methodological issues in analyzing multilevel data. Focus on appropriately conceptualizing, modeling, and reporting research on multilevel data. Training in the use of relevant statistical software. Mandatory weekly lab sessions. Assumes prior graduate training in applications of analysis of variance and multiple regression. Consent of instructor required. Instructor: Staff. 3 units.

773S. Reward and the Brain. This course will provide an overview of the neural basis of reward. We will read and discuss the classic and contemporary literature on both animal and human models. Topics to be covered include: 1) historical development of the concept of reward and its relationship with reinforcement; 2) reward, homeostasis, and motivation; 3) relationship between reward and learning (reinforcement learning, Pavlovian and instrumental conditioning); 4) contribution of dopamine and other neuromodulators to reward; 5) neural substrates of intracranial self stimulation; 6) limbic cortico-basal ganglia circuit contributions to reward. Instructor: Yin. 3 units. C-L: Neuroscience 773S

780S. Foundations of Behavioral and Computational Neuroscience. Survey and in depth discussion of the methods, theory, and current research in the field of behavioral and computational neuroscience. Emphasis on animal models and neurobiological underpinnings of learning, memory, and cognition. Covers the latest developments in research on neuroanatomical, cellular and molecular substrates of behavior with emphasis on the influence of development, environment, and experience across the lifespan. Instructor: Bilbo. 3 units. C-L: Neuroscience 780S

781S. Data Methods in Cognitive Psychology. Introduction to the analysis of behavioral data from cognitive research with a focus on the separation of accuracy and response strategy. Particular emphasis on Signal Detection Theory and other basic statistical decision models. Application of Matlab to both basic Monte Carlo simulation and cognitive experiment generation. Simple estimation of the parameters of decision models using iterative search algorithms and the use of bootstrap techniques to estimate the variability of parameter estimates. Investigation of the basic relationship between decision models and statistical tests typically used behavioral data analysis such as Student's t-test. Instructor: Staff. 3 units.

795S. Research Development in Psychological Science. The primary purpose of the course is to guide the development of a research project, related to dissertation research in psychology, utilizing the steps needed to develop and write a predoctoral National Research Service Award (NRSA) (F31). The course is pragmatic and oriented toward skills building in research development and grant writing. Instructor consent required. Instructor: Staff. 3 units.

797. Professional Issues in Clinical Psychology. This course is designed to provide an educational experience that will introduce and enhance the student in the science and profession of clinical psychology. Course topics will address and assure that the student understands critical issues in the professional activities of clinical psychologists, has exposure to a variety of career trajectories,

develops appropriate clinical skills in preparation for predoctoral internship training, initiates and is productive in an area of scholarly research, and integrates professional contributions with other important life activities. Instructor: Strauman. 1 unit.

798. Professional Issues in Clinical Psychology. This course is designed to provide an educational experience that will introduce and enhance the student in the science and profession of clinical psychology. Course topics will address and assure that the student understands critical issues in the professional activities of clinical psychologists, has exposure to a variety of career trajectories, develops appropriate clinical skills in preparation for predoctoral internship. Instructor: Strauman. 1 unit.

890S. Special Topics in Psychology. This seminar is designed to provide students with an opportunity to engage in an advanced and intensive examination of the research literature on a special topic in psychology. Specific topics will vary by semester. Instructor: Staff. 3 units.

950S. Neurophilosophy. 3 units. C-L: see Philosophy 950S

990. Special Readings in Psychology. Consent of instructor required. Instructor: Staff. 3 units.

Public Policy

Professor Kelley, *Dean of the Sanford School of Public Policy*; Professor Pizer, *Senior Associate Dean for Faculty and Research*; Professor Pattanayak, *Director of Graduate Studies (PhD)*; Professor of the Practice Rogerson, *Director of Graduate Studies (MPP)*; Professor of the Practice Pomerantz, *Director of Graduate Studies (MIDP)*; Professor Krupp, *Associate Dean for Academic Programs*; Professor Mayer, *Associate Dean for Strategy and Innovation*; Professors Brownell, Bradley (Law), Burton (Sociology), Chafe (History), Clotfelter, Darity, Dodge, Feaver (Political Science), Fleishman (Law), Jentleson, Korstad, Kuniholm, Krishna, Harris (Sociology), Hillygus (Political Science), McClain (Political Science), Mayer, Merli, Munger (Political Science), Napoli, Nechyba (Economics), Pattanayak, Pfaff, Pizer, D. Price (Political Science), V. Price, Sanders, Schroeder (Law), Sitkin (Business), Sloan (Economics), D. Taylor, Thomas (Economics), Vincent (Environment), Ubel (Business), Weiner (Law), Whetten, and Yamey; Associate Professors Ananat, Bail (Sociology), Balleisen (History), Bennear (Environment), Bermeo, Carnes Conrad, Gassman-Pines, Gibson-Davis, Goss, Jeuland, Mohanan Peck, Siegel (Political Science), Weinthal (Environment), and Zafar (Medicine); Assistant Professors Barnes, Hamoudi, Harding, T. Johnson, Meeks, Miles, Pearson, Rangel, Robertson (Psychiatry), Rose, and Sexton; Research Professors Frankenberg, Lansford, Nuamah, Odgers, and Vaupel; Associate Research Professors Babinski, Büthe (Political Science), Philipsen, Pickus, and Muschkin; Assistant Research Professor Gifford; Professors of the Practice Adair, Bennett, A. Brown, Fernholz, Frey (Law), Gill, Glenday, Harris, Kelly, Krupp, McCorkle, Pomerantz, Schanzer, Rogerson, Shukla, So, Stangl (statistics), and T. Taylor; Associate Professors of the Practice Charney, Mirovitskaya, and Profeta; Adjunct Professors Boucher, Hollowell, and Sorenson; Lecturers Blount and Mlyn; Visiting Professors Hemming, Smith, Swatz, and Walden; Visiting Associate Professor MacMullen; Visiting Assistant Professors McKethan and Schewel; Visiting Professors of the Practice Boehmer, Brook, Burness, Eacho, Garr, Hemming, MacArdle, Webb, and Zapotoczny; Visiting Assistant Professors of the Practice Angrist, Eglite, and Nichols; Visiting Lecturers Auffret, Barnes, Biewen, Boex, Byerley, Byrne, Chandler, Cossio, Dhakal, Dukes, Graham, Elkins, Emmett, Fandohan, Gilbert, Hahn, Hankins, D. Hart, Hepburn, Hill, Holmes, Hood, Kaufman, Katz, Katzenelson, L'Homme, Mataxis, Millsaps, Morris, Moses, Mulot, Perault, Prakash, K. Price, Quinterno, Rivera, Rosch, Schoenfeld, Searing, Stegman, Stencel, Storelli, Unell, Vyborny, Wallace, Warren, Weddington, and Webster; Professors Emeriti Blount, Cook, James, Joseph, Kuniholm, Ladd, Lethem, and Mickiewicz

A PhD is available in this department through The Graduate School.

The PhD in public policy is an applied, interdisciplinary social science degree. Graduates of the program are prepared for academic positions in public policy, public administration, and other policy-oriented schools, and for professional positions in domestic and international public agencies, research organizations, and policy consulting firms.

The program requires a two-course sequence in theories of public policy, microeconomics, and research methods. Students also complete coursework in a designated disciplinary concentration such as economics, political science, psychology, or sociology, as well as a policy focus, such as social policy, globalization and development, or health policy.

Students in the program are expected to pass a comprehensive exam at the beginning of the third year and a preliminary exam that is a dissertation prospectus defense at the end of the third year.

Students who complete sufficient coursework and either the comprehensive exam or a substituted completion exercise may be eligible for the MA in public policy.

More information about the PhD in public policy and the MA in public policy can be found at https://sanford.duke.edu/.

Courses in Public Policy (PUBPOL)

501S. American Grand Strategy. 3 units. C-L: see Political Science 562S; also C-L: History 567S

502S. Contemporary United States Foreign Policy. Focus on challenges and opportunities for American foreign policy in this global age including the impact of interests, ideals and values. Draws on both the scholarly literature and policy analyses. Addresses big picture questions about America's role in the world as well as major current foreign policy issues that raise considerations of power, security, prosperity and ethics. Open to undergraduates with permission of instructor and priority to Public Policy Studies and Political Science majors, and to graduate students. Instructor: Jentleson. 3 units. C-L: Political Science 670S

503S. United States Policy in the Middle East. From World War II to the present with a focus on current policy options. Instructor: Kuniholm. 3 units. C-L: History 509S

504. Counterterrorism Law and Policy. This course explores the novel legal and policy issues resulting from the United States' response to 9/11 attacks and the threat posed by modern terrorist organizations. Topics include preventative/preventive war; detention, interrogation, and prosecution of suspect terrorists; domestic surveillance; and government secrecy and public access to information. Instructor: Schanzer. 3 units. C-L: Political Science 543

507S. Intelligence for National Security. Addresses complex US intelligence enterprise that has been established to support our national security priorities. First, students review and discuss current structure of national intelligence apparatus. Case studies are used

to evaluate effectiveness and design of intelligence agencies and their accompanying capabilities. Finally, students conduct independent research on select intelligence agencies and organizations. Instructor consent required. Instructor: Nichols. 3 units.

508. Culture and Explosion: How Russian Culture Changed the World. 3 units. C-L: see Russian 533; also C-L: Cultural Anthropology 533

510S. Science and the Media: Narrative Writing about Science, Health and Policy. 3 units. C-L: see Bioethics and Science Policy 510S; also C-L: Policy Journalism and Media Studies 510S

511. Social Innovation Practicum. 3 units. C-L: see Innovation and Entrepreneurship 510

513S. International Democratization. Focus on critical analysis of international efforts to improve governance, build democracy and increase respect for human rights through a series of methods or tools: international law, sanctions, aid, conditionality, and a vast array of activities broadly labeled democracy promotion, including election assistance and civil society development. Class requires a high level of discussion and preparation for each meeting. Emphasis on student application of reading material to a particular country. Instructor: Kelley. 3 units. C-L: Political Science 647S

515S. Assisting Development. Examines evolution of international development theory and practice since early 1950s. Investigates how different solutions advanced to deal with poverty have fared. Different streams of academic and policy literature, including economics, political science, and sociology, are consulted with a view to understanding what could have been done in the past and what should be done at the present time. Examines alternative formulations weekly in seminar format. Individual research papers (60% of grade) which analyze past and present development practices in a country of their choice, or examine trends within a particular sector (e.g., agriculture, population, gender relations, the environment). Instructor: Krishna. 3 units. C-L: Political Science 546S, International Comparative Studies 514S

519. Introduction to International Organizations and Technology Policy. 3 units. C-L: see Science & Society 519

524S. Social Determinants of Health Disparities. This course utilizes a Social Determinants of Health (SDH) perspective to explore health differences. The SDH are life enhancing resources and life compromising risks the differential distribution of which determines inter-population differences in health. The SDH perspective suggests that a range of policy decisions are systematically associated with health. Consequently, virtually all policy is health policy. The objective of this course is to have students critically examine the various processes influencing health across diverse population groups. We will examine identity construction, stratification, marginalization, inequality and the physical embodiment of lived social experience. Instructor: Pearson. 3 units.

525S. Poverty Policy After Welfare Reform. An examination of causes and consequences of poverty in the United States, reviewing major social policies used to combat poverty. Examines evidence on the effects of the 1996 welfare reform and studies the piecemeal anti-poverty programs that have risen in place of traditional welfare. Considers tradeoffs and unintended consequences present in America's safety net. Instructor: Gassman-Pines. 3 units.

526S. Race and American Politics. 3 units. C-L: see Political Science 525S; also C-L: African & African American Studies 544S

527S. Poverty, Inequality, and Public Policy in the U S. Examines causes and consequences of poverty and inequality in the United States; reviews major social policies used to combat poverty's ill effects. Acquaint students with definition and extent of poverty and inequality, examine poverty's "causes", including family structure and low wage employment, discuss effects of poverty on family and child well-being, and analyze the primary poverty policies employed by the United States, including Temporary Aid to Needy Families, Food Stamps, Medicaid, and WIC. Lecture and class discussion, drawing on material from a variety of disciplines. Instructor: Gibson-Davis. 3 units.

528. History of Poverty in the United States. 3 units. C-L: see Study of Ethics 561; also C-L: History 546, Human Rights Program-Franklin Humanities Institute 561

529S. Race and Ethnicity. Explores in depth policies of redress for intergroup disparities or inequality across countries. Examination of policies that attempt to systematically correct differences across racial/ethnic groups in income, wealth, health, rates of incarceration, political participation, and educational attainment, e.g. affirmative action, land redistribution, parental school choice, and income redistribution measures in a number of countries including India, the United States, Brazil, Malaysia, Chile, and South Africa. Address question of why intergroup differences in outcomes should be viewed as a social problem. Instructor: Darity. 3 units. C-L: African & African American Studies 551S, International Comparative Studies 529S

530S. Gender, Identity, and Public Policy. The role of women and women's organizations as advocates for, and targets of, public policymaking. The grounding of women's collective action claims in understandings of women's "sameness as" and "difference from" men, and the implications of those frames for women's citizenship. Gender differences in individual civic engagement and in the styles and priorities of male and female elected officials. The historic evolution of women's organizational engagement in gender-specific and general-purpose public policies. The impact of globalization on women. The oppression and emancipation of women in traditional societies. The legitimacy crises facing maternal, second wave, and third wave feminism. Instructor: Goss. 3 units. C-L: Political Science 521S, Gender, Sexuality, and Feminist Studies 515S

531S. Philanthropy: The Power of Money. Seminar course with applied project designed to deepen understanding of role of private wealth in shaping public policy. Provides overview of philanthropy in America, emphasizing new generation of billionaires. Engages philosophical debates over obligations and opportunities of wealth in an age of income inequality and governance challenges. Discusses laws structuring politically oriented giving. Explores strategies donors use to pursue their vision of the public good, including new work at intersection of business, social sector. Evaluates why some strategies succeed while others fail. Case studies may include education reform, community development, clean energy, etc. Instructor: Goss. 3 units.

542S. Schooling and Social Stratification. This course will examine educational policies in a comparative, cross-national fashion with a focus on the implications for the construction of social hierarchy and inequality. Instructor: Darity. 3 units. C-L: African & African American Studies 549S, Education 542S

544S. Schools and Social Policy. Overview and selected current policy issues related to K-12 education. Includes small-group research projects that require data analysis, literature searches, and interviews with education policy makers. Consent of instructor required. Instructor: Staff. 3 units.

555S. The Politics of Market Competition in a Global Economy. 3 units. C-L: see Political Science 555S; also C-L: Study of Ethics 555S

556S. The Global Cold War. Examines key episodes and issues in the international history of the Cold War. Seminar readings will be drawn from historical literature and primary sources. Topics will extend beyond the traditional focus on US-Soviet rivalry and examine the conflict's impact on societies around the world, especially in newly independent states. Evaluation will be based on seminar participation and written assignment focused on primary source usage. Students will think about not only history, but also how the Cold War's effects are still being felt today. Instructor: Miles. 3 units. C-L: Political Science 542S, History 556S

558S. Understanding Ethical Crisis in Organizations. 3 units. C-L: see Study of Ethics 562S; also C-L: Political Science 502S, Sociology 542S

559S. Philanthropy, Voluntarism, and Not-for-Profit Management. An examination of the role and functioning of the not-for-profit sector in relation to both the public sector and the private for-profit sector in dealing with significant social problems. Also taught as Law 585. Instructor: Fleishman. 3 units.

560S. Philanthropy: the Theory of Practice and the Practice of Theory. Role of grantmaking foundations as engines of social, economic, and political change. Normative implications for democracy of elites using wealth to influence society. Theories of strategic vs. expressive philanthropy. Debate over time-limited vs. perpetual foundations. Cases of philanthropy's impact in realms such as education, public television, and AIDS research. New philanthropic ventures that hybridize for-profit and non-profit approaches. Consulting project to guide newly wealthy individuals in philanthropic strategy. Instructor: Goss. 3 units.

561. 9/11: Causes, Response & Strategy. Examination of the origin and ideology of al-Qaeda and affiliated organizations, the events that led to the 9/11 attacks, and the public policy response in terms of use of force, preventive intelligence and law enforcement policies, and homeland security. Comparative examination of the efficacy and ethics of alternative counterterrorism policies. Instructor: Schanzer. 3 units. C-L: Political Science 544, International Comparative Studies 561

562S. Monuments and Memory: Public Policy and Remembrance of Racial Histories. Processes of memorialization of various dimensions of racial pasts, via statuaries, naming of parks and buildings, films (both documentary and fiction), novels, historical works. In depth treatment of political and economic basis for determining what events or persons are remembered and how they are remembered. Interdisciplinary course encompassing literary studies, memory studies, history, political science, anthropology, and economics. Instructor: Darity. 3 units. C-L: African & African American Studies 541S

563S. Making Social Policy. Examines the policymaking process, the role of different sectors in policymaking, policymakers' use of research and communicating with policymakers. Focus on social policy. Includes experiential and written work as well as visits from policymakers and to policymaking "events." Instructor: Staff. 3 units. C-L: Child Policy 634S, Sociology 634S

564. Democracy Lab. The Democracy Lab involves teams of students working on finding innovative approaches to a variety of political issues. The course will largely consist of client-based projects in which the teams, coached by the professor, that produce a substantial report or the equivalent that contributes to the health of political processes. Examples of topics may include, but not be limited to: reforming redistricting processes, designing voter rules, social media and politics, student voting at Duke, money in politics, and bridging societal divides. Instructor: Staff. 3 units.

574. Economic Evaluation of Sustainable Development. Examines how one could rationally defend a choice of 'sustainable development' policy. Applies cost-benefit thinking in environment-natural-resources and development contexts. Presents microeconomic concepts emphasizing logic and principles more than mechanics. Intertemporal equity is a focus and equity-efficiency tradeoffs are a theme. Microeconomics prerequisite not required. Instructor: Pfaff. 3 units. C-L: Environment 572

575D. Resource & Environmental Economics I. 1.5 units. C-L: see Environment 520D; also C-L: Economics 530D, Energy 520D

575L. Resource and Environmental Economics. 3 units. C-L: see Environment 520L; also C-L: Economics 530L

576. Resource & Environmental Economics I. 1.5 units. C-L: see Environment 520; also C-L: Economics 530, Energy 520

577. Environmental Politics. 3 units. C-L: see Environment 577; also C-L: International Comparative Studies 577

578. Land Use Principles and Policy. 3 units. C-L: see Environment 550

578D. Land Use Principles and Policy. 3 units. C-L: see Environment 550D

579S. Collective Action, Environment, and Development. Examines the conditions under which collective or participatory decisions may raise welfare in defined ways. Presents the growing empirical evidence for an environment and development setting including common property issues (tragedy of the commons and competing models). Identifies what evidence exists for sharing norms on a background of self-interested strategies. Definitions of and reactions to equity and/or its absence are a focus. Providing scientific information for policy is another. Experimental and behavioral economics are frequently applied. Instructor: Pfaff. 3 units. C-L: Environment 579S

580S. Water Cooperation and Conflict. Focuses on potential for transboundary water resources-related conflict and cooperation. Discusses water scarcity concepts, natural resource conflict theory, hydro politics, hydro hegemony, water security, water markets and institutions, game theory, and international water law. Other topics include the economics of water and health. Case studies complement the broader course outlook. Instructor: Jeuland. 3 units. C-L: Global Health 533S, Environment 543S, International Comparative Studies 580S

581S. International Environmental Regimes. 3 units. C-L: see Political Science 545S; also C-L: International Comparative Studies 521S

582. Global Environmental Health: Economics and Policy. Social science perspective on global environmental health. Students will learn to identify primary environmental causes of high burden diseases such as malaria, diarrhea, and respiratory infections; describe how to measure socio-economic impacts of global environmental health diseases; discuss key policies to control global environmental health problems based on private prevention and therapeutic behaviors; and propose frameworks to empirically monitor and evaluate global environmental health policies. A sub-module will focus on climate change and water-borne diseases. Prerequisites: Introductory course in statistics. Instructor: Pattanayak. 3 units. C-L: Environment 538, Global Health 538

583S. Energy and U.S. National Security. Examines link between reliable, affordable, and sustainable sources of energy and U.S. national security. Includes ethical considerations related to energy resources and wealth distribution, analysis through case study of top foreign oil suppliers to U.S., as well as newer "unconventional" sources of energy such as shale gas and renewables. Extensive use of guest experts from U.S., local and foreign governments as well as industry. Specific skills include thinking like a U.S. diplomat (cross-cultural perspective), writing concise policy memos, and delivering a compelling, succinct oral presentation. Final project will require policy recommendation on an assigned energy security topic. Instructor: Kelly. 3 units. C-L: Political Science 663S, Environment 583S

583SK. Energy and National Security. Energy and National Security examines links between available, reliable, affordable, and sustainable energy supplies and economic and national security of an advanced economy in early the 21st Century. Countries of particular interest are China and the United States. Both are net energy importers, depend on smoothly functioning global energy markets and open sea-lanes, and face ethical and environmental issues as they choose among their energy sources and suppliers. Both also are highly dependent on energy to power their economies, fuel their militaries, and preventing enemies or competitors from inflicting damage on their economies or populations. Taught at Duke Kunshan University. Instructor consent required. Instructor: Staff. 3 units. C-L: Environment 583SK, Political Science 663SK

584. Resource & Environmental Economics II. Variable credit. C-L: see Environment 521; also C-L: Economics 531

584D. Resource & Environmental Economics II. Variable credit. C-L: see Environment 521D; also C-L: Economics 531D

585. Climate Change Economics and Policy. 3 units. C-L: see Environment 640

585K. Climate Change Economics and Policy. 3 units. C-L: see Environment 640K

590. Advanced Topics in Public Policy. Selected topics. Instructor: Staff. 3 units.

590S. Advanced Topics in Public Policy. Selected topics. Seminar version of Public Policy Studies 590. Instructor: Staff. 3 units.

595S. Regulation of Vice and Substance Abuse. The traditional vices of drinking, smoking, gambling, and the recreational use of drugs. Evaluation of government policy on these activities. The intellectual framework for evaluation drawn from economics, although readings refer to law, psychology, philosophy, and statistics. Instructor: Cook. 3 units.

596. Evaluation of Public Expenditures. Basic development of cost benefit analysis from alternative points of view, for example, equity debt, and economy as a whole. Techniques include: construction of cash flows, alternative investment rules, inflation adjustments, optimal timing and duration of projects, private and social pricing. Adjustments for economic distortions, foreign exchange adjustments, risk and income distribution examined in the context of present value rules. Examples and cases from both developed and developing countries. Instructor: Staff. 3 units. C-L: Economics 521, Environment 532

596D. Evaluation of Public Expenditures. Basic development of cost benefit analysis from alternative points of view, for example, equity debt, and economy as a whole. Techniques include: construction of cash flows, alternative investment rules, inflation adjustments, optimal timing and duration of projects, private and social pricing. Adjustments for economic distortions, foreign exchange adjustments, risk and income distribution examined in the context of present value rules. Examples and cases from both developed and developing countries. Instructor: Staff. 3 units. C-L: Economics 521D, Environment 532D

597S. Seminar in Applied Project Evaluation. Initiate, develop, and perform a project evaluation. Range of topics include measuring the social cost of deforestation, the B1 Bomber, a child nutrition program, the local arts program. Prerequisite: Economics 285 or Public Policy Studies 596. Instructor: Staff. 3 units. C-L: Economics 522S

598. Economic Growth and Development Policy. Basic principles and policy issues in the study of economic growth and development. The roles of physical, natural and human capital, technological innovation, productivity improvements, history and institutions in explaining patters and causes of variations in growth and developmental performance of countries. Effects on growth, development, wellbeing and poverty levels of many current policy issues including HIV/AIDS, financial crises, macro-stability, foreign aid and investment, debt burdens and forgiveness, governance and corruption. Instructor: Fernholz. 3 units. C-L: International Comparative Studies 598

601S. Urban Policy. Overview of basic political, sociological, and economic models of urbanization coupled with application of these models to modern urban problems, including concentrated poverty, traffic congestion and mass transit, crime, land use and environmental quality, housing affordability, and fiscal crises. Special emphasis on historical evolution of cities. Students write a major project focusing on the problems facing one American city, and propose solutions to those problems. Instructor: Staff. 3 units.

602S. Law, Economics, and Organizations. Overview of field of law and economics. Economics of information, contract theory, economic analysis of law, and New Institutional Economics. Consequences of failure of law and institutions; alternative mechanisms to sustain markets and transactions. Instructor consent required. Instructor: Staff. 3 units. C-L: Economics 502S

603S. Microeconomics of International Development Policy. Microeconomic foundations of international development policy using tools of microeconomics to study behavior of individuals, households, and firms in developing countries. Topics may include household and intrahousehold modeling; market participation; agrarian contracts; credit and microfinance; nutrition and health; poverty traps; etc. Public Policy Studies 303D prerequisite or instructor approval. Instructor: Staff. 3 units. C-L: Economics 503S

604. Using Data to Analyze and Evaluate Public Policy. This course reviews the basic methods of inferring the causal impact of public policy initiatives. Topics include randomized controlled trials, instrumental variable analysis, regression discontinuity designs,

difference-in-difference "natural experiments," and propensity score/nearest neighbor matching methods. Assignments include analysis using Stata software; final project entails proposing a quantitative study focused on causal inference. Either Statistical Science 101 or Public Policy 812 required; further coursework in multiple regression preferred. Consent of instructor required. Instructor: Staff. 3 units.

605. International Trade and Policy. Focus on economics of trade and trade policy. Includes theoretical models explaining patterns of trade, economic gains from trade, and distribution effects (winner and losers), as well as the economic effects of trade barriers, major agencies and institutions affecting trade, preferential trading arrangements, outsourcing and offshoring, multinationals, and labor and environmental issues. (No finance.) Prerequisite: Public Policy Studies 303D or Economics 201D. Instructor: Krupp. 3 units. C-L: Economics 505

606. Macroeconomic Policy and International Finance. Survey of macroeconomic theory and analysis of policies designed to reduce unemployment, stimulate economic growth, and stabilize prices. Conventional monetary and fiscal instruments, employment policies, and new policies designed to combat inflation. Instructor: Staff. 3 units. C-L: Economics 506

607. Cost-Benefit Analysis for Health and Environmental Policy. 3 units. C-L: see Global Health 531; also C-L: Environment 563

608. Economics of the Family. Examines ways extended families function as economic institution. Primarily empirical, but also draws on relevant microeconomic theory. No formal prerequisites, but students should have experience with intermediate microeconomics and econometrics/statistics. Instructor: Staff. 3 units.

609S. The Regulatory Process. Study of theories in economics, political science, and law to examine the structure, conduct, and performance of U.S. regulatory agencies. Emphasis on why decisions are delegated to agencies, the degree to which regulators behave strategically, and the impact of regulatory actions on society. Focus on political and economic roots of scientific and technological debates in regulatory policy. Required research paper on origins and effectiveness of a particular regulation. Instructor: Staff. 3 units. C-L: Political Science 617S

610. Analysis for Strategic Design of Policy and Regulation. Applies tools from welfare economics, information economics, and mechanism design in order to analyze public policy problems in the context of asymmetric information and strategic behavior. Applications include: financial regulation, private and social insurance, corruption and accountability, provision of public goods, and others. Requires previous exposure to intermediate microeconomics (including basic game theory), and reasonable comfort with the mathematics of constrained optimization. Instructor: Staff. 3 units.

613S. Technology Policy for the New Administration: Antirust, Speech and Other Emerging Issues. A seminar that will explore the technology policy agenda for the administration that will begin in January 2021. The course will examine how the new administration should consider policy design for technology, and will evaluate the potential impact of various policy proposals in consideration. Topics will include antitrust policy, harmful content, and free expression. Additional topics may include privacy, cybersecurity, law enforcement and national security, and artificial intelligence. The focus of the course may shift based on current events. Instructor: Perault. 3 units. C-L: Science & Society 613S

632K. Environmental Science Research Methods II. A more advanced version of PUBPOL 631K Research Methods I. A survey of research methods used in anthropology, social science, public health, and economics. Based on readings, students will present and formulate discussions on research questions, research method, data source, findings, inference, and policy implications. Introduces theoretical foundations of applied research and guidance on applying methods to specific research questions. Topics covered in this course include quantitative and qualitative methods, experimental and quasi-experimental research study design, and the academic publication process. Instructor: Ji. 3 units.

633. Topics in Population, Health, and Policy. Substantive findings and policies/policy debates around selected topics in the field of population and health in industrialized and developing societies. Demographic models used to examine selected current population and health topics through framing, defining and evaluating key concepts. Topics include: end of population growth; relations between population, development and environment; health of populations; population aging; potentials for mortality increases; HIV/AIDS epidemic and resurgence of infectious diseases. Readings from disciplines of demography, sociology and public health. Topics Course. Instructor: Merli. 3 units. C-L: Sociology 534, Global Health 550

634. Ethics and Policy in Genomics. 3 units. C-L: see Science & Society 612; also C-L: Computational Biology and Bioinformatics 612

635. The Politics of Health Care. The history, status, and future of health care policy. Grounded in political theories such as distributive justice, altruism, and contractarianism. Focus on policy formation. Case discussions of American reform controversies in light of international experience. Instructor: Conover. 3 units. C-L: Political Science 518

636. Global Health and Health Systems in Africa. 3 units. C-L: see Global Health 671

637. Health Policy Analysis. Group analysis of a current health-policy problem. Project involves background research, data acquisition, analysis, writing, and presentation of a substantial policy report. Designed for candidates seeking the undergraduate certificate in health policy. Consent of instructor required. Instructor: Taylor. 3 units.

638. Global Health Ethics: Interdisciplinary Perspectives. 3 units. C-L: see Global Health 540

639S. Public Health Research Methods and Issues. Focus on prevention of diseases and health problems; funding, policy, and management decision making. Overview of public health interventions and outcomes in United States, Europe, and less industrialized nations. Emphasis on understanding the social construction of race and ethnicity and the impact of socioeconomic variables such as race, ethnicity, gender, income and education on health. Public health perspective applied to such topics as: HIV/AIDS; teen pregnancy; cocaine use during pregnancy; infant mortality and low birth weight; violence; major causes of mortality in less industrialized countries; and role of public health in state and national health reform. Instructor: Whetten. 3 units.

640S. Value for Money in Health Care: Rationing in Theory and Practice. Determining which health interventions and programs are "worth it." Resource allocation and priority setting in practice. Analytical topics of cost benefit and cost effectiveness. Prerequisite: Economics 101 or 201D. Instructor: Staff. 3 units.

641S. Cancer in Our Lives: Film, Narrative, Fiction, History and Politics. Cancer and cancer research viewed through history, narrative, film, fiction. Covers how cancer affects the lives of individuals and families, how cancer research has changed, the politics of cancer research, and the academic-industry-government ecosystem that gives rise to new cancer diagnostics and treatments. Intended for undergrads from humanities, social sciences or sciences and grad or professional students. Heavily discussion-based. Instructor: Cook-Deegan. 3 units. C-L: Science & Society 641S

642S. Designing Innovation for Global Health: From Philanthropy to People. Explores the introduction, adaptation, and globalization across borders of health technologies, with emphasis on resource-limited settings. Students will critically examine how policy can influence and funding can enable (or not) their innovation and access in low- and middle-income countries. Topics include policies to minimize inequity, systems for sharing and owning knowledge, approaches to innovative financing, and ethical issues. Instructor: Staff. 3 units. C-L: Global Health 642S

644S. Poverty, Inequality, and Health. Impact of poverty and socioeconomic inequality on the health of individuals and populations. Attention given to both United States and non-United States populations. Topics include the conceptualization and measurement of poverty and socioeconomic inequality; socioeconomic gradients in health; globalization and health; socioeconomic deprivation across the life-course and health in adulthood; and public policy responses in the United States and elsewhere to growing health inequities in the age of globalization. Prerequisite: An introductory course in statistics. Seniors and graduate students only. Instructor: Staff. 3 units. C-L: African & African American Studies 548S

645S. Global Inequality Research Seminar. Engagement of vertically integrated research teams in projects exploring racial and ethnic disparities exhibited and expressed in six arenas: employment, wealth, health, political participation, education, and arts and culture. Each team will produce a major paper that will qualify for submission to a refereed journal in the area relevant to the focus of the study. Instructor consent required. Instructor: Staff. 3 units. C-L: African & African American Studies 642S, Economics 541S, Sociology 642S, Political Science 642S, Human Rights Program-Franklin Humanities Institute 642S

646S. Strategic Storytelling: Narratives for Development. With a broad array of storytelling mediums, we ask how "sticky" stories told about poverty or development strategically can add to our ability properly to understand poverty and to conduct appropriate development policies more effectively. What are the benefits and limitations of considering public policy problems by entering through the arts of storytelling and of storylistening? How do stories help readers/listeners become alive to ethical and cultural considerations previously unseen or unheard? How might these stories enable storytellers to tell stories on their own terms, opening up new and critically important terrains for public policy? Soft power strategy. Guest practitioners. Instructor: Admay. 3 units. C-L: Study of Ethics 646S, International Comparative Studies 646S

647S. Legal Analysis for Development Governance. Using case scenarios, we apply a legal analytical framework to development-related governance challenges in investment, trade, environment, land, community and human rights, health, corruption, corporate social responsibility, consumer literacy, children's legal personality and other sectors. "Rules of the Game" and legal rules. Three levels: international, national (constitutional), community. De-mystify the way legal processes and legal authorities work (and don't work) to advance development, and help public policy students and others engage effectively on the strength of this knowledge. For non-lawyers and those considering law careers. Guest practitioners. Case debriefings, briefings. Instructor: Admay. 3 units. C-L: Political Science 682S

651S. Theories of International Political Economy. 3 units. C-L: see Political Science 651S

667S. American Civil-Military Relations. 3 units. C-L: see Political Science 667S

674. Media and Democracy. Examines the relationship between mass media and democracy in the United States, other developed democracies, and societies in transition. Seeks to explain how the media cover politics and public policy, examining the nature of media institutions, the economics of news production and consumption, and the strategic interplay of politicians, journalists, editors, and other actors who influence the content of news. Instructor: Staff. 3 units. C-L: Visual and Media Studies 563

676. Media and Social Change. 3 units. C-L: see Policy Journalism and Media Studies 676; also C-L: Political Science 619, Russian 516

677S. Federal Programs: Using the Paper Trail to Track Promises and Follow the Money. Follows a federal spending or regulatory program from inception through implementation. Research of primary records, including state and local governments, and standard federal sources of primary documents, to compare performance with expectations. GIS and other visualization techniques to analyze program implementation. Website creation to detail program performance. Instructor: Staff. 3 units.

680S. Ethical Foundations of Innovative Technology Policy. 3 units. C-L: see Science & Society 680S

681S. Political Economy of Macroeconomics. 3 units. C-L: see Political Science 705S

700S. Policy Analysis of Development. The broad objectives of this seminar are: 1) to examine the role of policy analysis in solving important social problems; and 2) to develop the analytical and communication skills of participants in order to undertake effective policy analysis. This seminar examines public policy objectives and the role of policy analysis in achieving these objectives, market and government failures, the role of the public and private sector, policy analysis tools (e.g. cost-benefit analysis, decision analysis, etc.), and policy implementation and evaluation. Emphasis is given to specific policy problems (e.g. social, environmental, health problems) based on the interests of the participants. This seminar relies on case studies, application of policy analysis tools, exercises, memos, policy critiques, and discussions with policy analysts. At the end of the semester participants should be able to understand policy issues and choices, why policies fail, how to use policy tools to reach decisions, and how to evaluate policies. Instructor consent required. Instructor: N. Mirovitskaya or R. Fernholz. 3 units.

701. Economic Foundations for Development. This course is an overview of microeconomic and macroeconomic principles related to development. The objective of the course is to provide analytical tools for the study of economic policies and problems in developing countries. The seminar includes presentation of theoretical material and its application to current topics and problems. Instructor consent required. Instructor: Krupp. 3 units. 3 units.

702. Applied Development Economics. This seminar uses macroeconomic and microeconomic principles to analyze developmental challenges. We will use a core textbook to provide an integrated overview of many of the topics covered in the seminar, but the content and structure of the seminar will not follow the textbook and fellows will be required to read more widely and deeply on the topics covered. Many of the topics can be analyzed from both a microeconomic and macroeconomic angle, as well as from an institutional perspective, and the emphasis is on how to use a range of techniques to analyze different problems rather than identifying a problem that lends itself to the application of a particular technique. Instructor: Richard Hemming. 3 units.

703. DCID Summer Academic English Institute. This program is designed to help MIDP international graduate students with their academic studies. This program will develop and strengthen academic English skills and help with acclimation to the US university environment. Please note: this is a non-degree, pre-academic English program. No credits are awarded and it does not count toward any Duke degree. Instructor: Dean Storelli. 0 units.

704. Master's Project Preparation. This one-credit mandatory seminar is intended to facilitate efficient preparation of the master's project. It focuses on preliminary preparation up to prospectus defense. The seminar reviews lessons from past experience, selection of topic, and development of a research plan as well as the key elements of the policy analysis methodology. Grading is based on participation and the quality of the final prospectus. Consent of instructor is required. Instructor: Francis Lethem, Natalia Mirovitskaya, Rosemary Fernholz. 1 unit.

705. Master's Project in International Development Policy. Emphasis on individual projects. Open to MIDP students only. Instructor: Francis Lethem. 2 units.

707. Capacity Development. Over the last forty years our understanding of the what, the why, and the how of capacity development has continued to evolve. While there remain challenges in gaining agreement on which practices are most effective, what we do know is that those efforts which are most enduring include a multi-pronged approach working at the various levels. During this course we'll look at: various dimensions of capacity development; individual, organizational, and environmental; the role of training, learning, and performance in developing capacity at the various levels; the role of systems thinking and practice in capacity development; and fragile and conflict-affected states and capacity development. Instructor: Moreau. 3 units.

711. Public Policy Writing Practicum. Good writing comes from good thinking. In most cases, the biggest problem in "bad writing" is not bad grammar but poor style. We have all heard advice like "be clear" or "never use the passive," but what we need is to understand how to write clearly and why the passive may or may not be a good option. This mini-seminar will introduce a simple system of writing style that can be learned and put to use immediately. (Please bring your computer to class.) It is open to all MIDP and MPP students. Instructor: Storelli. 0 units.

712. Public Policy Presentation Practicum. This 5-week course will help you prepare for public policy presentations. It is a class about PowerPoint slides, but it is also about how to prepare your argument and yourself. We will look at design and content issues, including topics such as what to say in the first 45 seconds of a presentation, what kinds of content to avoid in a presentation and how to display complex data. The only homework will be to come to class prepared to work on your next presentation. This class is open to all MIDP and MPP students. Instructor: Storelli. 0 units.

713. Professional Editing Practicum. To be effective, policy writing must be well-structured, clear and free from distractions. While most of our writing efforts must be focused on content, in today's world, writers must also learn how to pay attention to form and format. In this short course, you will learn the mindset and specific skills needed for a professional level of writing and editing. Instructor: Storelli. 0 units.

721S. Institutional Design for International Development Managers. The objective of this seminar is to explore organizational and institutional design theory and its application towards promoting a more sustainable development. The seminar is structured to deal with the macro and micro institutional levels; structures and processes, including interagency coordination; and policy and implementation issues. Intensive use is made of case studies from various sectors in developing and transitional countries, though with emphasis on environmental management issues. As a seminar product, participants are expected to apply tools they have acquired to an institutional design problem of their choice that would be relevant to the management of the environment or any sector in which they have a special interest in their preferred country. Instructor consent required. Instructor: F. Lethem. 2 units.

723. Poverty Reduction and the International Financial Institutions. Over the last 50 years, development and poverty reduction have been the twin concerns of the International Financial Institutions (the World Bank, the International Monetary Fund (IMF) and the regional development banks). The course will trace the evolution of international poverty reduction theory, policy and implementation from the emphasis on capital accumulation and large infrastructure projects in the 1960s to the integrated rural development programs and basic needs approaches of the 1970s, through structural adjustment and sectoral programs in the 1980s and 1990s, to today's emphasis on debt relief and Poverty Reduction Strategies. As these changes were happening, related changes also were taking place in the structures, policies, and practices of the IFIs. The course will, look at the rationale, basic features, and effectiveness of each poverty reduction approach, as well as the accompanying changes in the two principal IFIs, the World Bank and the 1MF. The course will use general studies and reviews, as well as actual project and program examples. The course is primarily a group discussion, with occasional mini-lectures and student presentations. Written requirements include a mid-term assignment and final paper. Instructor consent required. Instructor: Phyllis Pomerantz. 3 units.

724. The Politics of International Aid in Low-Income Countries. This course will examine the evolving context, objectives, and results of international development aid in the post World War II period, with an emphasis on the period from the 1980s through today. It will review the track record of aid and lessons thus far, and the reform proposals for change currently under discussion in the

international community. Attention will be focused on the principal stakeholders, their motivations and capacity, and the quality of interaction among the various players (governments, bilateral donors, multilateral institutions, and NGOs). It will also evaluate the results achieved and the prospects for future success. Special reference will be given to Africa, the center of much of the evolving debate surrounding aid effectiveness. The course is primarily a group discussion, with occasional mini-lectures, student presentations, debates, case studies, and a final simulation exercise. Instructor consent required. Instructor: P. Pomerantz. 3 units.

725. The Role of Global Programs in International Development. Global programs have emerged as an increasingly important element in international development efforts. This seminar will examine and contrast different types of global programs, including those involving global public goods and those centering on global advocacy. The course will: explore the complexity of defining global public goods; trace the evolution and motivations for global programs in general and several of the programs in particular; examine how selected programs are managed, financed, and functioning in practice; and analyze the emerging contradictions and/or complementarities between global programs and country-specific development strategies and programs. Class sessions will include individual and/or small group presentations. Students will also select a prominent global program and examine if and how the program is contributing to overall development efforts within a specific country/subregional setting. Instructor consent is required. Instructor: P. Pomerantz. 3 units.

726. Innovation and Policy Entrepreneurship. Innovative approaches are increasingly seen as key to solving difficult, complex or new challenges in this century, whether the challenges are local survival in the face of persistent droughts or boosting productivity to meet global competition. It is policy entrepreneurship that is needed to craft the policy innovations or the frameworks that encourage innovation and private sector entrepreneurship. This course will focus on the analytical tools and skills needed by policy makers and analysts to build and sustain an enabling policy environment for innovations and entrepreneurship to occur at global, country and local levels. Instructor: Rosemary Fernholz. 3 units.

727. Service Delivery Systems. What happens to policy after laws are made, budgets are approved, and either public or nonprofit agencies try to implement public policy? This course will provide students with a way to understand the issues involved in delivering services to the public at the "street level". It will also give students an overview of a wide variety of services including: child protective services, education, law-enforcement, mental-health, juvenile-justice, public health, and other services that government, and increasingly non-profit and for-profit organizations, try to deliver to the public. Consent of instructor required. Instructor: Joel Rosch. 3 units.

728. Monitoring and Evaluating. This course takes a critical look at the range of issues and challenges typical in program M&E, with a strong focus on international development programs or projects. Students will develop or strengthen key program design and management skills for stronger results and demonstrated impact. Hands-on practical assignments will draw on material presented, your own experience, and class discussions to test your ideas and constructively challenge others. Half of the class grade depends on a group or individual project (M&E design and case study). Requirements: Experience in international development programs, comparable practical exposure to real-world low-resource political economies, or professor's approval. Logic or philosophy of science, and social science analytical methods. Instructor consent required. Instructor: Catherine Elkins. 3 units.

729. Strategic Management of Policy Change. This seminar examines the complex environment for policy change and explores management and organizational strategies to assure effective implementation of policy initiatives. Among the issues covered are leadership, strategic planning, change management, environmental mapping, organizational capacity-building, policy advocacy and constituency-building, performance monitoring, and sustainability. We also will explore how new information technologies can be used to facilitate policy dialogue and policy support. The seminar builds on the premise that management and organizational factors play a major role constraining (or promoting) effective policy implementation. A further assumption is that participants will have important leadership opportunities in the course of their future careers. There are management skills and techniques that can increase your ability to accomplish personal goals and those of the public or private agencies in which you serve. The seminar stresses mutual learning through the practice of teamwork and effective oral presentation of team learning. These will be important skills in your future careers. This emphasis also reflects the assumption that we have much to learn from each other. Instructor consent required. Instructor: Staff. 3 units.

730. Project Management for International Development. A significant proportion of international development assistance is offered in the form of complex projects. The management of such projects is challenging and quite different from the management of repetitive day-to-day operations. In addition, the environment for international development projects presents further challenges for the project manager. we will explore in some detail three of the most important phases of the project life cycle-project identification, project design and implementation planning-before considering how the project manager builds and leads the project team, manages risk and monitors and controls implementation towards a successful conclusion. Instructor: Staff. 3 units.

731. Science, Technology and Development Policy. This course examines the complex interactions between science, technology, policy and development using a comparative perspective. The course will cover the role of science and technology in development, the tools and methods used to regulate science and technology, and the differing structure and impacts of science and technology policies in various contexts. The goal of the course is to critically examine the linkages between science, technology and development and the myriad ways in which they shape and are shaped by policy. Instructor: Bal. 3 units.

740. A-C. Applied Economics Courses - International Development Policy. A. Statistics for Development B. Public Finance Policy in LDC and Transitional Countries C. Budgeting and Financial Sector Management. Topics of economic policy aspects of development; including issues of international trade and competitiveness, public finance and evaluation of public expenditures, banking and financial sector management, privatization, external debt management, and international capital markets. Instructor: Fernholz, Shukla (770). Variable credit.

741. Empirical Analysis for Economic Development. The objective of this course is to provide future decision makers with the necessary tools of statistical analysis to enable them to eventually conduct effective empirical analysis of policy issues in economic development. The course focuses on providing tools for using data to gain insight into real development problems for professionals whose primary activity is not advanced data analysis. Instructor: Staff. Variable credit.

742. Impact Evaluation for Development. The course will focus on (1) learning the tools of regression required for quantitative impact evaluation using STATA; (2) learning the theory on which quantitative impact evaluation is based; (3) applying the skills learnt to actually design and implement impact evaluations. The course places more emphasis on the nuts and bolts of actual program evaluation using STATA and the choice of techniques based on available data, and less on the philosophical or broader theoretical aspects. It will rely strongly on publicly available materials prepared by the World Bank with the aim to familiarize students with the actual design, conduct and quantitative evaluation of real world programs. Instructor: Staff. 3 units.

743. Design and Analysis of Public Private Partnerships. This course focuses on the difficult choices governments need to make to improve service provision in a wide range of sectors from public utilities and transportation to health and education services. It covers the range of contractual arrangements open to governments to construct, maintain and operate infrastructure services and facilities such as hospitals and schools, as well as service provision in varied contexts in the world. Key concerns we address are the identification, analysis, allocation and management of risks and incentives under different contractual arrangements, including the guidelines and criteria that are appropriate to analyze and implement PPPs. lnstructor: Femholz. 3 units.

750. A-F. Social Policy, Environmental Policy and Peace and Conflict Courses - International Development. A. Urban and Rural Development in Developing Countries B. Structural Adjustment and Poverty C. Development and Social Sector Reform D. Communities and Sustainable Development E. International Development, Conflict and Cooperation: Crucial Linkages F. Peace, Conflict and Sustainable Development: The Challenge of Transition. Education, health, gender, ethnic and economic inequality, social entrepreneurship; international environmental policy, security, institutional development; democracy, negotiation, conflict resolution, cooperation in international development, resource management, global environment, sustainable development for world peace. Instructor: Staff. Variable credit.

751. Culture, Policy, and Action. Starting with the premise that 'culture matters', the course covers the impacts of values and attitudes, historical differences, religion, ethnicity, language, and regional identities to shape public policy, action and debate. It draws insights from various disciplines such as history, anthropology, sociology, economics, natural sciences, politics and religion. During the semester, we discuss approaches to value cultural diversity, culture relevant dilemmas in development, policy making by various actors in divided societies, and the cost of culture related difficulties. Fellows enrolled in the course are expected to participate actively through class discussions/debates and presentations. There will be group presentations (2-3 persons to a group) made on selected themes during the course. A major paper on the topic presented is also required. Consent of Instructor required. Instructor: Rosemary Fernholz. 1.5 units.

752. Indigenous Peoples, Human Rights, and Development. This seminar focuses on indigenous peoples, their basic rights, and their roles in national and international development processes. Through class discussions, case studies and role-playing, students will examine the impact of national policies and global trends on indigenous populations and vice versa, and the dynamics of conflict generation and resolution. Among the issues to be discussed are notions of sovereignty and governance, land and other property rights, community management of natural resources, indigenous social movements, international networks and assistance, culture, access and survival. This seminar is designed for graduate students from diverse fields such as public policy, environmental science, law, religion, education and business, who are concerned with international development issues and processes. Fellows enrolled in the course are expected to participate actively in class sessions and to read the course materials. We will have class discussions of theories relevant to power and participation, case studies, and role playing. Fellows will be required to submit short individual policy papers and one major group paper which will also be presented in class. Consent of instructor required. Instructor: Rosemary Fernholz. 1.5 units.

753. Social Policy in the Context of Development. This course explores the role of social policy as one important approach or channel that policy makers at different levels use to address complex and interrelated issues affecting human wellbeing. It starts with a quick survey of the condition of poverty, high income inequality and structural disadvantage affecting populations across a range of countries in the world, and the achievement of social policies and programs as reflected in human development and Millennium Development Goal indicators. Our main focus in the course, however, is on the national and local levels. Instructor: Fernholz. 3 units.

754. International Energy System, Sustainable Development and Security. One of the main challenges for the 21st century policy-makers is how to develop and manage adequate. affordable and reliable energy services to fuel sustainable social and economic development. Thus far, in many countries energy production and use have been inefficient and unsustainable, resulting in missed development opportunities and/or serious policy failures, aggravation of international and domestic conflicts, and wasted resources and environmental damage. The course explores why these problems occur and what are the implications of the most recent shifts in global energy patterns for global economy and politics. Instructor: Mirovitskaya. 3 units.

760. Conflict, Security and Development. The course aims to explore the "development-security-conflict" nexus. The linkages between insecurity and rising levels of inequality and poverty are many and complex. High levels of conflict and societal fragility undermine prospects of achieving "freedom from want." Meantime, development strategies, policies and programs that often generate 'winners' and 'losers' may sow seeds for violent conflict. The course explores what spurs risks of violence, why conflict prevention and recovery have proven difficult to address and how national governments and their international development partners can design policies that can simultaneously address development and peace. Instructor: Mirovitskaya. 3 units.

761. Human Rights and Conflict. One story of the relationship between human rights and conflict is told in the Preamble to the UN Charter: the human rights framework of our age came about because of the 20th century's two world wars. But for the "untold sorrow" brought about by these conflicts, so the story goes, there would have been no effective demand for and no construction of a set of legal, political and ethical norms intended to help "save succeeding generations from the scourge of war". In this course we will examine the link between human rights and conflict in an interdisciplinary fashion. What are the multiple ways in which the law and political advocacy of human rights relate to conflict? Do demands for human rights precipitate or fuel as much as prevent-conflicts, whether as war or in other forms of large scale suffering? Are human rights essential for what the field of conflict resolution has termed "positive peace"? Should policymakers involved in multiple stages of conflict, both inter-and intrastate, be more cautious about viewing rights as a remedy for conflicts? What are relevant ethical considerations? With the benefit of greater analytical and contextual understanding of competing priorities and tradeoffs, what positive role might be cast for human rights in the conflicts of the 21st century? To consider

these and other questions, we will draw substantially on historical and policy analyses, learning the legal/political history of the contemporary framework for human rights and connecting it to real world efforts underway by lawyers and other practitioners to reframe and transform conflict and build peace. Consent required by instructor. Instructor: Catherine Admay. 3 units.

763. Introduction to Peace and Conflict Resolution. The objective of this seminar is to provide an introduction to the multi-disciplinary field of Peace and Conflict Studies as a foundation for and complement to the overall Rotary Curriculum through course content which: Provides an introduction to the field of Peace and Conflict Studies; Emphasizes the interdisciplinary nature of peace and conflict studies and analyzes the nature and causes of conflicts from a variety of perspectives and inquiries including gender, political science, sociology, social psychology, economics, biology, ethnicity etc.; Provides students with the appropriate analytical tools to think critically about conflicts, including terrorism. Instructor: Staff. Variable credit.

764. Governance and Development. Exactly how governance, economic growth, and poverty reduction are interrelated is a subject of much controversy. The first part of this course will explore questions such as "What is governance?" "What does good governance mean?" "How is it measured?" "What is the relationship among governance, growth, and poverty reduction?" "Does good governance necessarily mean democratic governance?" From there, the course will move on to selected topics central to the good governance agenda, including public sector reform, corruption, and decentralization. The course will end with a look at global influences on developing country governance. Instructor: Pomerantz. 3 units.

770. Public Finance in Developing and Emerging Economies. Covers the basic theory, policy and practice of public finance in these economies. It examines the economic roles and rationale for government and potential methods of financing government. The nature of fiscal policy and its relationship to macroeconomic policy is examined, including issues of foreign aid, debt financing and inflation. The course analyzes the approaches to pricing, financing and evaluating public sector outputs such as roads, water, education and electricity. It then reviews and analyzes taxes on trade, consumption, income, property and natural resources considering their economic efficiency and administrative costs and distributional impacts. Methods and importance of forecasting revenues are presented. Special topics include the design and role of tax incentives and environmental taxes. Instructor consent required. Instructors: G. Glenday, G. Shukla. 3 units.

771. Comparative Tax Policy. This course is required for ITP fellows. Investigates in detail the design and policy options in the major taxes on consumption and income, comparing these taxes across countries. The impacts of these tax designs on revenues, economic efficiency, administrative and compliance costs and income distributions are considered. The course reviews the principles of taxation, including those used in allocating taxes to the multiple levels of government in the context of decentralization and across states in common markets or federal systems. In the area of consumption taxes, the course focuses in detail on value-added taxes and general goods and service taxes, but turnover and selective sales taxes are also considered. For income taxes, detailed design features covered include the definition of income, capital gains, employment benefits, business expenses, accounting conventions, inflation indexation, tax integration, international tax harmonization, transfer pricing, thin capitalization and tax incentives. For all taxes, issues of the treatment of small businesses and the informal sectors are featured. This course follows Public Policy Studies 770, Public Finance in Developing and Emerging Economies, but can also be taken by students with appropriate backgrounds in public finance or taxation. Instructor consent required. Instructor: GP Shukla. 3 units.

772. Comparative Tax Administration. This course is required for ITP fellows. Reviews modern approaches to tax administration for both border and domestic taxes, and compares approaches across countries. The course covers all the major functions of tax administration, considering legal, technical and managerial issues. The trends in tax administration toward a greater degree of self-assessment, and toward functional and client-oriented organization are themes throughout the course. In addition, new trends and techniques are highlighted, including computerization and e-governance, the design of risk-weighted random audit selection, and valuation and transfer pricing issues. The organization of tax administration is a core issue, including the use of revenue authorities and the legal frameworks underpinning tax administration and organization. Finally, tax reform experiences are reviewed, including planning and change management. Instructor consent is required. Instructors: GP Shukla. 3 units.

774. Economic Principles for Public Finance. Examines the principles of microeconomics and macroeconomics required for the analysis and forecasting of taxes and expenditures. The microeconomic component covers basic market principles with a focus on the applied welfare economics necessary for public finance analysis. Accounting conventions underlying costs and profits are examined. The impacts of taxes, subsidies and other policies on domestic and international markets are studied. The macroeconomic component covers national accounting aggregates and input-output structures of an economy and relates them to the structure and growth of tax bases. The relationships between savings, investment and growth are examined. The effects of government expenditure, revenue and deficit policies on the balances in the domestic and international financial and trade markets are introduced. Instructor consent required. Instructor: Fernando Fernholz. 3 units.

775. Analytical Methods for Public Finance. Covers the quantitative analytical methods and tools required in public financial analysis, forecasting of revenues and public expenditures and statistical analysis. Microcomputer-based packages and techniques for handling, analyzing, modeling and presenting revenue and expenditure data and analytical results are reviewed. Modeling and statistical methods are studied to assist in the analysis and forecasting of growth in the economy, expenditure and revenues, and the distributional impacts of revenues and expenditures, including the building of databases for, and the use of, micro-simulation models. Consent of instructor required. Instructor: Staff. 3 units.

776. Public Budgeting and Financial Administration. Focuses on the policies, procedures, and skills needed for effective budgeting and financial management in the public sector. Core topics to be covered in the course include budget systems and controls, public sector accounting and costing, financial reporting for accountability, and capital budgeting and debt management. The course provides the analytical skills needed to understand the links between budgeting and the macro-fiscal framework, the political decision-making process, and the interests of citizens. The emphasis is on the theory and international practice of budgeting, with particular application to developing countries. Issues of program and performance budgeting, participatory budgeting and citizen accountability, and decentralized fiscal systems will be discussed. Consent of instructor required. Instructor: Shukla, Kelly. 3 units.

777. Macroeconomic Analysis for the Public Sector. Focuses on how public sector activities and finances affect economic growth and other macroeconomic outcomes. The course develops an accounting and analytic framework that can be used to assess fiscal policy choices, discusses approaches to fiscal targeting, examines tax and expenditure issues from a medium-term perspective, and considers the use of fiscal policy for short-term macroeconomic stabilization. Among the specific topics covered are: debt sustainability, public investment, fiscal responsibility frameworks, aid and natural resource management, globalization and capital flows, and financial crises. Consent of instructor required. Instructor: Richard Hemming. 3 units.

778. Fiscal Decentralization and Local Government Finance. Focuses on analyzing policy and administrative options to effectively empower local governments to improve service delivery, economic governance and citizen participation. The course covers the theory and practice of fiscal decentralization with detailed analysis on the four pillars of rationalizing central-local expenditure and revenue responsibilities, designing effective intergovernmental transfers and structuring local borrowing. Special attention will be paid to the practical aspects of designing and implementing effective decentralization reforms to improve efficiency and accountability within the public sector. Consent of Instructor required. Instructor: Roy Kelly. 3 units.

779. Sales and Value Added Tax Law. This seminar on Sales and Value-Added Tax Law examines the legal framework and technical issues that arise in VAT and retail sales tax systems. The class focuses on the differences between consumption taxes (such as the VAT and sales taxes) and income taxes, and explores why a government may choose one system or the other-- or both. The class explores both technical concerns and administrative issues, such as compliance burdens and fraud. There is a strong focus on tax policy issues. Instructor: Shukla. 2 units.

780. Project Appraisal and Risk Management. Application and consent required. Project Appraisal and Risk Management teaches financial, economic, stakeholder, and risk analysis and risk management through real and applied case studies, lectures and group discussions. The workshop takes students through a flexible appraisal framework designed to handle different types of projects, from commercial enterprises and utilities to infrastructure investments and social programs. It also covers a wide range of issues such as environmental impacts, risk management and poverty reduction. Admitted students typically have held employment with: government ministries and public enterprises; banks (private and public) and financial institutions; investment analysis agencies; international development agencies; individual and corporate investment firms; private management, engineering and business consulting firms; regulatory institutions; international aid agencies. Instructor consent required. Instructor: Fernholz and F. Graham. 6 units.

781. Tax Analysis and Revenue Forecasting. Available to MIDP ITP fellows only. TARF covers the economic foundations of tax policy, revenue forecasting and statistical techniques to give participants the capacity to implement successful tax reforms. The course covers a wide variety of taxes such as value-added tax, personal and corporate income tax, excises, property tax, trade taxes and taxes on natural resources and their forecasting techniques. This training program is open to individuals working professionally in tax policy, tax administration, economics, finance, accounting, management or other related fields. Instructor consent required. Instructor: Shukla. 6 units.

786. Independent Research Topics in International Development Policy. Selected topics. Consent of instructor required. Instructor: Staff. Variable credit.

787. Applied Internship. For students working in international development organizations or on international development research projects under the supervision of a faculty member. Prior consent of director of graduate studies required. Requires detailed terms of reference or a research plan. Non graded . 1 unit Instructor: Staff. 1 unit.

789. Master of International Development Policy Mini-Seminars. Short-term, mini-seminars on variable topics in International Development Policy. Instructor: Staff. Variable credit.

790. Special Topics in International Development Policy. Variable topics on International Development. Current offerings include: Human Rights and Conflict (3 units), Law and Development (3 units), Monitoring and Evaluation for Policy and Project Success (3 units), Fiscal Policy, Globalization and Development (3 units), Indigenous Peoples, Human Rights and Development (1.5 units), Culture, Policy and Action (1.5 credits), Capacity Development (1.5 credits). Instructor: Staff. Variable credit.

790-1. Special Topics in International Development Policy. Variable topics on International Development. Current offerings include: Human Rights and Conflict (3 units), Law and Development (3 units), Monitoring and Evaluation for Policy and Project Success (3 units), Fiscal Policy, Globalization and Development (3 units), Indigenous Peoples, Human Rights and Development (1.5 units), Culture, Policy and Action (1.5 credits), Capacity Development (1.5 credits). Instructor: Staff. Variable credit.

792. Special Readings in Public Policy Studies. Instructor: Staff. Variable credit.

800. MPP Career and Professional Skill Development. Various professional development topics in preparation for fulfilling the MPP and MIDP summer internship requirement. Open only to first-year MPP and MIDP students. Instructor: Dyer. 0 units.

801. Graduate Curricular Practical Training in Policy Analysis. The course is designed to foreign graduate students who will undertake paid internship opportunities off-campus, corresponding to the fulfilment of a Curricular Practical Training (CPT) requirement. The course is designed to make it possible for graduate students to advance professionally by interacting with entities outside the university and enrich their postgraduate experience in a way that is integrated with the curriculum. CPT corresponds to external employment like alternate work/study, internship, or any other type of required internship or practicum deemed complementary to the curricular training within the School. Per immigration regulation, CPT is available only prior to the completion of a degree program and must be processed by Visa Services only after a job offer is issued. CPT employment may not delay completion of the academic program. Instructor consent required. Instructor: Staff. Variable credit.

802. Master's Student Summer Internship. The course provides a structure for the master's students to complete required summer internships. Students will complete summer internships off campus and prepare reflection documentation on learning objectives and skills gained. Instructor consent required. Instructor: Dyer, Rogerson. 0 units.

803. Policy Analysis I. Introduction to policy analysis and advising. Emphasis on written and oral communication skills, the substance of public policies, and the role of policy analysts. Open to public policy studies MPP students only. Department consent required. Instructor: Staff. 3 units.

804. Policy Analysis II. The role and influence of policy analysis. The examination of specific public policy cases and recommendations for action. Emphasis on written and oral communications skills. Open to public policy studies MPP students only. Instructor: Staff. 3 units.

807. Master's Project I. Emphasis on individual or group projects. Preparation for Master's Project. Open to Public Policy Studies MPP students only. Prerequisite: for 808, Public Policy Studies 807 or consent of instructor. Instructor: Staff. 3 units.

807D. Master's Project I. Same as PubPol 807 except instruction is provided with a lecture and small discussion meetings each week. Emphasis on individual projects. Preparation of Master's Project. Open to Public Policy students only. A prerequisite for 808 taken in the subsequent semester. 3 units.

808. Master's Project II. Emphasis on individual or group projects. Preparation for Master's Project. Open to Public Policy Studies MPP students only. Prerequisite: for 808, Public Policy Studies 807 or consent of instructor. Instructor: Staff. 3 units.

809. Master's Project Completion for Dual Degree Students. This is a no-credit course created for dual degree MPP students who were admitted August 2007 or before under the 30 credit program agreement. Students registering for this course will complete their Master's Projects under the supervision of a Sanford School faculty advisor, but will not receive graded credit for their projects. This course will charge a flat fee for each student registered. Instructor: Staff. 0 units.

810. Microeconomics and Public Policy-Making. Consumption and production theory, welfare economics, theories of collective choice, market structures and regulation, and nonmarket decision making. Not open to students who have taken Public Policy Studies 302. Graduate status only. Instructor: Clotfelter, Pfaff, Johnson, or staff. 3 units.

811. Microeconomics: Policy Applications. Application of microeconomics to government and public policy. Equity and efficiency of public policy. Cost-benefit analysis. Taxation, regulation, social insurance, provision of goods and services. Policies include minimum wage, excise taxes, bans, information, and regulation of utilities. Recommended prerequisite: intermediate microeconomics. Instructor: Clotfelter, Krupp, Pattanayak, Pizer. 3 units.

811D. Microeconomics: Policy Applications. Application of microeconomics to government and public policy. Equity and efficiency of public policy. Cost-benefit analysis. Taxation, regulation, social insurance, provision of goods and services. Policies include minimum wage, excise taxes, bans, information, and regulation of utilities. Recommended prerequisite: intermediate microeconomics. Instructor: Clotfelter, Krupp, Pattanayak, Pizer. 3 units.

812. Statistics and Data Analysis for Policy Makers. The purpose of this course is to ensure that students are both critical consumers and effective producers of statistical evidence presented in support of policy arguments. Upon completing this course, students will have the capacity to analyze and evaluate arguments based on simple descriptive statistics, correlation, or multiple regression analysis. Students will also receive hands-on training in the creation of convincing statistical reports, from manipulating large datasets to conducting sensitivity analysis and presenting results. Instructor: Gassman-Pines or staff. 3 units.

812L. Data Analysis for Policy Makers Laboratory. This course teaches students to analyze data using statistical software. Students learn to manipulate a variety of databases, produce analyses and visual displays of quantitative information, interpret results, and write about results. Knowledge of basic statistics, including at least one introductory course, is assumed. 1 unit.

813. Quantitative Evaluation Methods. Problems in quantifying policy target variables such as unemployment, crime, and poverty. Experimental and nonexperimental methods for evaluating the effect of public programs, including topics in experimental design, regression analysis, and simulation. Graduate status only. Prerequisite: Public Policy Studies 604 or equivalent. Instructor: Meeks. 3 units.

814. The Politics of the Policy Process. The formulation of public policies, substantive policies in a variety of contexts from local government to international affairs; the role of legislatures, interest groups, chief executives, and the bureaucracy in defining alternatives and in shaping policy from agenda formulation to implementation. Graduate status only. Instructor: Staff. 3 units.

815. Public Management I. Operations management, information and performance, personnel management, public sector marketing. Instructor: T. Taylor. 3 units.

816. Ethics and Policy-Making. Normative concepts in politics, liberty, justice, and the public interest: historical and philosophical roots, relationship to one another and to American political tradition, and implications for domestic and international problems. Not open to students who have taken Public Policy Studies 302. Graduate status only. Department consent required. Instructor: Pearson or staff. 3 units. C-L: Global Health 840

818. Advanced Microeconomics and Public Policy-Making. Consumption and production theory, welfare economics, theories of collective choice, market structures and regulation, and non-market decision making. Prerequisites: Intermediate microeconomics and multivariate calculus necessary. Matrix algebra and differential equations useful. Intended for advanced master's students and PhD students. Instructor consent required. Instructor: Staff. 3 units.

820. Globalization and Governance. Seminar explores economic, political, and social aspects of globalization and their implications for public policy making in the twenty-first century. Focus on issues of governance, particularly international cooperation, the design of international organizations, and the role of international NGOs. Policy areas include international trade and finance, environment, security, human rights, media and communications, and international development. Instructor: Jentleson. 3 units.

822. Advanced Applied Econometrics I. The course focuses on methods of drawing inference from non-experimental, cross-sectional data. The foremost among these is the basic linear regression model (OLS). Topics include measurement error, collinearity, functional form assumptions, heterokedasticity, and omitted variable bias. We will also discuss instrumental variables regression, maximum likelihood estimation, and probit and logit models. Instructor: Staff. 3 units.

823. Advanced Econometrics II - Methods for Causal Inference and Program Evaluation. The course is designed for those who would like to conduct causal research and/or program evaluations, but also for those who want to interpret research appropriately and understand how results can inform policy. The idea is to provide a framework for data-based analysis of: i) reasons for government intervention; ii) benefits associated with possible government policies, and; iii) economic agents' (likely) response to governmental actions. Discussions will be based on examples from the literature focusing on domestic and international policy issues, and will offer an opportunity to obtain hands-on experience using actual and simulated data sets and statistical software. Consent of instructor is required. Prerequisite: Public Policy 822. Instructor: Staff. 3 units.

825. Topics in Health Policy. Seminar introduces students to major health policy concepts and methods of analysis of health policy problems. Focus on domestic and international health policy topics, including: nature of disease, health and economics, health care delivery systems, demography and health. Consent of instructor required. Instructor: D. Taylor. 3 units.

827S. Environment and Development Economics. 1.5 units. C-L: see Environment 851S

829. Hertie Study Abroad: Special Topics. Graduate-level courses taken at the Hertie School of Governance in Berlin, Germany. 3 units.

830. Special Topics Module. Selected topics. Instructor: Staff. 1.5 units.

840S. Introductory Demographic Measures and Concepts. 3 units. C-L: see Global Health 761S

845S. Racial and Ethnic Minorities in American Politics. 3 units. C-L: see Political Science 703S; also C-L: African & African American Studies 740S

849A. Marine Policy (A). 3 units. C-L: see Environment 786A; also C-L: Political Science 707A

850. Special Topics in Social Policy. This course will introduce students to the major methods used in the analysis of problems in social policy. These methods derive from economics, political science, human development, ethics, and systems analysis. Students will learn to apply these methods to contemporary problems. Students will learn to think critically, analytically, and synthetically. Students will write critical reactions, policy briefs, and opinion papers. Class time will be devoted to lectures, student discussion of readings, oral presentations by students, and occasional guest speakers. Instructor: Barnes and Gibson-Davis. 3 units.

860. Special Topics in Global Policy and Governance. This course seeks to explore some central questions of global policy and governance. Taking advantage of its location in Geneva, it provides students with an opportunity to experience the real world of international diplomacy, to access key actors and institutions involved in global policy processes, and to think critically about the international system today, and what it might become. It is designed to give students access to a range of international organizations, and to develop the skills knowledge and contacts necessary to enter a career in international affairs. Consent of instructor required. Instructor: Staff. Variable credit.

870K. Statistics and Program Evaluation. This course teaches students to use data to analyze the impact of policies, make recommendations, attempt to persuade others, and make environmental policy decisions. It will cover the tools and techniques of program evaluation, familiarizing students with the various research methods that can be employed to evaluate the effect of environmental policies and innovations. It will also teach students to read empirical research in a more critical manner. Finally, through applied problem sets, students will become more proficient in the use of the statistical software. Taught at Duke Kunshan University. Instructor: Ji. 3 units.

871K. Environmental Policy Analysis. The objective of this class is to learn how to organize and present analyses of data to solve important environmental problems. The course draws upon specific policy analysis tools and case studies to evaluate and distinguish between different policy issues and choices. There is a focus on the special challenges posed by environmental policy analysis, including the importance of translating core terms and concepts between cultures so that policy analysts in differing countries can learn from one another's experiences. Taught at Duke Kunshan University. Instructor: Guttman. 3 units.

872K. Environmental Economics Policy Practicum. This course will use environmental policy issues as a platform for students to develop their analytic, writing, and oral presentation skills. Students will work on three environmental policy problems over the course of the semester. Each will include a diverse set of readings and a prompt. Based on these readings, students will conduct policy analysis and produce a set of deliverables such as briefing memos, policy decision memos, visual presentations, and oral presentations. Throughout the semester, students will receive feedback from instructors and peers and learn to work both individually and collaboratively. Class sessions will be devoted to discussions about the policy problems, evaluating strengths of arguments, in-class presentations, peer feedback and collaborative work-sessions. Taught at Duke Kunshan University. Instructor: Schanzer. 3 units.

890. Advanced Special Topics in Public Policy. Contents and methods vary with instructors and from semester to semester. Instructor consent required. Instructor: Staff. 3 units.

890-1. Introductory Special Topics Skills. This course is a skills course designed to strengthen skills in various areas for incoming first-year graduate/professional students. Content and methods vary with instructors and from semester to semester. Department consent required. Instructor. Staff. 0 units.

890S. Advanced Special Topics in Public Policy. Contents and methods vary with instructors and from semester to semester. Instructor: Staff. 3 units.

891. Advanced Special Topics in Public Policy. Contents and methods vary with instructors and from semester to semester. Instructor: Staff. Variable credit.

892. Advanced Special Topics in Public Policy. Contents and methods vary with instructors and from semester to semester. Consent of department required. Instructor: Staff. 3 units.

897. Master's Project International Master in Environmental Policy I. Designed to help students develop a master's project (MP). Guide students in conceptualizing an idea, identifying key environmental policy question, writing a prospectus, finding an

advisor, finding a client, designing an analytical approach, data collection, and producing a draft of their project. Instructor: Ewing, Goron. 3 units.

897K. Master's Project International Master in Environmental Policy I. Designed to help students develop a Masters Project (MP). Guide students in conceptualizing an idea, identifying key environmental policy question, writing a prospectus, finding an advisor, finding a client, designing an analytical approach, data collection, and producing a draft of their project. Instructor: Goron. 3 units.

901. Political Economy of Public Policy. Introduces PhD students to core set of social science ideas relevant to public policy: theories of collective action, institutions and governance. Provides students with a framework for evaluating market, political and social failures; identifying possible policy interventions; and predicting ways in which such interventions would translate into policy outcomes. Consent of department required. Instructor: Staff. 3 units.

902. Ethics of Public Policy. Introduces PhD students to normative frameworks for evaluating public policies and governance processes drawing on social choice theory, political theory and social theory. Provides student with normative and analytical bases to evaluate the public good, tradeoffs between efficiency and equity, political legitimacy and justice. Consent of department required. Instructor: Staff. 3 units.

904. Using Data to Analyze and Evaluate Public Policy. This course reviews the basic methods of inferring the causal impact of public policy initiatives. Topics include randomized-control trials, instrumental variable analysis, regression discontinuity designs, difference-in-difference "natural experiments," and propensity score/nearest neighbor matching methods. Assignments include analysis using Stata software; final project entails proposing a quantitative study focused on causal inference. Either both 812 Statistics and Data Analysis for Policy Makers and 813 Quantitative Evaluation Methods, or both 822 Advanced Econometrics I and 823 Advanced Econometrics II required. Consent of instructor required. Instructor: Staff. 3 units.

907. Sanford PhD Student Graduate Seminar. This weekly workshop is required for all Sanford School of Public Policy PhD students to attend and to participate by presenting policy-relevant and in-progress research. Students present a work in progress that is at a stage where it would benefit from friendly, constructive comments from a diverse audience. Students are required to present at least once during the academic year. Student advisors, faculty and peers provide feedback during or after the presentation. 0 units.

908S. Dissertation Proposal Seminar I. Required seminar for all 3rd year PhD students in Public Policy preparing to make a dissertation proposal. Instructor: Staff. 3 units.

909. Dissertation Proposal Seminar II. Required seminar for all 3rd year PhD students in Public Policy preparing to make a dissertation proposal. Prerequisite: Public Policy Studies 908S. Instructor: Staff. 3 units.

910. Environment and Energy Economics. This course surveys the analytical tools and methods used to identify suboptimal environmental outcomes and policies to correct them. It also introduces students to energy markets and the economic and environmental regulations that govern them. Students will apply microeconomic concepts to contemporary challenges confronting the environment and energy market participants. Consent of instructor is required. Prerequisite: Economics 701D and 705D. Instructor: Sexton. 3 units. C-L: Energy 910

01-G-K

583SK. Energy and National Security. Energy and National Security examines links between available, reliable, affordable, and sustainable energy supplies and economic and national security of an advanced economy in early the 21st Century. Countries of particular interest are China and the United States. Both are net energy importers, depend on smoothly functioning global energy markets and open sea-lanes, and face ethical and environmental issues as they choose among their energy sources and suppliers. Both also are highly dependent on energy to power their economies, fuel their militaries, and preventing enemies or competitors from inflicting damage on their economies or populations. Taught at Duke Kunshan University. Instructor consent required. Instructor: Staff. 3 units. C-L: Environment 583SK, Political Science 663SK

585K. Climate Change Economics and Policy. 3 units. C-L: see Environment 640K

631K. Environmental Science Research Methods. Research methodology for environmental sciences, including health sciences and social sciences. Topics covered include quantitative and qualitative methods, experimental and quasi-experimental research designs, sampling and sample size determination, survey design and implementation, and the process of publishing academic research. Students will review published research of other scholars and critically evaluate the strengths and weaknesses of the methods they employ in addressing their specific research questions. Taught at Duke Kunshan University in Kunshan, China. Instructor: Ji and Ward. 3 units.

872K. Environmental Economics Policy Practicum. This course will use environmental policy issues as a platform for students to develop their analytic, writing, and oral presentation skills. Students will work on three environmental policy problems over the course of the semester. Each will include a diverse set of readings and a prompt. Based on these readings, students will conduct policy analysis and produce a set of deliverables such as briefing memos, policy decision memos, visual presentations, and oral presentations. Throughout the semester, students will receive feedback from instructors and peers and learn to work both individually and collaboratively. Class sessions will be devoted to discussions about the policy problems, evaluating strengths of arguments, in-class presentations, peer feedback and collaborative work-sessions. Taught at Duke Kunshan University. Instructor: Schanzer. 3 units.

Quantitative Financial Economics

Professor Burnside, *Chair*; Professor of the Practice Rasiel, *Director of Graduate Studies*; Professors Abdulkadiroglu, Adler, Ambrus, Anton, Arcidiacono, Ariely, Bansal, Bayer, Bollerslev, Burnside, Clotfelter, Cohen, Coleman, Conitzer, Conrad, Cook, Darity, Field, Frankenberg, Hoover, Hotz, Hsieh, Khan, Kimbrough, Kramer, Kranton, Kuran, Ladd, Lewis, Lopomo, Marx, McAdams, McElroy, Munger, Nechyba, Newell, Pattanayak, Patton, Peretto, Pfaff, Pizer, Rampini, Sanders, Sloan, Smith, Tauchen, Taylor, Thomas, Timmins, Tower, Viswanathan, Weintraub, and Yildirim; Associate Professors Ananat, Bennear, Boyd, Bugni, Collard-Wexler, Daley, Leventoglu, Ridley, Roberts, Sarver, and Xu; Assistant Professors Bianchi, Dix-Carneiro, Garlick, Hamoudi, Harding, Ilut, Jurado, Lanteri, Li, Macartney, Masten, Maurel, Mohanan, Rangel, Sadowski, Sexton, Sidibe, Suarez Serrato, and Wang; Professors Emeriti Burmeister, De Marchi, Goodwin, Grabowski, Graham, Kelley, Toniolo, Treml, and Wallace; Research Professors Becker and Caldwell; Professors of the Practice Connolly, Fullenkamp, Leachman, and Rasiel; Senior Research Scholar Boyd

A master's degree is available in this program.

Students preparing to enter the Quantitative Financial Economics Program will find an undergraduate background in mathematics, engineering, computer science, statistics, and economics to be very helpful. It is designed to train and develop quantitative skills linked to economics, finance, and related areas to prepare graduates for PhD studies or related professions. Graduates will be awarded an MS in quantitative financial economics as their degree.

The MQFE program requires a minimum of 30 graded course credits in financial economics and related fields. Students' course selections are based on their specific interests and on recommendations made by their academic advisors in order to meet their longer-run goals. Courses offered through The Graduate School—those listed under the subject Graduate Studies (GS)—do not count toward the 30-course credit requirement.

All MQFE students must complete five core courses (15 course credits) offered by the Economics department; the following 3 credit classes: Economics 571, 623, 672, and 676; and the following 1.5 credit classes: 882: Finance in Macroeconomics, and Economics 885: Continuous Time Finance. Students must also complete a combination of five electives (15 course credits), which may include: Economics 514, 573, 590: Regulation & Ethics in Financial Markets, 674, 883: Time Series. Certain other Master's level economics courses (500-699) and PhD-level economics courses (700-999), as well as 900-level finance courses at Fuqua. Certain courses in the Mathematics, Computer Science and Statistics departments may also be taken for elective credit with advance approval from the student's advisor. Students must also complete a Capstone course from among a list of approved such courses.

Each student has a completion meeting with his/her committee, involving presentation and discussion of either a portfolio of completed work from course projects and papers, and/or a summary of applied work from an internship, and/or and independent study project mentored by a faculty member. The completion exercise will be reviewed and approved for master's credit by the student's faculty advisor in conjunction with the MQFE director. Each student will be expected to submit a hard copy of the portfolio to the committee two weeks prior to the completion date.

Elective Courses in Economics (ECON)

514. Fixed Income Markets
570. International Finance
571. Financial Markets and Investments
572. Intermediate Finance
573. Theoretical Corporate Finance
590. Selected Topics in Economics
590S. Selected Topics in Economics
591. Independent Study
623. Forecasting Financial Markets
672. Financial Econometrics
673. Mathematical Finance
674. Financial Derivatives
675. Corporate Finance Theory
676. Empirical Asset Pricing
690. Selected Topics in Economics
690S. Selected Topics in Economics
699. Internship
701. Microeconomic Analysis I
702. Macroeconomic Analysis I
703. Econometrics I
705. Microeconomic Analysis II
706. Macroeconomic Analysis II
707. Econometrics II
882. Special Topics in Macro International Finance
883. Special Topics in Econometrics
885. Special Topics in Economic Theory
887. Special Topics in Financial Econometrics

Religion

Professor Goodacre, *Chair*; Associate Professor Chapman, *Director of Graduate Studies (PhD)*; Associate Professor Winters, *Director of Graduate Studies (Master's)*; Professors Beeley, Bretherton, Brettler, Campbell, Chaves, Davis, Goodacre, Jaffe, Jones, Knust, Lian, Lieber, Maddox, Morgan, Peters, Rowe, and Wirzba; Associate Professors Bowler, Chapman, Colon-Emeric, Cooper, Hall, Hassan, Pak, Portier-Young, Prasad, W. Smith, P. Smith, Wagner, and Winters; Assistant Professors Pak, Riedel, and Wilson; Associate Professor of the Practice Eastman; Research Professors Begbie, Freeman, and Kadivar

The Graduate Program in Religion offers a PhD in religion. The program is a collaboration between the Department of Religious Studies and Duke Divinity School.

The Department of Religious Studies offers a master's degree in religious studies.

For the PhD, students may concentrate their studies in one of the following fields of study: Hebrew Bible/Old Testament, New Testament, early Christianity, American religions, history of Judaism, Islamic studies, world Christianity, Christian theological studies, religion and modernity, and Asian religions.

Students will be expected to take courses that contribute to an understanding of their field of specialization and will be required to take two written preliminary examinations within that field. In addition to coursework in their major and dissertation fields, students will take courses in minor fields that will contribute to the enrichment of their major studies and will be required to take a written preliminary examination in each area of their minors. A minor requirement may be fulfilled in the program or by work in a cognate department or program, such as women's studies, English, history, literature, philosophy, political science, or sociology, and will constitute the outside minor and material for a fourth written preliminary examination. There is, in addition, an oral examination conducted by the student's committee shortly after the written examinations. Foreign language requirements determined by the faculty in the field of specialization must be met before taking the doctoral preliminary examination.

The program of doctoral studies normally presumes a foundation in the academic study of religion. Students applying for graduate work in religion directly from an undergraduate program should possess a strong undergraduate major in religion or a closely related field.

For more information on the master's degree in religious studies, visit https://religiousstudies.duke.edu/graduate/ma-religious-studies. For more information on the PhD in religion, visit the Graduate Program in Religion's website at https://graduateprograminreligion.duke.edu/ or email carol.rush@duke.edu.

Courses in Religion (RELIGION)

503S. The Black Radical Tradition: COVID-19, #JusticeForGeorgeFloyd, and the Movement for Black Lives. 3 units. C-L: see African & African American Studies 503S; also C-L: Cultural Anthropology 503S, Political Science 589S, International Comparative Studies 504S

511S. The Fetish: The Role of Things in Spiritual, Economic, and Sexual Life. 3 units. C-L: see African & African American Studies 512S; also C-L: Cultural Anthropology 511S

519S. Andalusia: Muslim, Jewish, Christian Spain. 3 units. C-L: see Asian & Middle Eastern Studies 519S; also C-L: Jewish Studies 519S, Romance Studies 519S

526A. Religion and Civil Society in the Arab World. 3 units. C-L: see Asian & Middle Eastern Studies 526A

527S. Islam and Human Rights. The main focus of the course is inquiry about possibility of human rights for Muslims in the modern time. The notion of human rights is represented by the United Nations documents, while Islamic teachings are divided into Islamic ethics and Islamic law. The former contains universal values such as dignity, justice, mercy, love, and freedom. The latter, in its traditional iterations, suffers from issues of gender discrimination, religious intolerance, restriction of religious freedom, the problem of apostasy, and violent punishments. Students will survey major conservative and reformist Muslim approaches to human rights to foster the development of critical analytic and comparative skills. Instructor: Kadivar. 3 units. C-L: Human Rights Program-Franklin Humanities Institute 527S

550. Archaeology of Palestine in Hellenistic-Roman Times. The study of material and epigraphic remains as they relate to Judaism in Hellenistic-Roman times, with special emphasis on Jewish art. Instructor: Staff. 3 units. C-L: Jewish Studies 550

552S. Live Images: Ancient and Medieval Representations of the Divine. 3 units. C-L: see Visual and Media Studies 533S; also C-L: Classical Studies 558S, Medieval and Renaissance Studies 507S

560S. Reading Heidegger. 3 units. C-L: see Asian & Middle Eastern Studies 540S; also C-L: Literature 543S

564S. Toleration, Freedom of Conscience, and Religious Liberty. 3 units. C-L: see Classical Studies 564S; also C-L: Political Science 588S, History 564S

580S. History of Buddhist and Christian Interactions. The study of the global encounter between Buddhists and Christians from the sixteenth century to the present. Topics to be covered include missionary encounters, conversion, polemical literature, inter-religious dialogue, and religious exchange, as well as the portrayal of these interactions in literature and the arts. At least one previous course in Buddhism or Asian religions and a course in religious studies is recommended. Instructor: Jaffe. 3 units. C-L: Asian & Middle Eastern Studies 580S

581S. Pan-Asianism, Religion, and the State in Modern Asia. An examination of the interaction between religious institutions and the state in modern Asia. The role of religion in the formation of pan-Asian identity in Asia also will be investigated. Instructor: Jaffe. 3 units. C-L: Asian & Middle Eastern Studies 581S

606S. Hebrew Biblical Texts. Select prose and poetic Hebrew biblical texts. Prerequisite: Old Testament 760 and 761 or equivalent. Instructor: Brettler. 3 units. C-L: Jewish Studies 606S

607. Hebrew Prose Narrative. Focus on the grammar, syntax, and prose style of classical Hebrew composition; a comparative reading of modern and precritical Jewish and Christian commentary. Readings spanning the spectrum from the early Hebrew prose of Genesis and I and II Samuel to the late compositions of Chronicles and Ezra-Nehemiah. One year of classical Hebrew required. Consent of instructor required for undergraduates. Also taught as Old Testament 860. Instructor: Brettler, Chapman, Davis, Peters, or Portier-Young. 3 units. C-L: Jewish Studies 607

608. Classical Hebrew Poetry. The problem of defining and understanding what is "poetic" in classical Hebrew. Theories of Hebrew poetry from Lowth to Kugel and O'Connor illustrated with readings from Psalms, Isaiah, Job, and Jeremiah. One year of classical Hebrew required. Consent of instructor required. Also taught as Old Testament 861. Instructor: Staff. 3 units. C-L: Jewish Studies 608

609. Rabbinic Hebrew. Interpretive study of late Hebrew, with readings from the Mishnah and Jewish liturgy. Consent of instructor required for undergraduates. Instructor: Staff. 3 units. C-L: Jewish Studies 609

610. Readings in Hebrew Biblical Commentaries. Selected Hebrew texts in Midrash Aggadah and other Hebrew commentaries reflecting major trends of classical Jewish exegesis. Consent of instructor required for undergraduates. Instructor: Staff. 3 units. C-L: Jewish Studies 610

611. Studies in Apocrypha and Pseudipigrapha. Selected documents of the Apocrypha and Pseudepigrapha examined exegetically and theologically in their relation to postexilic Judaism. Instructor: Staff. 3 units.

612. Language and Literature of Dead Sea Scrolls. A study in interpretation. Prerequisite: A knowledge of Hebrew. Instructor: Staff. 3 units.

613S. Introduction to Jewish Studies. 3 units. C-L: see Jewish Studies 601S; also C-L: History 601S

620. Exegesis of the Hebrew Old Testament. A. Pentateuch B. Historical Books C. Major Prophets D. Minor Prophets E. Writings F. Proverbs G. Genesis Consent of instructor required for undergraduates. Instructor: Staff. 3 units.

630-11. Exegesis of the Greek New Testament II: The Synoptic Gospels. Concentration on the "classical" methods of studying the first three gospels: source criticism, form criticism, and redaction criticism. Some attention to textual criticism. Students expected to become proficient in using the Greek synopsis. Prerequisite: two years of Greek or the equivalent. Consent of instructor required. Instructor: Goodacre. 3 units.

630-12S. Exegesis of Greek NT II: Hebrews. Consent of instructor required for undergraduates. Instructor: Staff. 3 units.

630-2. Exegesis of the Greek New Testament: Romans. Consent of instructor required. Instructor: Staff. 3 units.

630-6. Exegesis of the Greek New Testament: I and II Corinthians. Consent of instructor required. Instructor: Staff. 3 units.

631. Biblical Interpretation in Early Christianity. How early Christian writers of the second—mid-fifth centuries made meaning of the Scriptures in their own, postbiblical environments. Focus on the new historical, religious, and theological situations that required new readings of scriptural texts, the role of heresy and the ascetic movement in the development of biblical interpretation and canon development, and special problems that arose around these issues. Instructor: Staff. 3 units.

632. Origen. The systematic and apologetic writings of an important Alexandrian thinker and exegete of the third century. Instructor: Staff. 3 units. C-L: Medieval and Renaissance Studies 662

633. Augustine. The religion of the Bishop of Hippo in late antiquity. Instructor: Staff. 3 units. C-L: Medieval and Renaissance Studies 664

634. Early Christian Asceticism. The development of asceticism and monasticism in the first six centuries of Christianity. Instructor: Staff. 3 units. C-L: Medieval and Renaissance Studies 655

635S. Exegesis of the Greek New Testament: John's Gospel. Discussion and analysis of the Gospel of John with a special focus on historical-critical approaches, including authorship, date, sources, theology, literary analysis, and relationship to other early Christian works. Prerequisite: two years of Greek or the equivalent. Instructor consent is required. Instructor: Goodacre. 3 units.

636S. Passion Narratives in Greek. This course offers a critical, historical approach to the Passion and Resurrection Narratives in the Gospels of Matthew, Mark, Luke, John and Peter. Participants in the course will analyze the texts from a variety of perspectives, focusing especially on source-criticism, form-criticism, redaction-criticism, textual criticism, feminist, and literary-critical approaches. This course is for master's students who already have familiarity with the Greek texts. Instructor: Goodacre. 3 units.

660. Justice, Law, and Commerce in Islam. History and schools of Islamic jurisprudence; Islamic legal reasoning; approaches to ethics and procedural justice, the ethical regulation of commerce, including a detailed study of pertinent issues in Islamic law. Also taught as Law 568. Instructor: Staff. 3 units. C-L: African & African American Studies 575, Medieval and Renaissance Studies 659

663. Islam and Modernism. Cultural, religious, and ideological forces that shape Muslim responses to modernism. Instructor: Staff. 3 units.

664. The Religion and History of Islam. Investigation of the historical study of Islam: historiography as a discipline, the historical study of Islam in the Western world, Muslim views of Islamic history. Required critical essays and major research paper. Instructor: Staff. 3 units.

665S. Islamic Philosophy & Mysticism (Sufi's Approach to Philosophy). The course explores the critical analysis of the creative products of the human intellect in mystical experiences including the symbolic stories of Avicenna, al-Gazali, Ibn Tufail, Suhrawardi & Mulla Sadra. It covers the key points of the theoretical and practical mysticism such as nature of the man, asceticism, unity and final abode, Sufi's style of life, four spiritual journeys, light and varieties, angelology, the archetypal world, vision and intellect, knowledge & presence, the hierarchy of knowing, the semantics of the modulation of being, reality & the circle of being, diversity in unity and unity in diversity, the unity of the knower and the known, unity of existence, and salvation. Instructor: Kadivar. 3 units.

680S. Buddhist Thought and Practice. A historical introduction to Buddhist thought and practice, with special attention to their interrelationship in the living religion. Instructor: Jaffe. 3 units.

690S. Special Topics in Religion. Subject varies from semester to semester. Instructor: Staff. 3 units.

700. East Asian Studies Core Course: Fields and Methods. 3 units. C-L: see East Asian Studies 700; also C-L: History 707

701S. Elementary Syriac. Introduction into the language; reading and analysis of simple texts. Instructor: Staff. 3 units.

703S. Aramaic. Study tests representing "Standard Literary Aramaic": Biblical, Qumran, and Targumic (Targum Onkelos). Other Aramaic language forms may be included. Prerequisite: Should preferably have elementary knowledge of Hebrew. Instructor: Staff. 3 units.

704. Targumic Aramaic. An introduction to the language and literature of the Aramaic translations of the Old Testament. Instructor: Staff. 3 units.

705. Elementary Akkadian. Study of the elements of Akkadian grammar Reading of neo-Assyrian texts shedding light on the Old Testament. Prerequisite: biblical Hebrew. Instructor: Staff. 3 units.

706. Elementary Akkadian. Study of the elements of Akkadian grammar Reading of neo-Assyrian texts shedding light on the Old Testament. Prerequisite: biblical Hebrew. Instructor: Staff. 3 units.

707. Introductory Sanskrit Language and Literature I. 3 units. C-L: see Sanskrit 701

708. Introductory Sanskrit Language and Literature II. 3 units. C-L: see Sanskrit 702

709. The Septuagint. A study of the modern critical use of the Greek Old Testament. Prerequisite: knowledge of Greek and Hebrew. Instructor: Wagner. 3 units.

711. Pharisaic Judaism in the First Century. An exploration of the principal sources: Josephus, early Rabbinic literature, New Testament. Some consideration of recent secondary literature. Prerequisites: doctoral status or two years of Greek, two years of Hebrew, and some German. Instructor: Staff. 3 units.

712S. Early Jewish Apocalypses: Daniel and 1 Enoch. Examines earliest Jewish historical apocalypses, including Daniel, Apocalypse of Weeks, and Animal Apocalypse/Book of Dreams of 1 Epoch. Apocalypses will be situated within religious, social, and historical contexts of Antiochian persecution and Maccabean revolt and studied as literature of resistance. Primary texts studied in their original languages as well as ancient and modern translations. Instructor: Portier-Young. 3 units.

713S. Greek-Speaking Judaism. An exploration of selected texts and other evidence from western diaspora, including Joseph and Aseneth, the wisdom of Solomon. parts of Philo, and a few papyri. Secondary literature will include the major studies by E.R. Goodenough and H. A. Wolfson. Instructor: Staff. 3 units.

716S. The Deuteronomistic History. Course investigates Martin North's influential characterization of the Former Prophets as literary unity with goal of interpreting Israel's past from Canaan to destruction of Northern and Southern Kingdoms. Evaluates criticisms of North's theory and counter-proposals. At issue is nature of historiography in ancient Israel and its relation to Greek historiography. Consent of instructor required. Instructor: Chapman. 3 units.

717S. Modern Historical Study of the Prophets. Within the history of scholarship on biblical prophecy, the late twentieth-century 'turn to the book' entailed the reevaluation of a consensus established one hundred years earlier. By tracing the trajectory of modern critical study of the Bible's prophetic literature, contemporary interpretive debates and theories are contextualized and illuminated. Instructor: Chapman. 3 units.

720S. Old Testament Seminar. Research and discussion on selected problems in the Old Testament and related fields. Fall only. Instructor: Staff. 3 units.

721S. Old Testament Seminar. Research and discussion on selected problems in the Old Testament and related fields. Spring only. Instructor: Staff. 3 units.

730S. Seminar in the New Testament. Research and discussion on a selected problem in the biblical field. Fall only. Instructor: Staff. 3 units.

731S. Seminar in the New Testament. Research and discussion on a selected problem in the biblical field. Spring only. Instructor: Staff. 3 units.

733. Living Issues in New Testament Theology. Critical examination of major problems and issues in New Testament interpretation and theology. Instructor: Staff. 3 units.

735. The Doctrine of the Trinity. Biblical bases, patristic developments, contemporary statements and connections. Instructor: Staff. 3 units.

741. The Old Testament in the New: New Testament Writers as Interpreters of Scriptures. This doctoral seminar examines the ways in which New Testament authors read and interpreted Scripture. Working knowledge of Greek and Hebrew required. Instructor: Wagner. 3 units.

742. The Christian Mystical Tradition in the Medieval Centuries. Reading and discussion of the writings of medieval Christian mystics (in translation). Each year offers a special focus, such as: Women at Prayer; Fourteenth-Century Mystics; Spanish Mystics. Less well-known writers (Hadewijch, Birgitta of Sweden, Catherine of Genoa) as well as giants (Eckhart, Ruusbroec, Tauler, Suso, Teresa of Avila, Julian of Norwich, Catherine of Siena, and Bernard of Clairvaux) are included. Also offered as Church History 800 and Medieval and Renaissance Studies 672. Instructor: Staff. 3 units.

743. The Life of Paul. A detailed critical reconstruction of Paul's biography, including his chronology, movements, and sociological locations(s), in order to provide the appropriate backdrop for the exegesis of his letters. Prerequisites: doctoral students or permission of instructor. Instructor: Campbell. 3 units.

744. Pauline Theology. Studies in some aspects of Paulinism in the light of recent scholarship. Instructor: Staff. 3 units.

745. The Theology of Paul: Coherence and Development. "Righteousness by faith" and "being in/dying with Christ" in Paul's letters. Attention paid to internal consistency and chronological shifts. Prerequisites: doctoral status or two years of Greek and good knowledge of German. Instructor: Staff. 3 units.

746. The Gospel According to Saint Matthew in Recent Research. Instructor: Staff. 3 units.

748S. Theology of St. Thomas Aquinas. Seminar on themes and problems in the thought of Thomas Aquinas. Consent of instructor required. Also taught as Historical Theology 958. Instructor: Staff. 3 units.

749S. Theology of St. Thomas Aquinas. Seminar on themes and problems in the thought of Thomas Aquinas. Consent of instructor required. Also taught as Christian Theology 962. Instructor: Staff. 3 units.

750S. Seminar in Christian Theology. Research and discussion of a selected problem in the systematic field. Instructor: Staff. 3 units.

751. God, Freedom, and Evil. Study of phenomenon of evil by approaching through works of three eminent thinkers: Thomas Aquinas, F.W.J. Schelling, and Karl Barth. Also taught as Christian Theology 955. Permission only. Instructor: Staff. 3 units.

752S. Faith and Reason. Variable credit. C-L: see Christian Theology 961

753. Catholic Moral Theology: Its History and Contemporary Issues. The development of Catholic social and moral theory from a historical and analytical perspective. Study of the Catholic social encyclicals as well as the casuistical tradition. Reading of works by Rahner, Haering, Fuchs, Schuller, McCormick, and Curran. Instructor: Staff. 3 units.

754. Icon Theology. A study of theological controversies surrounding the use of images in Christian worship, followed by an attempt to perceive the symbolic conventions and doctrinal content of some Eastern, Western, and contemporary icons. Instructor: Staff. 3 units.

755. Theology and Contemporary Secular Understanding of Human Nature. Critical theological examination of selected current interpretations of human nature and the human situation. Instructor: Staff. 3 units.

756. Happiness, Virtue, and Friendship. Issues of their relationship in moral philosophy. Instructor: Staff. 3 units.

757S. Seminar in Theological Ethics. Philosophical paradigms and the nature of the Christian life. Instructor: Staff. 3 units.

759. Medicine, Ethics, and Theology: An Introduction. 1 unit. C-L: see Christian Ethics 763

760S. Seminar in Contemporary Christian Ethics. Instructor: Staff. 3 units.

762S. Saying and the Unsayable: Introduction to Lyric/Literary Theory. 3 units. C-L: see Romance Studies 710S; also C-L: English 710S, Literature 710S

767. How Blackness Thinks. This course examines current directions in conceptualizing black social life and performance. Examples are "black feminist theory and practice," "queer of color discourse," and more recently "Afro-pessimism" and "Black Optimism." The guiding premise of the course is that when understood as exceeding racial category, blackness emerges as out(sider) ness, as differentiated social practice internal to which is a mode of thinking, a practice of study, perhaps even a certain performance of the sacred that is at once connected with the religious and the secular but that cannot be equated with either. In considering this outness of black thinking, authors we may read include: Fanon, Wynter, Spillers. Instructor: Staff. 3 units. C-L: African & African American Studies 767, English 767, Christian Theology 774

768. Segregated Sundays: Church, Race, Class, and Caste. 1 unit. C-L: see Black Church Studies 806

770. Islam and Its World. This course introduces various aspects of global Islamic history and historiography. It interrogates how to define, analyze, and probe the interconnectedness of Muslim societies across time. After exploring a range of theoretical and historiographic models for what scholars have referred to as a "multi-civilizational civilization," the "Islamicate," and a "discourse-based world-system," the course delves into thematic examinations of the transregional links and networks that have worked to connect Muslims across Afro-Eurasia. Instructor: Hassan. 3 units. C-L: History 770

771S. Islam, Medicine, and Healing. This course explores the intersections of religion and medicine in multiple Muslim contexts. Drawing on several disciplinary perspectives including anthropology, history, gender studies, and religious studies, it investigates how questions of health, healing, and illness have been addressed from premodern patterns to colonial and post-colonial transitions to the present. We will examine how different approaches to spirituality, law, and science congeal and compete in the sites of the human body, animals, food, medicines, and hospitals. From traditional healing practices to contemporary bioethics, the course considers how religion and medicine have been constituted, lived, and experienced. Instructor: Hassan. 3 units.

774S. Ideology and Religion in Muslim Central Eurasia. 3 units. C-L: see Slavic and Eurasian Studies 774S; also C-L: History 774S, Asian & Middle Eastern Studies 774S

775S. Sociology of Religion. 3 units. C-L: see Sociology 775S

777. Gandhi's Modernity: Insights & Ironies. How did Gandhi define modernity, reject it, or embody it? This course discusses Gandhi's modernity as a two-sided paradox—passionate critic of civilizational modernity while also radically modern. Through discourses of development, secularism, and capitalism that underlie notions of modernity, study how Gandhian praxis reformulates the modern through self-transformation and a program for collective good. Do traditional concepts of the ashram, the ascetic, and homespun fabric express Gandhi's vision of a modern utopia, or an actualizable political future? What ironies surface as Gandhi navigates the terrain of the modern? What challenges? What insights? Mandatory, time-sensitive training and approval process—see synopsis. Instructor: Prasad. 3 units. C-L: History of Religion 710

780. American Foreign Missions and Chinese Christianity. 1 unit. C-L: see World Christianity 813

781. Protestantism and the Making of Modern China. 1 unit. C-L: see World Christianity 814

782. The Next Christendom: The Rise of Christianity Outside the West. 1 unit. C-L: see World Christianity 815

783. Christianity's Encounter with Other Religions and Cultures: The Case of East Asia. 1 unit. C-L: see World Christianity 816

790. Readings in Buddhist Texts. Advanced readings in Buddhist texts in Chinese, Japanese, and/or Korean. Ability to read classical Chinese, Japanese, and Korean at an intermediate level is required. The texts selected for the course will vary from term to term. The course may be repeated. Instructor consent required. Instructor: Jaffe. 3 units.

799. Special Readings in Religion. Readings vary from semester to semester. Consent of instructor required. Instructor: Staff. 3 units.

803S. Intermediate Syriac. Continuation of reading and analysis of Syriac texts. Instructor: Staff. 3 units.

809. Intermediate Sanskrit. 3 units. C-L: see Sanskrit 803

811S. Origins of Orthodoxy 380-750 C.E.. Introduction to the development of eastern Christian theology during period between pro-Nicene theologies to the death of John of Damascus. Instructor: Staff. 3 units.

812. Readings in Latin Ecclesiastical Literature. Readings in Latin of pastoral, theological, and church-disciplinary literature from the late patristic and medieval period. Also taught as Church History 806 and Medieval and Renaissance Studies 667. Prerequisite: knowledge of Latin. Instructor: Staff. 3 units.

814. The Sacraments in the Patristic and Early Medieval Period. A study of the celebration and interpretation of baptism or eucharist in the church orders and texts of the early church writers. Instructor: Staff. 3 units.

818. Pioneers in World Christianity. 1 unit. C-L: see World Christianity 818

820. Women in the Medieval Church. The history of the medieval Church told from its women figures: the life and writings of saints, heretics, abbesses, queens, mystics, recluses, virgins, bishops' wives, and reformers. Instructor: Staff. 3 units.

840. Luther and the Reformation in Germany. The theology of Martin Luther in the context of competing visions of reform. Instructor: Staff. 3 units.

841. The Radical Reformation. Protestant movements of dissent in the sixteenth century. Special attention will be devoted to Müntzer, Carlstadt, Hubmaier, Schwenckfeld, Denck, Marpeck, Socinus, and Menno Simons. Instructor: Staff. 3 units.

842. Calvin and the Reformed Tradition. The theological development of John Calvin. A comprehensive examination of his mature position with constant reference to the theology of other reformers. Instructor: Staff. 3 units.

843. Zwingli and the Origins of Reformed Theology. Instructor: Staff. 3 units.

844. Protestants and Pictures. History of Protestant visual culture from the sixteenth century to the present. Explores images and visual practices that characterize the early formation of European Protestantism, primarily Germany, France, and England, then moves outward to North America and Africa and Asia from the nineteenth century to the present. Special interest in the history of print and mass-produced imagery. Instructor: Morgan. 3 units. C-L: Art History 844

846. Visual Culture of Modern Christianity. A historical examination of leading visual themes in Catholicism and Protestantism from the sixteenth century to the present, concentrating on the emergence of imagination, imagery, uses of images and symbolic objects, and the place of the visual arts in these traditions. Book illustration, print culture, devotional practices, illustrated materials supporting evangelization, mission efforts, and education, political propaganda, and the quest for the likeness of Jesus in portraiture and devotional imagery form the primary visual artifacts to be examined. Instructor: Morgan. 3 units.

850S. Evangelical Traditions in America. A study of some of the major themes in the development of transdenominational evangelicalism and fundamentalism in America from the eighteenth century to the present. A reading seminar involving analyses and discussions of literature (mostly secondary works) important for understanding American evangelicalism as a distinct movement. Instructor: Staff. 3 units.

851. Interpretations of American Religion. An opportunity for advanced students in North American religious studies to deepen their understanding of some of the major questions in the field. Examination of how religious history is actually written—with special attention to the imaginative and moral motivations that enter into that process. Instructor consent required. Instructor: Staff. 3 units.

852S. Contemporary American Religion. A seminar dealing with trends in American religion in the twentieth century; critical assessment of primary paradigms for interpreting American religious change, and examination of major characteristics and issues facing American religion. Instructor: Staff. 3 units.

853S. Religious Issues in American History. A reading seminar devoted to selected topics, problems, and issues in American religion. Instructor: Staff. 3 units.

854S. The Social Organization of American Religion. Addresses religion's formal and informal social organization. Examines how religion is organized, and explores causes and consequences of variation in religious social organization. Considers impact of demographic changes on American religion, and asks how ideas from study of social networks, formal organizations, and professions apply to religion. Instructor: Chaves. 3 units.

857. American Religious Biography. Consent of instructor required. Instructor: Staff. 3 units.

858. Catholic Traditions in the United States. Historical exploration of the U.S. Catholic traditions, including Roman Catholicism, independent Catholicism, and other religions' engagements with Catholicism, both friendly and hostile, through primary and secondary texts and other media. Course themes include historiography of American Catholicism, theories of Catholic difference, the new "Catholic Studies," "Catholicizing" the field of U.S. religious history, and professional development. Instructor: Staff. 3 units.

859. Roman Catholic Visual Piety in the Modern Era. An examination of leading themes, imagery, and visual practices in Catholic devotion to saints since the sixteenth century in Europe, North America and beyond. Instructor consent required. Instructor: Morgan. 3 units. C-L: Art History 859, Visual and Media Studies 859

865. Nineteenth-Century European Theology. Protestant theology from Kant to Herrmann. Instructor: Staff. 3 units.

866. Twentieth-Century European Theology. Instructor: Staff. 3 units.

871. Readings in the History of Religion. An examination of the theories, methods, and purposes of the study of non-Western religions within the Western tradition. Instructor: Staff. 3 units.

872. Readings in North American Religious History. Directed research on selected topics in the history of religion in the United States and Canada. Instructor: Staff. 3 units.

880. Special Problems in Religion and Culture (Topics). Intensive investigation of the relations of religion and modernity, using seminal contemporary texts. Topics announced each semester. Consent of instructor required. Instructor: Staff. 3 units.

882S. Spaces, Bodies, and Narratives: Mapping Religion in Colonial India. How imperial cartography, understood as the mapping of territories, human bodies, cultural practices, and oral traditions, influenced mapping of religion in colonial India. Political and personal contexts of British and Indian-authored ethnographies, folklore collections, colonial census reports, and their impact on anthropological imagining of religion in South Asia. Instructor: Prasad. 3 units. C-L: History 741S

884. Religion & Technology. This course explores the intimate and ancient role of the cultural construction of the human body and its environment to perform sacred work. Technology is taken to mean the production of instruments that interface with the body, but it is also understood to mean the body itself as it is shaped and disciplined by religious practices and authority into selves and social bodies. Readings will range from the philosophy of technology to the literature on embodiment, religious practice, and material culture of religion. The history of religious technology in devotional culture and divination will be paired with the study of modern media technologies and the practices of religion. Instructor consent required. Instructor: Morgan. 3 units.

885. Christian Manuscript Culture. Investigating provenience & provenance of Christian manuscripts, esp. in Duke University collections. Manuscripts as windows into religious and cultural priorities of Christians from late antiquity to beyond medieval period. Books as liturgical objects; histories of transmission & reception of biblical & patristic texts; manuscripts as gifts and plunder; texts and paratexts as evidence of lived religion. Canon formation and representation, philological and aesthetic notions of "the authentic," and scribal and scholarly expertise as aspects of book production and circulation will also be addressed as individual manuscripts are placed within their complex historical and material contexts. Instructor: Staff. 3 units. C-L: History 881, Classical Studies 881

886. Christian Ethics and Contemporary Culture. A study of the interaction between Christian thought and current social theory. Instructor: Staff. 3 units.

887S. Introduction to Rabbinic Literature. Selected studies in Jewish material culture and problems in Jewish religious and intellectual history. Instructor: Staff. 3 units.

888S. Biblical Hebrew Advanced Prose Syntax. A doctoral seminar in reading biblical Hebrew prose, for students already advanced beyond the intermediate level. For those who are not doctoral students, permission of the instructor is required. Open only to Religion PhD or Divinity School ThD students. Prerequisite: Old Testament 760, 761, and 860, or equivalent. Instructor: Davis, Ellen. 3 units.

889. Religion, Restrictions, and Violence. An examination of the historical roots and current manifestations of religiously-justified violence and disenfranchisement, with a focus on the Abrahamic traditions (Judaism, Christianity, and Islam). The violence treated will include the expressly physical as well as the more insidiously existential, including political and cultural marginalization. Major loci of exploration will include gender and sexuality; Israel-Palestine, and the intersection of contemporary identities. Topics include the nature of extremisms within each tradition, the challenges of assimilation and "modernity," and the role and nature of citizenship and territory. This graduate version of the course will be distinguished by the length of readings, length of writing assignments, and nature of final paper. Instructor: Antepli, Davis, and Lieber. 3 units. C-L: History of Religion 889

890. Special Topics in Religion. Graduate level special topics in religion. Topics may include Early Christianity and Deuteronomy, among others. Instructor consent required. Instructor: Staff. 3 units.

890S. Special Topics in Religion. Graduate level special topics in religion. Topics may include Early Christianity and Deuteronomy, among others. Instructor: Staff. 3 units.

895S. Medieval Jewish Biblical Interpretation. A survey of medieval Jewish exegetical texts, read in the original Hebrew, focussing on both narrative and legal matters. We will concentrate on the Jewish medieval interpretation of the Akedah (the binding of Isaac) and on how these commentators "reconciled" the different Torah laws concerning slavery. Reading ability of unpointed Hebrew texts is expected; this course is intended to extend historically the texts studied in Religion 810, which is helpful as a prerequisite. Instructor: Brettler. 3 units.

900. African American Religion Through the Literary Imagination. In this course, we will examine and trouble the notion of African American religion by reading different genres of literature. By engaging slave narratives, autobiography, fiction, and the critical essay, the aim of the course will be to re-imagine categories that are associated with black religion: piety, spiritual, opacity, trauma, liberation, transgression, anguish, intersectionality, and the 'afterlife of slavery.' Two general ideas will motivate the direction(s) of the course. For one, black religiosity is not reducible to institutional forms like the church. Secondly, any endeavor to study black piety, or blackness more generally, requires multiple genres and approaches. Instructor: Winters. 3 units. C-L: African & African American Studies 900, English 900

904S. Advanced Syriac. Advanced reading and analysis of Syriac texts. Instructor: Staff. 3 units.

905S. Advanced Syriac. Reading and study of Early Syriac Christian tests (2nd-7th) with a general introduction into scholarship on Syriac Christianity. Combination of class work and individual reading. Spring only. Instructor: Staff. 3 units.

910S. Ethnography of Religion. Examines emergence of ethnography as major research methodology in study of religion. Considers how anthropology has historically constructed a "religious" subject and how contemporary ethnographic theory and praxis are articulated by postcolonial and postmodern critiques representation. Includes proto-ethnographic accounts of religious practice from the 16th and 17th century in Europe and Asia, colonial documentation so-called tribal communities, and ethnographic studies of contemporary religious settings ranging from women's storytelling in Himalayan foothills to Cuban Catholicism in United States. Instructor: Prasad. 3 units.

911. Religious Material Culture in Theory and Practice. Examines prevailing theories and methods of studying objects, spaces, images, and the senses as primary forms of evidence for understanding religions. Instructor: Morgan. 3 units. C-L: Art History 911

912S. Theorizing Religion. Late nineteenth- and twentieth-century theories, interpretations, and approaches to the study of religion. Instructor: Morgan or staff. 3 units.

914. Modernity of Religion. Emergence and form of "religion" in modernity; religions in the context of multiple modernities; exploring both conceptions of "religion" and "modernity" in broadest formulations including particular understandings of culture, power, self and the cosmos; examines cultural grammars, politics, epistemologies, technologies, histories and self-accounts that mark religion-in-modernity drawing on multiple global experiences. Instructor: Staff. 3 units.

915. Readings in Theology and Language. Sample treatments of religious language in linguistic analysis, hermeneutical theory, literary criticism, liturgical practice, and fundamental theology. Instructor: Staff. 3 units.

916. Topics in the Study of Japanese Religions. An In-depth examination of selected topics in the study of Japanese religions. Advanced Japanese or instructor permission required. Instructor: Jaffe. 3 units.

920. Systematic Theology. Method and structure of systematic theology, the doctrine of God, theological anthropology, and Christology. Instructor: Staff. 3 units.

925S. Exegesis of the Hebrew Text of the Hebrew Bible/Old Testament. The books studied will vary from semester to semester—Exodus, Deuteronomy, Biblical Historical Texts, Amos, Psalms, Song of Songs. Can be taken more than once for credit, as topics vary from one semester to another. Prerequisite: two years of biblical Hebrew. Instructor: Brettler. 3 units.

930. Death and Dying in Late Antiquity. Death, in antiquity as in the present era, sat at the intersection of a wide range of discourses. Medical doctors, for example, sought to avert it, jurists to mitigate its impact upon family relations and the flow of capital, philosophers and theologians to prescribe approaches to it, and bishops and other religious professionals to create rituals by which to assist the departed's transition into the afterlife and to channel the grief of her surviving loved ones. This seminar aims to locate death at the intersection of material and literary culture, liturgical practice and economic impact upon ancient Christian communities. Instructor: Staff. 3 units. C-L: Classical Studies 940

930S. History and Theory. Explores debates among historians, philosophers, and theorists during nineteenth and twentieth centuries over the status of history as a discipline and as an intellectual enterprise. Particular attention given to the study of religious texts as an aspect of the "new" intellectual history. Seminar will seek to relate these discussions to students' respective sub-disciplinary specialties. Instructor: Staff. 3 units.

934. Synoptic Gospels in Greek. Critical, historical approach to the Synoptic Gospels, with a special focus on the Synoptic Problem. In-depth examination of the history of the Synoptic Problem; detailed study of contemporary approaches and solutions to the Synoptic Problem; discussion of the role played by Synoptic Problem studies in New Testament scholarship, including Historical Jesus studies, redaction-criticism, textual criticism and literary-critical approaches. Prerequisite: two years of Greek or the equivalent. Doctoral students only. Instructor: Goodacre. 3 units.

935. Gospel of John in Greek. Discussion and analysis of the Gospel of John with a special focus on historical-critical approaches, including authorship, date, sources, theology, literary analysis, and relationship to other early Christian works. Prerequisite: two years of Greek or the equivalent. Doctoral students only. Instructor: Goodacre. 3 units.

936S. Passion Narratives in Greek. This course offers a critical, historical approach to the Passion and Resurrection Narratives in the Gospels of Matthew, Mark, Luke, John and Peter. Participants in the course will analyze the texts from a variety of perspectives, focusing especially on source-criticism, form-criticism, redaction-criticism, textual criticism, feminist, and literary-critical approaches. This is a doctoral-level course and it involves studying the primary texts in Greek. Instructor: Goodacre. 3 units.

937S. Historical Jesus. Critical exploration of research into the Historical Jesus, including history of scholarship, historical context, source materials, methods and criteria, non-canonical texts, Birth Narratives, miracle accounts, eschatology, the death of Jesus, and the resurrection stories. Instructor consent required. Instructor: Goodacre. 3 units.

940S. Christian Theology/Western Metaphysics. Offers an explanation of the delicate, albeit crucial function of metaphysics in relationship to Christian theology. Also taught as Christian Theology 965. Consent of Instructor required. Instructor: Staff. 3 units.

941. Philosophical Theology I. Theology, as the knowledge of God, considered in dialogue with selected pagan and Christian philosophers from Plato to Kant. Instructor: Staff. 3 units.

942. Philosophical Theology II. Continuation of Philosophical Theology I. Instructor: Staff. 3 units.

943S. Philosophy and Theology After Wittgenstein. Follow-up to Theology of Wittgenstein course to see various ways his work has influenced philosophers and theologians, including Anscombe, Edwards, Diamond, Preller, Burrell, Ernst, McCahe, Kerr, R. Williams, and McClendon. Instructor: Staff. 3 units.

945. Philosophical Method in Religious Studies. Instructor: Staff. 3 units.

946S. Comparative Medieval Philosophy (Al-Farabi, Avicenna, Al-Ghazali, Averroes, Maimonides, Aquinas). The interaction between major philosophers of three Abrahamic religions in the medieval period. Maimonides as the representative of Jewish philosophers. Thomas Aquinas as the representative of Christian philosophers. Al-Farabi, Avicenna, Al-Ghazali and Averroes as the representatives of Muslim philosophers. Translation movement from Arabic to European languages. Theological subjects, philosophical approach. Epistemology, ontology, teleology, and eschatology. Major themes: Causality, God (existence, attributes and actions), world (seen an unseen), creation, soul, prophesy and revelation, resurrection, predestination and free will, theoretical and practical reason. Instructor: Khadivar. 3 units.

947S. Comparative Religious Studies (Case Study of Judaism, Christianity & Islam). The course offers a general framework and methodology of comparative religious studies. It is a case study of Judaism, Christianity, and Islam. The key elements of discussions are: faith, belief and theological continuity in the pre-modern era; Scriptures of the Hebrew Bible, Old and New Testament, and the Qur'an; God's essence, attributes and deeds; monotheism and Trinity; free will and predestination; creation and original sin; prophets and biblical figures; ethical orientation toward life; reason and revelation; and eschatology: life and death, end time, afterlife, salvation. Instructor: Khadivar. 3 units. C-L: Study of Ethics 947S

950. Hermeneutics. Consideration of the nature of understanding and of several interpretive methods—such as phenomenological, existential, historical, literary, structural—along with their application to New Testament texts, primarily the parables of Jesus. Instructor: Hays. 3 units.

952S. Doctoral Seminar in Early Christianity. This seminar is intended for students in the PhD and ThD programs. It will provide a close examination of important early Christian texts in the original language. The seminar will also give attention to the social, intellectual, and religious contexts of the ancient documents as well as grammar, rhetoric, and theological argument. Consent of instructor is required. Instructor: Smith. 3 units.

955. Practical Reason and Personal Identity: Explorations in Narrative. This course will deal with questions of the nature of rationality in morality and theology and attend particularly to those suggestions about narrative as the form of such rationality. The readings will involve works by Frei, Ricoeur, Goldberg, MacIntyre, and McClendon, as well as work in literary criticism. Instructor: Staff. 3 units.

960. Moral Theology in the Twentieth Century. Critical and comparative examination of ethical theory as exhibited in the work of selected contemporary theologians. Instructor: Staff. 3 units.

996S. Teaching in Religion. Course specifically designed for students in Graduate Program in Religion. Offers students chance to engage with different faculty members on methods and strategies concerning classroom teaching. Students will be asked to reflect on their own classroom experience and student evaluations of their teaching. Pass/fail only. Consent of instructor required. Instructor: Staff. 1 unit.

Romance Studies

Associate Professor Rosa, *Chair*; Professor Jenson, *Director of Graduate Studies*; Professor of the Practice Fellin, *Director of the Italian Language Program*; Professor of the Practice Paredes, *Director of the Spanish Language Program*; Professors Dainotto, Dubois, Hardt, Jameson, Jenson, Longino, Mignolo, Moi, Sieburth, and Solterer; Associate Professors Eisner, Gabara, Milian, Rodríguez-García, Rosa, Saliot, Viego, and Vilches; Assistant Professors Aidoo and Furtado; Research Professor Garrèta

A PhD is available in this department.

The Department of Romance Studies offers graduate work leading to the PhD in French and Francophone studies; Italian studies; and Spanish and Latin American studies; as well as a comparative track in Romance studies that combines two or more of these languages traditions. Interdisciplinary course work is required in areas related to the major field. Reading knowledge of one other language of study outside the major language is required; for those students in the Romance studies track, proficiency in two or more languages is required.

Courses in Creole (CREOLE)

590S. Special Topics in Haitian Creole Studies. Topics vary by semester. Instructor: Staff. 3 units.

701. Elementary Creole I. Introduction to essential elements of Haitian Creole or Kreyòl language and aspects of Haitian culture. First of two-semester sequence of elementary Haitian Creole or Kreyòl, the course provides practice in understanding, speaking, reading, and writing, culturally contextualized through units on health care, Haitian women's rights issues, and unpaid child servants (restavèk). Students will acquire enough vocabulary and idioms to be able to interact with Haitians. Language instruction will be complemented through additional class meetings with the co-Director of the Haiti Lab and submission of a paper in Creole on aspects of students' Haiti-related research. Taught in Creole. No prerequisite. Instructor: Pierre. 3 units.

702. Elementary Creole II. Second semester of elementary Haitian Creole provides essential elements of Creole language and aspects of Haitian culture. Students develop speaking, listening, reading, and writing skills and are exposed to different aspects of Haitian culture through films, storytelling, games, music, and proverbs. Pre-requisite: Creole 701 or a comparable level of previous Creole language experience, such as Duke Engage experience in Haiti or familial background in Creole. Language instruction is complemented through additional class meetings and submission of a paper in Creole on aspects of students' Haiti-related research. Taught in Creole. Instructor: Pierre. 3 units.

703. Intermediate Creole I. First semester of intermediate Haitian Creole or Kreyòl. This course moves beyond survival skills in Creole to more complex social interactions and expressions of analysis and opinion. Intermediate skills in understanding, speaking, writing, reading will be contextualized within a broad range of issues such as rural life in Haiti, religion, frenchified Creole vs popular Creole, through texts, poems, and excerpts taken from novels in Haitian Creole. Students will learn to carefully follow contemporary events and debates in Haitian culture using internet resources in Creole. Prerequisite: Creole 102 or equivalent. Taught in Haitian Creole. Instructor: Pierre. 3 units.

704. Intermediate Creole II. Second semester of Intermediate Creole. Prerequisite: Creole 703 or equivalent. Instructor: Pierre. 3 units.

705. Advanced Haitian Creole 1. This class is designed to help students sharpen their listening, speaking, reading, and writing skills in Kreyòl at an advanced level while exploring different themes related to Ayiti such as literature(s), language(s), school system in Haiti, history, and different types of Haitian music. In addition, students will be able to work on different songs and music groups that left their mark on Haitian music for the past 50 years as well as Haitian films. Prerequisites: 204 or Advanced Intermediate Creole or completion of the Advanced Intermediate Level at any institution that offers Intensive Haitian Creole class or any native speaker who is fluent in reading and writing the language. Instructor: Pierre. 3 units.

706. Advanced Haitian Creole 2. This class is designed to help students sharpen their listening, speaking, reading and writing skills at an advanced level so that they will be able to make themselves understood by native speakers while using proverbs, historical references, common idiomatic expressions, and even simple jokes. To do so, students will explore the archives of Radio Haiti-Inter

available at Duke University which cover a range of significant themes that are linked with current events. All of these explorations will be supported by films and songs that go with each theme that will be studied in class. Prerequisite: Creole 705 Advanced Haitian Creole 1. Instructor: Pierre. 3 units.

Courses in French (FRENCH)

506. Contemporary French Extreme Fiction. Contemporary innovations and new models of narration at beginning of the twenty-first century. May include the autoportrait (Leiris, Perec, Roubaud), the documentary (Bon, Kuperman, Bergougnioux, Houellebecq), and the minimalist school (Chevillard, Echenoz, Deville, Lenoir). Instructor: Staff. 3 units.

507S. Mimesis in Theory, Embodied Practice, and Literary Arts. Theoretical exploration of mimesis from Plato and Aristotle to Tarde, Lacan, Girard, Rancière, Lacoue-Labarthe, Butler, Malabou, Cassin, and Latoo. Additional emphasis on mimesis in human and animal development and social/behavioral practice, with interdisciplinary intertexts from fields ranging from neuroscience to genomics. Frequent departures from paradigmatic and empirical evidence to revel in the sensory and intuitive renewal of literary/artistic mimetic agency and apperception. Course taught in French, with occasional sources in English. Flexible language of assignments and English discussion section for graduate students outside of the French field. Instructor: Jenson. 3 units. C-L: Art History 509S, English 581S, Literature 507S

510. Citizen Godard. This course explores the complex interactions of poetics and politics in the films of Jean-Luc Godard, from the French New Wave, through the experimental phase of the Dziga Vertov group, to the recent Histoire(s) du cinéma and Film socialisme. Drawing on a wide range of literary and philosophical texts (Merleau-Ponty, Althusser, Deleuze, Rancière), this seminar situates Godard's work within its intellectual and political contexts, investigating how developments in French culture and thought since 1950 have been reflected in - and sometimes anticipated by - Godard's films. In English with preceptorial available in French. Instructor: Saliot. 3 units. C-L: Visual and Media Studies 552, Literature 510

510P. Citizen Godard Preceptorial. A preceptorial, in French, requiring concurrent enrollment in French 510. Further information available from instructor. Instructor: Saliot. 0 units.

512. Structure of French. Modern French phonology, morphology and syntax. Pragmatic interpretation of the current modes of use, including language levels, situationism, and interrelations. Readings in current linguistic theory. Instructor: Staff. 3 units. C-L: Linguistics 512

525S. Moliere: The Phenomenon of Laughter. Study of laughter as human reflex (what makes us laugh), and social critique (why and when), in the context of the Classical Age and through the comedy of Molière. Instructor: Longino. 3 units. C-L: Theater Studies 521S, Medieval and Renaissance Studies 601S

530. Medieval Fictions. Premodern Times: A User's Manual. Introduction to the earliest languages, literatures, and cultures in France and across Europe. Topics include orality and literacy, the experience of allegory, fictionality, the modern uses of the past. Major writers include the inventor of romance, Chrétien de Troyes, Provencal troubadours and trouvères, Guillaume de Machaut, the first professional writer, Christine de Pizan and Alain Chartier. Instructor: Solterer. 3 units. 3 units. C-L: Medieval and Renaissance Studies 642, Literature 541

531. Imagining Community in Boccaccio and Christine de Pizan. This comparative seminar explores the controversial and complex works of Boccaccio and Christine de Pizan. Boccaccio, illegitimate, impoverished son of a Florentine banker, and Christine de Pizan, an Italian woman isolated at court in Paris during a civil war both use literary form to construct communities—local, linguistic, national, intellectual, gendered, universal. This seminar attempts a different conception of literary community beyond national types and hierarchies offering students opportunities to explore their works and modern critical debates about them. All works available in translation. Readings in original languages and preceptorial meetings for majors and graduate students. Instructor: Eisner or Solterer. 3 units. C-L: Romance Studies 530, Italian 531

531P. Imagining Community in Boccaccio and Christine de Pizan Preceptorial. A preceptorial in French or Italian, requiring concurrent enrollment in Romance Studies 530, French 531, or Italian 531. Further information available from instructor. Instructor: Eisner or Solterer. 0 units. C-L: Romance Studies 530P, Italian 531P

535S. L'age classique et la loi du genre. Rules governing French literary production and dictating standards for specific genres developed in the 17th century under the guidance of the newly formed Académie française and the influence of a number of self-designated arbiters of taste. In this introduction to French classical literature, students will gain a firm grounding in the canon, read critical theory, and explore different approaches to the question of genre. Readings drawn from a wide variety of contemporary genres and from recent criticism relating to the question of genre. Instructor: Longino. 3 units.

556. Modern Literature and History. The interaction of history and literature in a particular period, for example: the occupation of France, the French Revolution. Problems of interpretation, historical memory, social identity, and narrative. Instructor: Staff. 3 units. C-L: History 587

571. French Symbolism. Poetry and literary theories of Baudelaire, Rimbaud, Mallarmé. Writings of Laforgue, Lautréamont, Huysmans, Louys, and others as they define new aesthetical and ethical values in the framework of the Symbolist and the Decadent intellectual movements. Instructor: Staff. 3 units.

572. Paradigms of Modern Thought. An introduction to contemporary French philosophy and thought with a focus on identity and difference, truth and falsehood in enunciation, globalization and nationalism. Research work in French. Instructor: Staff. 3 units.

590. Special Topics in French Literature. A cross-cultural analysis focusing on specific literary or cultural French or Francophone topics to be announced. Instructor: Staff. 3 units.

590S. Seminar in French Literature. Cross-cultural analysis of literary and cultural topics focusing on specific objects of inquiry. May be repeated. Instructor: Staff. 3 units.

611. Biography, Life Writing, Autofiction. History and art of the life story, examining biography as it drives research and contemporary writing. From Montaigne to Rousseau, the biopic to the lives of troubadours, we will study modes, media and social functions: portrait, caricature, meditation, fragments, selfies. The subjects: famous or anonymous people; those who are not human, landscapes, the sea—even inanimate objects. The accounts of radical change or metamorphosis, personal epiphanies, self-conscious reflection. The aims of depicting lives as they unfold. Texts include Foucault, Augustine, Flora Tristan, Pascal, Ferraoun. Critical readings will be coupled with creative work culminating in a research project around your life. Same course as French 411 but with additional graduate-level work. Instructor: Solterer. 3 units. C-L: History 611, Literature 609

690-1. Topics in French Literature of the Eighteenth Century. Close study of a particular author, genre, or interpretive category of Enlightenment literature. Instructor: Staff. 3 units.

690-2. Topics in French Literature of the Modern Era. Close study of a particular author, genre, or interpretive category of the twentieth century. May include issues such as authorship, translation, reception or critical theory. Instructor: Staff. 3 units.

690S-2. Topics in French Literature of the Modern Era. Close study of a particular author, genre, or interpretive category of the 20th century. May include issues such as authorship, translation, reception or critical theory. Instructor: Staff. 3 units.

01-G-B

700S. Teaching French at the Post-Secondary Level: Theories and Techniques. An overview of approaches to teaching French and of the theoretical notions underlying current trends. Focus is both theoretical and practical. Course objectives: (1) to investigate current issues in foreign language teaching and the relevance of linguistics and research in second language acquisition for language teaching; and (2) to guide the student as he/she develops techniques for effective classroom teaching, and learns to evaluate teaching performance and materials, and to develop good assessment tools and to valuate outcomes. Instructor: Staff. 3 units.

701. Graduate Reading Course. An intensive course in French to develop rapidly the ability to read French in several fields. Graduate students only. Instructor: Staff. 0 units.

702. Medieval Theater and Modern Theatrical Culture. A comparative inquiry into the public rituals and spectacles in premodern France and the European world of theater in the twentieth century. Offers a chapter in the history of criticism: what is the part of medieval play in modernist aesthetics and politics. Medieval works will range from mystery, miracle, and carnival plays to royal ceremonies and legal trials. Modern works will include d'Annunzio, Artaud, Cocteau, Giraudoux, Sartre, Claudel, Fo. Instructor: Solterer. 3 units. 3 units.

704. The Enduring Classic. Studies of the influence of the French classics over time and their function in the formation of French collective identity. Instructor: Longino. 3 units.

705. The Epistolary Genre. Fundamental questions of referentiality, materiality, and communication in writing. The first half is theoretical; the second explores issues raised through a selection of readings across time. Attention to gender and genre considerations. Instructor: Longino. 3 units.

706. Literature of the Eighteenth Century. Problems of literary history, critical reading, and interpretation, focused on varying topics. Instructor: Staff. 3 units.

707. Romantic Literature and French Culture and Politics. A study of French literature in the context of postrevolutionary society and culture. Readings might include nineteenth-century poetry (Hugo, Desbordes-Valmore), theater (Musset), political or philosophical prose, and historical discourse as well as contemporary critical and historical analyses of the period. Instructor: Staff. 3 units.

710. Contemporary French Novel. A chronological and theoretical approach to the major writers and movements since 1970. Selections from Duras, LeClézio, Sallenave, Modiano, Sollers, Tournier, Oulipo, Yourcenar, and others. Instructor: Staff. 3 units.

711. Structuralism. Introduction to the history of an intellectual movement from Ferdinand de Saussure to Roland Barthes, Claude Levi-Strauss, Jacques Lacan, and Michel Foucault. An emphasis is given to questions of method and issues concerning the individuation of cultures and individualities. Additional readings include chapters from Georges Canguilhem, Vincent Descombes, Jean Hyppolite, Alexandre Kojeve, and Maurice Merlau-Ponty. Particular attention will be given to "non-Western" societies. Instructor: Staff. 3 units.

712. Culture and History in Twentieth-Century France. An interdisciplinary study of one relatively short historical period (the 1950s, the 1960s, the *entre-deux guerres*, etc.). The intellectual and cultural life of a period in its broader social, political, and historical context. Instructor: Moi. 3 units.

713. French and Francophone Literature. Concentration on twentieth-century literature. Historical and theoretical approach. Varying topics such as Regionalism, Nationalism and Postcolonialism; the status of fiction in a totalitarian space; Transtextuality and Francophone Literature. Readings include literary and nonliterary texts by writers such as Aquin, Chamoiseau, Confiant, Chauvet, Faye, De Certeau, Depestre, Miron. Taught in French. Instructor: Staff. 3 units.

714. Migration, Literature, Transnational Writers, and Postnational Literature. A study of contemporary productions of immigrant writers in Canada and France, exploring theoretical and sociological issues on citizenship, migration, transnational writers, and postnational literature. Readings might include literary and nonliterary texts by, among others: Ben Jelloun, Bouraoui, Charles, Huston, Kristeva, Robin, Sebbar, and Zumthor. Instructor: Staff. 3 units.

715. Cultural Memory. Investigates invention, reconfiguration, and use of literary fictions over time. Examines major theoretical models: Assmann on cultural memory; LeGoff on history vs. memory; Rancière, Agamben on Temporality and anachrony; Benjamin, Bon on media and transmission. Readings from modern, premodern, and contemporary fiction, crossing genres and modes—narrative, poetic, dramatic, verbal, pictorial, cinematographic (including e.g. Hugo, Villon, Glissant, troubadour poetry, Aragon, Pichette, Christine de Pizan, Dreyer, Artaud, Bernard, Lamartine, Chartier, Lurçat, the Bayeux tapestry). Research projects to be developed with collaborators at European universities and archives. Taught in English. Instructor: Solterer. 3 units. C-L: Romance Studies 715, History 715, Literature 715

716. France & Africa: A Case Study of Postcolonial Culture. As a result of particular circumstances—France's colonial doctrine of "assimilation," its geopolitical tutelage of Francophone Africa during the Cold War, elite cooptation and connivance, the existence of a "Franco-African state" (Jean-Pierre Dozon) well beyond formal independence and the emergence of a "Black France" due to postcolonial migration—France and its former African colonies share a cultural repertoire that is both common ground and disputed territory. Students will engage this Franco-African culture through a variety of its manifestations (literature, music, cinema, sports) to address questions of hegemony and resistance, alienation and emancipation. Taught in French. Instructor: Smith. 3 units.

790-1. Topics in Renaissance Prose. Rabelais, Marguerite de Navarre, Montaigne, and others. Instructor: Staff. 3 units.

790-2. Topics in Seventeenth-Century French Literature. Includes genres, authors, movements, and works. Instructor: Longino. 3 units.

790-3. Topics in Modern/Contemporary French Literature. Includes genres, authors, movements, and works. Instructor: Jameson. 3 units.

790S. Topics in French Studies. Topics vary. Instructor: Staff. 3 units.

890S. French Seminar: Special Topics. Topics to be announced. Instructor: Staff. 3 units.

Courses in Italian (ITALIAN)

531. Imagining Community in Boccaccio and Christine de Pizan. This comparative seminar explores the controversial and complex works of Boccaccio and Christine de Pizan. Boccaccio, illegitimate, impoverished son of a Florentine banker, and Christine de Pizan, an Italian woman isolated at court in Paris during a civil war both use literary form to construct communities—local, linguistic, national, intellectual, gendered, universal. This seminar attempts a different conception of literary community beyond national types and hierarchies offering students opportunities to explore their works and modern critical debates about them. All works available in translation. Readings in original languages and preceptorial meetings for majors and graduate students. Instructor: Eisner or Solterer. 3 units. C-L: Romance Studies 530, French 531

531P. Imagining Community in Boccaccio and Christine de Pizan Preceptorial. A preceptorial in French or Italian, requiring concurrent enrollment in Romance Studies 530, French 531, or Italian 531. Further information available from instructor. Instructor: Eisner or Solterer. 0 units. C-L: Romance Studies 530P, French 531P

532S. Comparative Modernisms. This course investigates the debated term modernism. We will explore a wide range of critical works on periodization, avant-garde movements, irony, stream of consciousness, and other key terms, to examine several major literary works of modernism, including selections from Woolf, Rilke, Marinetti, Pirandello, Musil, Joyce, and Kafka. Each student will select a representative work from a national literary tradition to contextualize for the class and research. Instructor: Ziolkowski. 3 units. C-L: Romance Studies 532S, Literature 532S, German 535S

532SP. Comparative Modernisms Preceptorial. A preceptorial, in Italian, requiring concurrent enrollment in Romance Studies 532S or Italian 532S. Enrollment allows the course to count toward the language requirement for the Italian major or minor. Further information available from instructor. Instructor: Ziolkowski. 0 units. C-L: Romance Studies 532SP

581S. Italian Linguistics. An interdisciplinary study of selected topics, such as history of linguistic theories and language ideologies. Language state formation and citizenship in Italy. Language and power, language and identity. Taught in English. Instructor: Fellin. 3 units.

581SP. Italian Linguistics: Preceptorial. A preceptorial, in Italian, requiring concurrent enrollment in Italian 581S. Further information available from instructor: Instructor: Fellin. 0 units.

582. Dante's Divine Comedy: Hell, Purgatory, and Paradise. A voyage through the three otherworldly places of Dante's philosophical poem (Hell, Purgatory, Paradise) whose transformation of human actions into an ordered ethical system continues to captivate readers. Same as Italian 481/Medieval and Renaissance Studies 450/Literature 245 but with additional graduate level work. Instructor: Eisner. 3 units. C-L: Medieval and Renaissance Studies 603, Literature 582

583S. Dante Studies. Focus on a particular aspect of Dante's work. Taught in English. Instructor: Eisner. 3 units. C-L: Medieval and Renaissance Studies 615S, Literature 583S

583SP. Dante Studies: Preceptorial. A preceptorial, in Italian, requiring concurrent enrollment in Italian 583S. Further information available from instructor. Instructor: Eisner. 0 units.

584S. Boccaccio Studies. Examines a particular aspect of Boccaccio's works, such as the Decameron. Issues may include Boccaccio's role in the construction of a vernacular literary community, his place in the history of literary criticism, his investigations of gender, or his relationship to the larger storytelling traditions. Taught in English with an Italian preceptorial available for majors or minors. Instructor: Eisner. 3 units. C-L: Literature 584S, Medieval and Renaissance Studies 618S

585S. Topics in Sexuality and Gender Studies. The study of identity and difference and the representation of bodies, genders, and desires through developments in medicine and anatomy. May include different historical periods. Readings from public to private documents, literary texts, playscripts, medical treatises, and pamphlets. Taught in English. Instructor: Staff. 3 units. C-L: Gender, Sexuality, and Feminist Studies 519S

585SP. Topics in Sexuality and Gender Studies: Preceptorial. A preceptorial, in Italian, requiring concurrent enrollment in Italian 585S. Further information available from instructor. Instructor: Staff. 0 units.

586S. Literary Guide to Italy. A journey of Italy through literary, cinematic, and musical texts through Italy's sights and customs, as well as the place of Italy, both the real and imagined, in the aesthetics of the Grand Tour. Taught in English. Instructor: Dainotto. 3 units. C-L: Literature 542S, German 586S

586SP. Literary Guide to Italy: Preceptorial. A preceptorial, in Italian, requiring concurrent enrollment in Italian 586S. Further information available from instructor. Instructor: Dainotto. 0 units.

587S. Cinema and Literature in Italy. A study of the relation between literature and film in Italy. Topics include: cinematic versions of novels, influence of literature and literary figures on the construction of an Italian cinematic imagination, effects of cinema on literature, women's fiction and the woman's picture, neorealism. Taught in English. Not open to students who have taken this course as Italian 170S. Instructor: Dainotto or Hardt. 3 units.

587SP. Cinema and Literature in Italy: Preceptorial. A preceptorial, in Italian, requiring concurrent enrollment in Italian 587S. Further information available from instructor. Instructor: Dainotto or Hardt. 0 units.

588S. Antonio Gramsci and the Marxist Legacy. Gramsci's reinterpretation of Marxism in the context of fascist Italy. The uses of Gramsci's key concepts—subaltern, hegemony, dominance, popular culture, Americanism, Southern question—in other cultural/historical contexts, such as Indian subaltern historiography, British cultural studies or American literary studies. Taught in English. Instructor: Dainotto. 3 units. C-L: Literature 572S

588SP. Antonio Gramsci: Preceptorial. A preceptorial, in Italian, requiring concurrent enrollment in Italian 588S. Further information available from instructor. Instructor: Dainotto. 0 units.

590S. Topics in Italian Studies. Specific aspects of Italian history, civilization, culture, and institutions. Topics may vary. Taught in English. Instructor: Dainotto, Eisner, Hardt. 3 units.

590S-1. Topics in Renaissance Studies. Focus on a particular aspect of the Italian or European Renaissance. Taught in English. Instructor: Dainotto, Eisner, Hardt. 3 units. C-L: Medieval and Renaissance Studies 690S-2

590SP. Topics in Italian Studies - Preceptorial. A preceptoral, in Italian, requiring concurrent enrollment in Italian 590S. Further information available from instructor. Instructor: Dainotto, Eisner, Hardt. 0 units.

590SP-1. Renaissance Studies: Preceptorial. A preceptorial, in Italian, requiring concurrent enrollment in Italian 590S-1. Further information available from instructor. Instructor: Staff. 0 units.

742S. Boccaccio's Decameron. The Decameron has surprised and shocked readers for centuries. This course asks why—and how. Investigating censored editions and translations, along with visual and cinematic adaptations, we will scrutinize Boccaccio's innovative representations of sex, women, and the disenfranchised to understand the overlooked political dimension of Boccaccio's attempt to re-imagine the world after a global pandemic. Instructor: Eisner. 3 units.

743. What Machiavelli Really Says. Everyone knows what "Machiavellian" means, but what does Machiavelli really say? Reading his classical political texts "The Prince," the "Discourses on Livy," and "The Art of War" in the company of his literary works, including "Mandragola," we will examine how Machiavelli's ideas about power, deception, language, ethics, and representation emerged from his reading of Plato, Livy, Ovid, and Dante, while also exploring the reception and consequences of his ideas. Just as Machiavelli searched history for answers to his own political situation, our guiding question cannot help but be "What would Machiavelli do?" Instructor: Eisner. 3 units. C-L: Literature 743, History 743, Political Science 752

791. Special Readings. Supervised independent study and reading. Consent of instructor required. Instructor: Staff. 3 units.

990T. Special Topics Tutorial. Directed reading and research in areas unrepresented by regular course offerings. Instructor: Staff. 3 units.

Courses in K'iche' Maya (KICHE)

701. Elementary K'iche' Maya I. Introduction to essential elements of K'iche' Maya language and aspects of Maya culture. K'iche' Maya, a language spoken by about a million people in the western Highlands of Guatemala, is one of the major indigenous languages in the Americas. Emphasis on active language production to develop basic conversational skills for everyday interactions. Course taught at Vanderbilt University; Duke students participate through video conference and/or telepresence classroom. No prerequisite. Instructor: Staff. 3 units.

702. Elementary K'iche' Maya II. Continuation of K'iche' Maya I. Second semester course that introduces the essential elements of K'iche' Maya language and aspects of Maya culture. K'iche' Maya, a language spoken by about a million people in the western Highlands of Guatemala, is one of the major indigenous languages in the Americas. Emphasis on active language production to develop basic conversational skills for everyday interactions. Course taught at Vanderbilt University; Duke students participate through video conference and/or telepresence classroom. Pre-requisite. K'iche' Maya 701 or equivalent. Instructor: Staff. 3 units.

703. Intermediate K'iche' Maya I. Develops greater competencies in writing in K'iche' and translation to/from K'iche'. Covers more advanced grammar (verb modalities) and broader range of scripts (colonial vs. modern orthography). Research conducted in K'iche' using the Oral History archive at the University of New Mexico (http://econtent.unm.edu/cdm/search/collection/kichemaya). Students select a story from the online archive, listen to audio, correct transcription, rewrite it in modern orthography and translate it into contemporary English to present to classmates. Taught at Vanderbilt University; Duke students participate through video conference/telepresence classroom. Prerequisite: K'iche' Maya 702 or equivalent. Instructor: Staff. 3 units.

704. Intermediate K'iche' Maya II. Students read and discuss K'iche' language socio-historical context beginning with colonial texts to the present. Primarily a translating class, students read primary sources in K'iche' going back to the 16th century using philological methods. Texts include colonial dictionaries and grammars, phrase books, wills and testaments, missionary texts from colonial period and late 19th century, dance dramas, and the Popol Wuj. Learn about the range of materials available in K'iche' and the tools and methods used to work with these sources. Taught at Vanderbilt University; Duke students participate through video conference/telepresence classroom. Prerequisite: K'iche' Maya 703 or equivalent. Instructor: Staff. 3 units.

Courses in Portuguese (PORTUGUE)

512S. Transatlantic Cultures: Narratives of Discovery, Empire, Decolonization, and Europeanization. Explores, through literature, film, and theoretical readings, basic themes of Portuguese culture. Focuses on narratives of discovery, empire, decolonization, the admixture of cultures, and concerns of contemporary Portugal within the European Union. Questions of Portuguese identity during the epoch of discovery and expansion; the Portuguese presence in Asia, Africa, and Brazil; the role of postcolonial Portugal and Lusophone culture within the European context. Taught in Portuguese, translations of readings available. Prerequisite: 300-level Portuguese course or consent of instructor. Instructors: Furtado, Aidoo, and staff. 3 units.

590. Topics in Lusophone Literature and Culture. Exploration of topics of cultural formation in the Portuguese-speaking world that emphasize autochthonous cultural theory. Examples include: Brazilian popular culture, Literatures of Resistance, Lusophone Africa and Independence, Portugal Post-Salazar. Level of Portuguese required varies with semester topic; students should consult instructor. Instructor: Staff. 3 units.

590S. Topics in Lusophone Literature and Culture. Exploration of topics of cultural formation in the Portuguese-speaking world that emphasize autochthonous cultural theory. Examples include: Brazilian popular culture, Literatures of Resistance, Lusophone Africa and Independence, Portugal Post-Salazar. A graduate-level course open to juniors and seniors. Level of Portuguese required varies with semester topic; students should consult instructor. Prerequisite: 300-level Portuguese course or consent of instructor. Instructors: Furtado, Aidoo, and staff. 3 units.

590SP. Preceptorial in Lusophone Literature and Culture. A preceptorial in Portuguese, requiring concurrent enrollment in Portuguese 590S. Further information available from instructor. Instructor: Furtado, Aidoo, and staff. 0 units.

890S. Contemporary Brazilian Culture and Society. Core course for Duke in Brazil. Taught in English. Introductory course on major aspects of Brazil and Brazilian history; race, religion, culture, social movements, film, theatre and visual arts. Course option for students to receive graduate credit for work done in Duke in Brazil. Students will be expected to attend class and complete assignments for Portuguese 140S and complete a complementary individual research project at the graduate level. Taught in Rio de Janeiro. Instructor: Staff. 3 units.

Courses in Romance Studies (ROMST)

501S. Methods and Theories of Romance Studies. Provides students in any PhD track of the department of Romance Studies with fundamental training in both general literary theory and in the specific methods of romance criticism. Instructor: Staff. 3 units. C-L: Literature 540S

505S. Visual Studies from the Global South. 3 units. C-L: see Art History 505S

509S. Issues in Second Language Acquisition. Advanced applied linguistics course examining different areas of interests in the field of second language acquisition (SLA). Overview of main research areas in the field. Topics include: Language Testing, Action Research in SLA, Communicative Language Teaching, the role of classroom instruction in SLA, or the relationship between SLA research and foreign language learning. Students expected to become conversant with the research literature in the area and the different methodologies used in SLA research, carry out a classroom-based quantitative and/or qualitative research project, and produce a research paper that might be submitted to relevant conferences. Topics vary each year. Consent of instructor required. Instructor: Staff. 3 units.

519S. Andalusia: Muslim, Jewish, Christian Spain. 3 units. C-L: see Asian & Middle Eastern Studies 519S; also C-L: Religion 519S, Jewish Studies 519S

520S. Translation Studies and Workshop. 3 units. C-L: see Theater Studies 530S; also C-L: Asian & Middle Eastern Studies 502S

521S. Anthropology and History. 3 units. C-L: see Cultural Anthropology 501S; also C-L: History 572S

522S. Africa, Cuba, Brazil: Great Powers of the Black Atlantic. 3 units. C-L: see African & African American Studies 610S; also C-L: Cultural Anthropology 610S, History 610S

530. Imagining Community in Boccaccio and Christine de Pizan. This comparative seminar explores the controversial and complex works of Boccaccio and Christine de Pizan. Boccaccio, illegitimate, impoverished son of a Florentine banker, and Christine de Pizan, an Italian woman isolated at court in Paris during a civil war both use literary form to construct communities—local, linguistic, national, intellectual, gendered, universal. This seminar attempts a different conception of literary community beyond national types and hierarchies offering students opportunities to explore their works and modern critical debates about them. All works available in translation. Readings in original languages and preceptorial meetings for majors and graduate students. Instructor: Eisner or Solterer. 3 units. C-L: French 531, Italian 531

530P. Imagining Community in Boccaccio and Christine de Pizan Preceptorial. A preceptorial in French or Italian, requiring concurrent enrollment in Romance Studies 530, French 531, or Italian 531. Further information available from instructor. Instructor: Eisner or Solterer. 0 units. C-L: French 531P, Italian 531P

532S. Comparative Modernisms. This course investigates the debated term modernism. We will explore a wide range of critical works on periodization, avant-garde movements, irony, stream of consciousness, and other key terms, to examine several major literary works of modernism, including selections from Woolf, Rilke, Marinetti, Pirandello, Musil, Joyce, and Kafka. Each student will select a representative work from a national literary tradition to contextualize for the class and research. Instructor: Ziolkowski. 3 units. C-L: Italian 532S, Literature 532S, German 535S

532SP. Comparative Modernisms Preceptorial. A preceptorial, in Italian, requiring concurrent enrollment in Romance Studies 532S or Italian 532S. Enrollment allows the course to count toward the language requirement for the Italian major or minor. Further information available from instructor. Instructor: Ziolkowski. 0 units. C-L: Italian 532SP

540S. Memory and Documentary Cinema in Latin America. Course focuses on work of several leading Latin American filmmakers from Brazil, Chile, Argentina, and Cuba. Explores problems such as construction of memory in the wake of repressive dictatorships, relationship between revolutionary imagination and urban decay in present day Cuba, cinema's potential as a tool for cross-cultural explorations of memory and time, including relationship between past and present and our understanding of "contemporary." Instructor: Furtado. 3 units. C-L: Visual and Media Studies 540S, Documentary Studies 540S, Literature 544S, Latin American Studies 540S

540SP. Memory and Documentary Cinema in Latin America Preceptorial. A preceptorial in Spanish, requiring concurrent enrollment in Romance Studies 540S or Latin American Studies 540S. Further information available from instructor. Instructor: Furtado. 0 units. C-L: Latin American Studies 540SP

590. Topics in Romance Studies. Topics to be announced. Instructor: Staff. 3 units.

590S. Seminar in Romance Studies. Topics to be announced. Instructor: Staff. 3 units.

590SP. Special Topics in Romance Studies - Preceptorial. A preceptorial in French, Italian, Portuguese or Spanish requiring concurrent enrollment in Romance Studies 590S. Further information available from instructor. Instructor: Staff. 0 units.

591. Independent Study. Individual study in a field of special interest, under the supervision of a faculty member, resulting in a substantive paper or written report containing significant analysis and interpretation of a previously approved topic. For students in the Master of Arts in Teaching Program. Instructor: Staff. 3 units.

612S. Theories of the Image: The Image in Walter Benjamin. 3 units. C-L: see Literature 612S; also C-L: German 512S, Visual and Media Studies 612S

690. Topics in Romance Studies. Topics to be announced. Instructor: staff. 3 units.

690S. Seminar in Romance Studies: Special Topics. Topics to be announced. Instructor: Staff. 3 units.

700. Theories and Techniques of Teaching Foreign Languages. A survey of approaches to foreign language teaching, an introduction to the theoretical notions underlying current trends, and a language-specific practicum. Instructor: Fellin and Paredes. 3 units.

701. Critical Frameworks (Special Topics). An introduction to critical theory through a series of interconnected readings organized around a major theoretical approach or issue. Topics may vary. Instructor: Staff. 3 units.

702. Europe in Theory: Culture, Language, Politics. Exploration of the idea of Europe as a political, moral, and cultural identity. Examines the construction of such identity throughout history, ending with today's European Union, at a moment in which integration of "Eastern" countries such as Turkey or Russia remains a hotly debated issue. Consistent attention devoted to literary, cinematic and artistic works which attempt to imagine a European Culture, as well as the evolution of aesthetics, and literary and art history. Graduate version of ROMST 201. Instructor: Dainotto, staff. 3 units.

704S. Nationalism and Visual Culture Since 1789. 3 units. C-L: see Visual and Media Studies 704S; also C-L: History 705S

710S. Saying and the Unsayable: Introduction to Lyric/Literary Theory. Do poetry readers listen mainly to "man speaking to man" (Wordsworth), such that the "conversation of humankind" provides a model for a community of equals? Or should literature focus on "écrire le silence" (Rimbaud), such that meaning remains in a state of latency and searching for what lies hidden replaces communication? We will sample the work of 16th-c. mystics (and their 20th-c. revivalists), baroque/ metaphysical writers, the British romantic poets, and the linguistic revolution of 19th-c. "poésie ivre." What can be said and what is left unsaid will also be explored through censorship, cultural colonialism, and ekphrastic & inter-linguistic translation. Instructor: Rodriguez-Garcia. 3 units. C-L: English 710S, Literature 710S, Religion 762S

715. Cultural Memory. Investigates invention, reconfiguration, and use of literary fictions over time. Examines major theoretical models: Assmann on cultural memory; LeGoff on history vs. memory; Rancière, Agamben on Temporality and anachrony; Benjamin, Bon on media and transmission. Readings from modern, premodern, and contemporary fiction, crossing genres and modes—narrative, poetic, dramatic, verbal, pictorial, cinematographic (including e.g. Hugo, Villon, Glissant, troubadour poetry, Aragon, Pichette, Christine de Pizan, Dreyer, Artaud, Bernard, Lamartine, Chartier, Lurçat, the Bayeux tapestry). Research projects to be developed with collaborators at European universities and archives. Taught in English. Instructor: Solterer. 3 units. C-L: French 715, History 715, Literature 715

790S. Topics in Romance Studies. A cycle of seminars that explores a theoretical problem cross-culturally through two or more Romance traditions: French and Francophone, Italian, Portuguese and Luso-Brazilian, Spanish and Latin American. Instructor: Staff. 3 units.

791. Independent Study. Independent study; directed reading and research in area unrepresented by regular course offerings. Instructor: Schachter. 3 units.

825S. Outside the Nation State: The Global Novel. 4 units. C-L: see English 825S

826S. Contemporary Genre Fiction: The Global Novel. This course examines the emergence of novels in various parts of the globe that address a readership beyond their respective nations or regions of origins, sometimes even beyond the novelist's national language. Under the heading of "Contemporary Genre Fiction," we will look particularly at adaptations and transformations of sub-genres of the novel in different contexts. Among the genres we will consider are: detective novel; science fiction;novel of manners; romance; historical and philosophical novel. Instructor: Staff. 3 units. C-L: English 826S, Literature 826S

827S. The Global Novel: Post, What?. 3 units. C-L: see Literature 827S; also C-L: English 827S

850S. Deleuze: Cinema and Philosophy. 3 units. C-L: see Literature 850S; also C-L: Visual and Media Studies 850S, English 860S, Visual Arts 850S, Computational Media, Arts & Cultures 85, Documentary Studies 850S

Courses in Spanish (SPANISH)

511S. Critical Methods in Spanish Studies. Capstone seminar. Open to seniors pursuing Graduation with Distinction. Instructor: Staff. 3 units.

512S. Topics in Spanish Linguistics. In-depth analysis of one area of Spanish linguistics. Topics may include Spanish phonology, Spanish syntax, discourse analysis, applied linguistics, or Spanish pragmatics. Small research projects with a hands-on approach required. Instructor: Staff. 3 units. C-L: Linguistics 512S

530. Emigrants and Immigrants: Spain in the Sixties and Now. A study of the cultural processes generated by two significant migratory movements in Spain: one in Catalonia in the 1960s and early 1970s, composed mostly of impoverished peasants coming from southern Spain; and the more recent global wave composed of Latin American, African, and Filipino immigrants to the affluent post-industrial areas. The seminar will use literary and cinematic texts, and testimonial narratives. Instructor: Staff. 3 units.

538S. Revolution in the Novel/Novel of Revolution. Exploration of Spanish novel from 1962 to 1987, a period of exceptional development highlighting 'radical artifice' including use of parody, multiple narrators, subplots and time schemes, as well as countless self-reflexive devices. Collectively representing a 'revolution in the novel', these works also provide complex and sophisticated commentaries on vexed contemporary questions concerning the direction of Spanish politics and society spanning the years of late Francoism and the transition to democracy, reflecting both 'revolutionary' and 'counter-revolutionary' trends—including the unfinished revolution of women's emancipation addressed through key works by women authors of the period. Instructor: Rodriguez-Garcia. 3 units.

539S. Atlantic Constellations: Migration, Exile, Second Slavery. This seminar explores the collective identities of migrant and exiled Spaniards away from the homeland. They remained on the move in large numbers for two centuries, immersing themselves in the cultures of their places of arrival while giving their preexisting persuasions a new life overseas. We'll consider four main themes: 1) Ibero-Atlantic diasporas since the mid-nineteenth century; 2) white slavery and second slavery in Cuba; 3) Spain's unfinished revolutions; and 4) the career of María Zambrano, an expatriate intellectual who turned her banishment from Spain in 1939 into the enabling condition of her radical revision of Western philosophy. Prerequisite: 300-level or above Spanish course that meets foreign language (FL) requirement or graduate standing. Instructor: Rodríguez García. 3 units. C-L: History 542S, International Comparative Studies 539S

540S. Many Mexicos. A fresh look at contemporary writing referencing the need for political change and the reality of social inertia caused by unexamined dogmas, sectarian violence and economic self-interest. Readings will include pre-1950 novels (Mariano Azuela, D. H. Lawrence, José Revueltas) variously engaging the "dark side" of mass movements and party politics; works drawn from the literary "saga del 68" focused on student protests of 1968, including Elena Poniatowska's controversial *La noche de Tlatelolco* (1971); Juan Villoro's novel *Arrecife* (2012), a window onto the rise of neoliberal markets in post-NAFTA Mexico. Primary readings subject to change. Conducted in Spanish in a jargon-free environment. Instructor: Rodriguez-Garcia. 3 units.

572. Paradigms of Modern Thoughts. Exploration of modern thought in Latin America. Theories in the social sciences relevant for the humanities (for example, dependency theory, internal colonialism, subaltern studies) will be compared with cultural theories mainly expressed in essays and literature in general and with philosophical thinking grounded in Latin American colonial and postcolonial histories. Instructor: Mignolo or staff. 3 units.

590S. Seminar in Spanish Literature. Topics to be announced. Instructor: Staff. 3 units.

700S. Teaching Spanish as a Foreign Language . Study of language learning and teaching from theoretical and practical points of view. Examines principles and practices of teaching a second or foreign language with concentration on recent interactive and communicative models of foreign language instruction. Goals include introducing principles of second language acquisition and learning; critically reading relevant literature in the area(s); and contributing to foreign language teacher education through reflective and critical thinking. Readings and discussions supplemented by classroom observation and evaluation. Graduate students only. Instructor: Paredes. 3 units.

701. Indigenous Chronicles of the Colonial Period. Exploration of the relationships between languages, writing, memories, and political practices by focusing on indigenous writers such as Guaman Poman de Ayala, Alvarado Tezozomoc, Pachacuti Yamki, Alva Ixtlilxochitl. Spanish and Portuguese writers will also be included as well as anonymous texts (for example, Huarochiri Manuscripts, Popol Vuh, and Mesoamerican Codices). Instructor: Mignolo. 3 units.

703. Contested Spaces: Writing in Nineteenth-Century Latin America. Questioning teleological constructions of "Literature," "national literature," and the like, this course studies literacy, nonfictional, and pictorial representational practices in nineteenth-century Spanish America and Brazil in their institutional and political setting. Instructor: Staff. 3 units.

704. Modern Spanish-American Fiction. Study of interaction between literature and visual culture during the twentieth century. Specific topics may focus on movements such as the avant-garde and *concretismo*, or concepts such as the neo-baroque and interdisciplinary fictions. Instructor: Gabara. 3 units.

705. Narrative Forms of Early Modern Spain. Specific topics may focus on one or more forms, including novels of chivalry; sentimental, Moorish, or pastoral novels; hagiography and the mystics; the novella form, picaresque fictions, and the Heliodoran romance. Attention given to such questions as the interaction of literary traditions and social institutions, the philosophical defense of fiction and kinds of censorship, women writers and the representation of women. Instructor: Staff. 3 units.

706. Cervantes. The life and works of Cervantes, with emphasis on the Quijote, the Novelas ejemplares and Persiles y Segismunda. Instructor: Staff. 3 units.

707. Drama of Renaissance and Early Modern Spain. Study of the nature, development, and cultural function of drama in sixteenth- and seventeenth-century Spain through representative plays-canonical and noncanonical-of the period. Specific topics may include: early drama and its cultural locations; forms and theories of tragedy and comedy; women and subjectivity in Golden Age

drama; critical perspectives on the comedia; historical and religious drama and protonational self-definition; or performance and the place of the stage as a cultural institution. Instructor: Staff. 3 units.

708. Spanish Lyric Poetry before 1700. Study of selected poetry of the Middle Ages, Renaissance, and baroque, with attention to such questions as the interaction of elite and popular culture in the evolution of poetic forms, the languages of love and faith, and the political uses of poetry. Instructor: Staff. 3 units.

709. Cross-Cultural (Mis)Understanding: Europe and the New World, 1480-1800. Survey form or in-depth analysis of specific topics: the interrelations between Europe and the New World from the Renaissance to the Enlightenment, and from the last decades of the Inca and Aztec Empires to the wars of independence. The "clash of civilizations" and its implications for the cultural history of the early modern period and for the colonial expansion of the west. Instructor: Mignolo. 3 units.

710. Thinking Independence: From Tupac Amaru to 1898. Study of the cultural problems surrounding the Latin American wars of independence, and the pre- and post-independence periods. May focus on foundational fictions, political writings, the so-called Romantic period. Instructor: Staff. 3 units.

711. Nineteenth-Century Prose Fiction. Readings by novelists such as Valera, Galdós, Alas, and Pardo Bazán in the light of current critical theory. Instructor: Sieburth. 3 units.

712S. The City, Modernity, Gender, and Literature: Nineteenth-Century Madrid. The course will examine the intersections among four terms: the city, modernity, gender, and literature. We will focus on 19th-century Madrid. We will explore the following topics: the concept of the public sphere and its contradictions; the gendering of public and private spheres and of the experience of modernity; the problem of representation in, and of, the city; mass culture and the city; the realist novel and women in the streets. Instructor: Staff. 3 units.

713. Spanish Texts of the Post-Dictatorship: La Movida en La Transicion, 1973-1993. An analysis of the political and cultural processes at play during the Spanish transitional period when, with the 1973 assassination of Almirante Carrero Blanco and the subsequent death of general Franco in 1975, the country transformed the autocratic and military state imposed by Franco's dictatorship into the current democratic state. Focus on literary and cinematic texts and of the period, drag culture, pop music, and comics. Instructor: Staff. 3 units.

714S. Cultural History and Theory. Seminar covering various topics in Latin American cultural history and theoretical production such as: (a) colonial legacies and postcolonial theories; (b) the construction of identities and the critique of cultural colonialism; (c) contemporary critical production in Latin America, from dependency theory to transnationalism and postmodernity. May be repeated for credit. Instructor: Mignolo or staff. 3 units.

715S. Latin American Vanguards. A seminar on the major avant-garde movements between 1915 and 1940, based in an interdisciplinary study of literature and visual culture. Examines contemporary criticism as well as theoretical texts from the period. Topics include: critical nationalism, indigenism vs. primitivism, formalism and political art, the "gender of modernity." Instructor: Gabara. 3 units.

716. Mass Culture and Political Repression in Spain and Latin America. Exploration of a significant body of Spanish and Latin American fiction produced under repressive political regimes, whose characters engage intensely with popular culture as a way to cope with persecution, silencing, and severe limitations on their conduct. Key mass culture theories will be put in dialogue with the fictional texts. Authors may include Cervantes, Marsé, Martín Gaite, Martín Patino, Borges, Puig. Instructor: Sieburth. 3 units.

717S. Art & Democracy: Madrid/Barcelona/Bilbao. Beyond the political poster and the large mural, was there a painterly art in the pre-digital age that found a fitting place on the street and the square, the quintessential citizen venues where democracy and populist politics first emerged? And is there a political praxis which may yield visual works of enduring value without sacrificing the imperative of communicability inherent in humanistic pursuits? Since the1960s such questions concerned committed Spanish artists in all styles (Tàpies, Genovés, Ibarrola, Saura, Equipo Crónica). Like Goya before them, these painters tried to help their society transition from tyranny to more inclusive forms of participation. Instructor: Rodriguez-Garcia. 3 units. C-L: Literature 717S, Art History 709S

790. Topics in Spanish Studies. Topics vary by semester. Instructor: Staff. 3 units.

790S. Topics in Spanish Studies. Topics vary by semester. Instructor: Staff. 3 units.

890-1. Hispanic Seminar: Special Topics. Each semester one of the following topics will be selected for intensive treatment: the Spanish language in America, studies in medieval literature, studies in the literature of the Golden Age, studies in Latin American literature, studies in the Spanish Renaissance and baroque, studies in Spanish poetry, studies in nineteenth-century Spanish literature, and studies in twentieth-century literature. Instructor: Staff. 3 units.

Slavic and Eurasian Studies

Associate Professor Gheith, *Chair*; Associate Professor Tuna, *Director of Graduate Studies*; Professors Andrews, Holmgren, and Miller; Associate Professors Gheith, Hacohen, Miles, and Tuna; Professors of the Practice Apollonio, Maksimova, and McAuliffe; Associate Professor of the Practice Van Tuyl; Visiting Professor Newcity; Adjunct Assistant Professor Zitser; Research Professor Becker

A master's degree is available in this program.

The Department of Slavic and Eurasian Studies offers graduate work leading to the MA in Russian literature and culture, Slavic linguistics, and Slavic and Eurasian studies.

Beyond the strong commitment to improving and diversifying the language proficiency of its students and giving them solid training in research, the faculty of the department prepare students in a variety of adjacent fields, such as art history, cultural anthropology, cultural studies, film, gender studies, history, legal studies, linguistics, literary studies, political science, religion, theater studies, translation, and visual and informational studies. All entering students must demonstrate advanced knowledge of Russian or another Eurasian language.

Reading knowledge of French, German, or another Eurasian language is also required. Requirements for the MA degree must be met by completion of coursework and by passing an oral exam after the completion of a master's thesis. Coursework in Russian literature and culture must include seven courses selected from literature, film, or other culture courses offered by the Department of Slavic and Eurasian Studies; two courses offered in other humanities or social science departments at Duke; and one elective. Coursework in Slavic and Eurasian studies requires a minimum of six courses in Slavic and Eurasian cultures, with at least four focused on comparative Slavic and Eurasian or non-Russian Slavic or Eurasian topics. Students in Slavic linguistics must demonstrate competence in Russian and Slavic diachronic linguistics, and in general linguistic theory. Linguistic students must demonstrate knowledge of one Slavic language from the West and one from the South Slavic area, in addition to Russian. Required courses are at least four courses in Slavic linguistics (including Old Church Slavonic), one course in the history of the West Slavic languages, one course in the history of the South Slavic languages, at least two courses in general linguistics and semiotics, and one course in Russian literature. The MA program must be completed in four semesters or less.

While the Department of Slavic and Eurasian Studies has offered a doctoral program, that program is currently suspended and until further notice the university will not be considering applications for the PhD in Slavic and Eurasian studies. Admission to the MA program is open.

Further information about the graduate programs, including specific requirements, can be obtained from the director of graduate studies.

Courses in Balto-Finnic (BALTFIN)

701. Elementary Estonian. Introduction to understanding, speaking, reading, and writing Estonian. No preliminary knowledge of Estonian necessary. Instructor: Staff. 3 units.

702. Elementary Estonian. Introduction to understanding, speaking, reading, and writing Estonian. No preliminary knowledge of Estonian necessary. Instructor: Staff. 3 units.

703. Elementary Finnish. Introduction to understanding, speaking, reading, and writing Finnish. No preliminary knowledge of Finnish necessary. Instructor: Staff. 3 units.

704. Elementary Finnish. Introduction to understanding, speaking, reading, and writing Finnish. No preliminary knowledge of Finnish necessary. Instructor: Staff. 3 units.

Courses in Polish (POLISH)

701. Elementary Polish. Introduction to understanding, speaking, reading, and writing in Polish. No preliminary knowledge of Polish necessary. Instructor: Staff. 3 units.

702. Elementary Polish. Introduction to understanding, speaking, reading, and writing in Polish. No preliminary knowledge of Polish necessary. Instructor: Staff. 3 units.

703. Intermediate Polish. Intensive classroom and laboratory practice in spoken and written patterns. Readings in contemporary literature. Prerequisites: Polish 101 and 102, or consent of instructor. Instructor: Staff. 3 units.

704. Intermediate Polish. Intensive classroom and laboratory practice in spoken and written patterns. Readings in contemporary literature. Prerequisites: Polish 101 and 102, or consent of instructor. Instructor: Staff. 3 units.

708S. Fragmented Memories: Polish and Polish Jewish Culture Through Film. Analyzes, compares, and assesses representations of Polish Christians and Polish Jews -- their life experiences, interactions, shared and separate fates -- in documentaries and fiction films made in Poland from the 1930s to the present day. Includes films by Wajda, Polanski, Munk, Kieslowski; also a 2008 documentary about pre-World War II Christian-Jewish relations in Poland by Jolanta Dylewska. All films screened with English subtitles. Instructor: Holmgren. 3 units.

788S. Trauma and Nostalgia: East European Film in the 21st Century. Examines the major thematic focus of East European filmmakers in the 21st century: their efforts to reconstruct and reassess the experience of the Cold War (1945-1989) and the Yugoslav wars (1991-1995). These films from the Czech Republic, Hungary, Poland, Romania, Croatia, and Serbia include ironic/sentimental tales of Cold War childhood, thrillers about sleeping with the enemy (political informers), and psychological dramas centering on political trauma, resistance, and compromise. All films shown with English subtitles. Instructor: Holmgren. 3 units.

Courses in Romanian (ROMANIAN)

703. Intermediate Romanian Language and Culture. Focus on the study of Romanian phonetics, grammar, discourse, textual analysis, and writing. Prerequisite: Romanian 711 or consent of instructor. Instructor: Staff. 3 units.

711. Intensive Romanian Language and Culture. Introduction to Romanian comprehension, speaking, writing, reading, and cultural acquisition. Instructor: Staff. 3 units.

712. Intensive Intermediate Romanian. Intensive study of Romanian at the intermediate level. Equivalent of two semesters. Prerequisite: Romanian 711. Instructor: Staff. 3 units.

Courses in Russian (RUSSIAN)

506S. Semiotics and Linguistics (DS4). A survey of modern semiotics, particularly the works of C. S. Peirce, Roman Jakobson, Yury Lotman, Roland Barthes and Umberto Eco. Analysis of semiotic works directly related to questions of the construction of cultural and linguistic meaning, and linguistic sign theory. Emphasis on semiotic theories from a multi-cultural perspective, especially the

European, Tartu, Soviet, and American schools. Research project required. Instructor: Andrews. 3 units. C-L: Linguistics 506S

507. Stylistic and Compositional Elements of Scholarly Russian. Intensive study of Russian scholarly and scientific texts from a variety of disciplines, including biology, business, anthropology, economics, law, history, mathematics, physics, political sciences, sociology, psychology, linguistics, and literary criticism. Mastery of stylistic and discourse strategies. Analysis of cultural patterning in textual construction in the humanities, social and natural sciences. Taught in Russian. Prerequisite: Russian 204 or consent of instructor. Instructor: Maksimova. 3 units.

508. Legal and Business Russian. Analysis of Russian language and culture in the area of legal studies and conducting business in or with Russia and other Commonwealth of Independent States countries. Primary materials include legal codes, law journals, contracts, advertising, financial documents, redactions of the Soviet and Russian constitutions (1905-present). Specific attention given to the analysis of evolution of property and ownership legislation, the workings of the legislative, executive and judicial branches of the Russian Federation government and contrastive analysis of Soviet, Russian (and where relevant Western) systems of jurisprudence. Taught in Russian. Prerequisite: Russian 302S or equivalent. Instructor: Andrews or Maksimova. 3 units.

509. Theory and Methods of Comparative Linguistics. Diachronic and synchronic approaches to the study of comparative linguistics in phonology, morphology, morphophonemics, syntax, and lexical categories in the context of the world's languages. Both Indo-European and non-Indo-European languages. Topics include theories of reconstruction, languages in contact, abductive processes, questions of linguistic typology and cultural-based approaches to the analytical study of human languages. Research project required. Instructor: Andrews. 3 units.

510. Cognitive and Neurolinguistics. 3 units. C-L: see Linguistics 501; also C-L: Neuroscience 501S

511. The Struggle for Justice and Faith: Russian Literature and Culture, 1855-1900. Considers how Russian writers, artists, and activists addressed 19th-century Russia's cursed questions of "who is to blame" and "what is to be done": specifically, how to reform an increasingly reactionary autocracy; how to bear witness for an impoverished underclass; what roles women should play in culture and politics; how to resist or improve on a soulless West; how to justify the existence of God in an unjust world. Course texts may include fiction and memoirs by Turgenev, Tolstoy, Dostoevsky, Kovalevskaia, Figner; works of fine art, drama, and opera. Instructor: Staff. 3 units.

512. Women and Russian Literature. Issues of gender and society in women's writing in Russian from the eighteenth to the twentieth centuries. Both autobiographical writings and prose fiction. Discussions of whether Russian women's writings constitute a tradition and what role these works have played in Russian literature and culture. Taught in English. Readings in Russian. Instructor: Gheith. 3 units.

513. The Russian Novel. Close reading of Tolstoy's *Anna Karenina*, Dostoevsky's *Possessed*, Andrey Bely's *Petersburg*, Bulgakov's *Master and Margarita*, Nabokov's *The Gift*, and Makine's *Memoirs of My Russian Summers*. Discussions will focus on these representative writers' changing perceptions of, and responses to social and ethical issues and of creativity, itself, as the genre evolved in the modern times between the 1870s and now. Final research paper required and can include in-depth discussion of one of the works or the comparison of one or more aspects of several texts. Taught in English. Readings in Russian. Instructor: Apollonio and Gheith. 3 units.

514. Russian Modernism. Russian culture between the 1890s and the 1920s, including visual, musical, literary arts, and developments ranging from Neo-Christian mysticism, cosmism, synthesis of the arts, and revolutionary activism. Focus on literary-philosophical thought of that period. Taught in English. Instructor: Staff. 3 units.

515S. The Russian Intelligentsia and the Origins of the Revolution. 3 units. C-L: see History 535S

516. Media and Social Change. 3 units. C-L: see Policy Journalism and Media Studies 676; also C-L: Political Science 619, Public Policy 676

517. Russian Poetry. Focus on nineteenth and twentieth centuries, including the Golden Age and the Silver Age. Authors include Pushkin, Lermontov, Bely, Blok, Akhmatova, Tsvetaeva, Mandelshtam, Pasternak, and Mayakovsky. Taught in English or Russian, according to students' Russian language proficiency. Russian texts. Instructor: Van Tuyl. 3 units.

523. Dostoevsky. Introduction to life, works, and criticism. Readings include: *Crime and Punishment*, *The Idiot*, and *The Brothers Karamazov*. Taught in English. Readings in Russian. Instructor: Apollonio or Gheith. 3 units.

525. Tolstoy and the Russian Experience. Historical approach to Tolstoy's depictions of major societal and ethical issues (e.g., war, peace, marriage, death, religion, relationships). Culture of salons, print culture, censorship, and changing political climate. Central questions on the relationship of fiction and history: uses of fiction for understanding history and dangers of such an approach. Readings include selected fiction of Tolstoy, excerpts from journals and letters, and critical and historical accounts of nineteenth-century Russia. Similar to Russian 325 but requires additional assignments. Instructor: Apollonio or Gheith. 3 units.

526. Tolstoy. Introduction to life, works, and criticism, including Tolstoy's philosophical and ethical discourse. Readings include: *War and Peace*, *Anna Karenina*, the shorter fiction, dramatic works and essays. Taught in English. Readings in Russian. Instructor: Van Tuyl. 3 units.

527S. Chekhov. Drama and prose works. Readings in Russian. Instructor: Apollonio. 3 units.

528S. Bunin: Mystery of the Russian Soul and Metaphysical Memory. Same as Russian 328S, but includes additional assignments. Taught in Russian. Readings in Russian. Intensive critical component. Instructor: Maksimova. 3 units.

529S. Zamyatin. The novel *We*, short fiction, plays, and critical essays. In-depth textual analysis and study of Russian, American, and European criticism on Zamyatin, including his role in science fiction and anti-utopian literature in Russia and the West. Readings in Russian and English. Final research project required. Instructor: Andrews or Maksimova. 3 units.

530. Apocalyptic Visions and Diabolic Drama: The Works of Mixail Bulgakov. Critical analysis of Bulgakov's short stories,

novellas, plays and novels. In-depth exposure to major critical works on Bulgakov and influential figures. Taught in English. Readings in English and Russian. Instructor: Andrews. 3 units.

530S. Apocalyptic Visions and Diabolic Drama: The Works of Mixail Bulgakov. Critical analysis of Bulgakov's short stories, novellas, plays and novels. In-depth exposure to major critical works on Bulgakov and influential figures. Taught in Russian. Readings in Russian. Instructor: Andrews. 3 units.

533. Culture and Explosion: How Russian Culture Changed the World. Examination of Russian contributions to advancements in the sciences, mathematics, and the arts (visual/textual/musical). Special attention is paid to the contributions of Mendeleev (chemistry), Vygotsky and Luria (cognitive and developmental psychology/neuroscience), Lobachevsky (non-Euclidean geometry), Sakharov (nuclear physics, dissident), Kandinsky and Filonov (visual arts), Rachmaninoff, Shostakovich, Stravinsky, Prokofiev (composers), Zamiatin, Jakobson, Lotman, Bakhtin, Voloshinov (semiotics, theories of artistic texts). Instructor: Andrews. 3 units. C-L: Cultural Anthropology 533, Public Policy 508

533S. Culture and Explosions: How Russian Culture Changed the World. Examination of Russian contributions to advancements in the sciences, mathematics, and the arts (visual/textual/musical). Special attention is paid to the contributions of Mendeleev (chemistry), Vygotsky and Luria (cognitive and developmental psychology/neuroscience), Lobachevsky (non-Euclidean geometry), Sakharov (nuclear physics, dissident), Kandinsky and Filonov (visual arts), Rachmaninoff, Shostakovich, Stravinsky, Prokofiev (composers), Zamiatin, Jakobson, Lotman, Bakhtin, Voloshinov (semiotics, theories of artistic texts). TAUGHT IN RUSSIAN. Students must be at CEFR B1 proficiency level. Instructor: Andrews. 3 units.

551. Classics of Russian Literature and Textual Culture. Reading and writing about the classical works of Russian literature with intensive textual analysis, including prose (short stories and povesti), poetry, essays, fiction and nonfiction of the 19th and 20th centuries. Authors include Pushkin, Gogol, Lermontov, Turgenev, L. Tolstoy, Chekhov, Bunin. Writing component will develop expository prose style and rhetorical strategies. Taught in Russian. Prerequisite: Russian 401 and 402, or consent of instructor. Instructor: Maksimova. 3 units.

552. Russian Culture through Literature. Reading and writing about the important works of 20th and 21st century Russian literature, with intensive textual analysis and discussion of cultural relevance of the discourse of totalitarian regimes, including prose (short stories, one novel), poetry, and essays. Authors include Kharms, Shalamov, Vodolaskin. Writing component will develop expository prose style and rhetorical strategies. Taught in Russian. Prerequisite: Russian 401 and 402, or consent of instructor. Instructor: Maksimova. 3 units.

561S. Soviet Art after Stalin 1956-1991. Dissident art, graphic design, fine arts and architecture in context of Cold War and decline of totalitarianism. Themes include Soviet artists and the west, and representation of women in times of flux. Open to juniors and seniors and graduate students who must follow a more comprehensive reading program and complete upper level assignments. Instructor: Staff. 3 units. C-L: Art History 544S

563. Theory and Practice of Translation. Detailed study of the American, European, and Slavic scholarly literature on translation combined with close analysis of existing literary and journalistic translations and a program of practical translation exercises and projects from English to Russian and Russian to English. Prerequisite: three years of Russian language study or consent of instructor. Instructor: Apollonio. 3 units.

564. Russian and Slavic Linguistics. Emphasis on synchronic linguistic theory focusing on East Slavic and Russian, but including diachronic approaches, and West and South Slavic languages. Focus on phonological, morphological, semantic and syntactic structures of Contemporary Standard Russian and modern Slavic languages. Instructor: Andrews. 3 units. C-L: Linguistics 564, Slavic and Eurasian Studies 564

577. Contemporary Russian Culture: Detective Novels and Film. Popular novelists and film/television from 1900s-early twenty first century Russia. Theories of genre, anthropological approaches to defining cultural trends, mass cultural phenomena, and impact of globalization. Authors include Marinina, Dashkova, Dontsova, Kunin, Ustinova, and Serova. Readings and films in Russian. Research paper of publishable quality required. Instructor: Andrews. 1 unit.

619S. The Empire's Western Front: Russian and Polish Cultures. Exploration through literature and film of the relationship between Russian and Polish cultures in the nineteenth and twentieth centuries when imperial Russia/Soviet Union figured as Poland's problematic "east," and subject state of Poland figured as Russia's problematic "west." Nineteenth century anti-tsarist uprisings, 1920 Soviet-Polish campaign, Poland's postwar sovietization, rise of Solidarity, construction of their respective national identity vis-a-vis an other imagined as foe or friend in fiction, drama, film, memoirs. Includes works by Pushkin and Dostoevsky; films by Andrzej Wajda. 3 units.

627. Soviet and Post-Soviet Economic History. 3 units. C-L: see Economics 627; also C-L: History 627

627D. Soviet and Post-Soviet Economic History. 3 units. C-L: see Economics 627D; also C-L: History 627D

690S. Special Topics. Seminars in advanced topics, designed for seniors and graduate students. Instructor: Staff. 3 units.

701. Elementary Russian. Introduction to understanding, speaking, reading, and writing. Audiolingual techniques are combined with required recording-listening practice in the language laboratory. Instructor: Staff. 3 units.

701S. Contemporary Russian Composition and Readings. Advanced grammar and syntax with intense composition component. Analytical readings in the original. Prerequisite: Russian 703 and 704, or equivalent. Instructor: Staff. 3 units.

702. Elementary Russian. Introduction to understanding, speaking, reading, and writing. Audiolingual techniques are combined with required recording-listening practice in the language laboratory. Instructor: Staff. 3 units.

703. Intermediate Russian. Intensive classroom and laboratory practice in spoken and written patterns. Reading in contemporary literature. Prerequisite: Russian 701, 702 or consent of instructor. Instructor: Staff. 3 units.

704. Intermediate Russian. Intensive classroom and laboratory practice in spoken and written patterns. Reading in contemporary literature. Prerequisite: Russian 701, 702 or consent of instructor. Instructor: Staff. 3 units.

705. Advanced Russian Conversation and Readings. Nineteenth- and twentieth-century literature in the original. Conducted in Russian. Prerequisite: Russian 703, 704 or consent of instructor. Instructor: Staff. 3 units.

706. Advanced Russian Conversations and Readings. Nineteenth- and twentieth-century literature in the original. Conducted in Russian. Prerequisite: Russian 703, 704 or consent of instructor. Instructor: Staff. 3 units.

707. Advanced Russian. Advanced grammar review with an emphasis on the refinement of oral and written language skills. Development of writing style through compositions and essays. Prerequisite: Russian 706 or consent of instructor. Instructor: Andrews. 3 units.

708. Advanced Russian: Readings, Translation, and Syntax. Intensive reading and conversation with emphasis on contemporary Russian literary and Soviet press texts. English-Russian translation stressed. Russian media, including television and films. Prerequisite: Russian 707 or consent of instructor. Instructor: Andrews. 3 units.

709. Classics of Russian Literature and Textual Culture. Reading and writing about the classical works of Russian literature with intensive textual analysis, including prose (short stories and povesti), poetry, essays, fiction and nonfiction of the nineteenth and twentieth centuries. Authors include Pushkin, Gogol, Lermontov, Turgenev, L. Tolstoy, Chekhov, Bunin. Writing component will develop expository prose style and rhetorical strategies. Taught in Russian. Recommended prerequisite: Russian 707 and 708. Instructor: Maksimova. 3 units.

710. Russian Culture through Literature. Reading and writing about the important works of 20th and 21st century Russian literature with intensive textual analysis and discussion of cultural relevance of the discourse of totalitarian regimes, including prose (short stories, one novel), poetry and essays. Authors include Kharms, Shalamov, Vodolaskin. Writing component will develop expository prose style and rhetorical strategies. Taught in Russian. Recommended prerequisite: Russian 707 and 708, or consent of instructor. Instructor: Maksimova. 3 units.

711. The Quest for Identity: Russian Literature and Culture, 1800-1855. Examines how Russian writers and artists distinguished imperial Russia's modern political, social, and cultural identity under "Western eyes." Topics include search for "truly Russian" models, topics, and styles; domestic debate between "Westernizing" and "Slavophile" camps; emergence of women writers; relations between urban and provincial cultures; connections between national identity formation and empire building. Course texts may include fiction, memoirs, and drama by Pushkin, Durova, Gogol, Lermontov, and Pavlova; social commentary by Belinsky and Herzen; works of fine art and folk culture. Instructor: Staff. 3 units.

711AS. Advanced Russian Language and Culture. Advanced grammar review with additional emphasis on phonetics and conversation. Culture component includes literature, films, museums, and theater performances. (Taught in St. Petersburg in Russian.) Prerequisite: Russian 706 or equivalent. Instructor: Staff. 3 units.

712AS. Advanced Russian Language and Culture. Advanced grammar review with additional emphasis on phonetics and conversation. Culture component includes literature, films, museums, and theater performances. (Taught in St. Petersburg in Russian.) Prerequisite: Russian 706 or equivalent. Instructor: Staff. 3 units.

713. Contemporary Russian Media. Analytical readings and study of change and development in all the primary forms of former Soviet mass media from 1985 to the present (newspapers, journals, and television). Topics include censorship, TASS, samizdat. Taught in English. Readings in Russian. Prerequisite: Russian 204 or equivalent. Instructor: Andrews. 3 units.

714. Methods in Teaching Russian. The theory and practice of teaching Russian language to English-speaking students. Instructor: Andrews. 1 unit.

717. Russian Art and Politics: 1800-Present. Historical and contemporary engagement of visual culture-painting, sculpture, architecture, graphic arts, film, photography-with the political sphere in Russia from the early nineteenth century to the present. Interactions between artists, art critics, censors, government authorities, and the public indicating how visual culture both responded to demands from the political sphere and shaped the political discourse of the day. Instructor: Kachurin. 3 units.

720S. End of Life in Russia & U.S.. Brief history of hospice movement in US and Russia. Examine key moments in end of life issues in each country; focus on social attitudes to death and dying and their effects on end of life care. Sources include memoirs, fiction, theoretical works, and policy documents. Service learning course; includes work at sites such as the Unicorn Bereavement Center, a skilled nursing facility, or the state's attorney's office. Instructor: Gheith. 3 units.

721. The New Russia: Reflections of Post-Soviet Reality in Literature and Film. Examination of fiction and film in the post-Soviet period. Topics include: crime and social breakdown in the 1990s and 2000s; transformations of classic character types (anti-hero, virgin-whore, swindler-rogue); religious and ethical quests; taboo-breaking themes. Works by authors Sorokin, Grishkovets, Pelevin, Petrushevskaya, Sadur, Shishkin, Minaev, Tolstaya, Akunin, Ulitskaya and filmmakers Bodrov, Rogozhkin, Bekmambetov, Khlebnikov/Popogrebsky, Balabanov, and Sokurov. Readings and class discussions in English. Instructor: Apollonio. 3 units.

730. Beat Generation/Russian New Wave: Cultural Dissent in the Cold War. Exploration of identity formation and cultural dissent in the US and Soviet Union during the Cold War through the lens of Beat Generation and New Wave literature and film; explores cultural dissent in relation to both a given culture context but also considers how such dissent is read and appropriated in comparative contexts; introduces students to key figures/features of the respective movements, placing these in historical context; figures include: Kerouac, Burroughs, Ginsberg, Snyder, R. Frank, Aksyonov, Bitov, Akhmadulina, Voznesensky, Visotsky, Tarkovsky and Yevtushenko. Instructor: Need/Gheith. 3 units.

733S. Soviet Life through the Camera's Lense. An in-depth look at images and representations of Soviet life through Soviet and Russian film. Film texts include films shown in theatres, television films and forbidden films/films with a very limited distribution. Emphasis on the period from the mid-1970s through 1991. Course taught in Russian. Instructor: Maksimova. 3 units.

753. Law, Culture, and the Russian Legal Tradition. The development of the Russian legal tradition, with particular emphasis on the historical, ethical and cultural factors that have contributed to its emergence, comparing the Russian tradition with the Western legal tradition. How law, lawyers, and legal institutions have been portrayed and perceived in Russian popular culture, especially Russian literature, including the relationship between secular legal institutions and the Russian Orthodox Church. Taught in English. Instructor: Newcity. 3 units.

773S. Russian Language and Culture through Film. Study of Russian cultural paradigms and constructs of self and other as demonstrated in Russia and Soviet films, primarily from 1960s to the present. Special attention to the analysis of linguistic constructs and their cultural semantic content as well as comparative analyses of Soviet and Russian culture and Russian and European/American culture. Film and computer technology, as well as access to these technologies and their implementation, are a central part of the cultural context. Includes oral and written presentations and analysis which require the usage of additional film text and secondary critical literature. Prerequisite: Russian 301S or equivalent or consent of instructor. Instructor: Maksimova. 3 units. C-L: Visual and Media Studies 773S

774S. Russian Language and Culture through Film II. 3 units. C-L: see Visual and Media Studies 719S

782. Art and Dissidence: Films of Tarkovsky, Kubrick, Kurosawa, and Lynch. Post-World War II Soviet and United States identity and culture explored through the lens of dissident film art; the use of inter-textuality and contrasting media to critique culture; film and visual art studied in relation to other modern, post-modern, positivist modes of expressing and constructing knowledge. Graduate section will have additional separate meetings, readings, film viewings, and writing assignments. Instructor: Gheith. 3 units. C-L: Art History 782

783. The Actress: Celebrity and the Woman. Explores through fiction, film, autobiographies, and biographies the significance and influence of the actress (on stage and screen) from eighteenth century to present day. Highlighted topics: actress's self-image and perception of her art; relationship between her public profession and private life; how she reflects/sets contemporary standards for beauty and lifestyle; how she provokes public debate over women's "appropriate" sexual, familial, professional, and public roles; her function as symbol/role model for her gender, race, nation. Includes Sarah Bernhardt's memoirs, Chekhov's The Seagull, Susan Sontag's In America, films All About Eve and Mommie Dearest. Taught in English. Instructor: Holmgren. 3 units.

790. Teaching Methodology. Application of linguistic principles in the classroom. No prior knowledge of linguistics required. Instructor: Staff. 2 units.

810. The Russian Fairy Tale and Its Cultural Legacy. Introduction to Russia's extraordinary fairy tales and their rich legacy in modern Russian literature, music, visual and performing arts, and handicrafts. Reflects on the genesis of the Russian fairy tale; samples thematic groups of tales (e.g., the "foolish" third son, stepmother-stepdaughter tales); reads tales as expressions of folk belief, works of oral art, explorations of the human psyche and human relations, and stylized reflections of their sociopolitical context. Also traces how certain tales have been reworked into other art forms. All texts in English translation. Instructor: Holmgren. 3 units.

990. Directed Readings. Advanced readings in nineteenth- and twentieth-century Russian literature in the original. Instructor: Staff. 3 units.

SERBIAN AND CROATIAN (SERBCRO)

701. Elementary Croatian and Serbian. Introduction to understanding, speaking, reading, and writing Croatian and Serbian. No preliminary knowledge of Croatian and Serbian necessary. Instructor: Andrews. 3 units.

702. Elementary Croatian and Serbian. Introduction to understanding, speaking, reading, and writing Croatian and Serbian. No preliminary knowledge of Croatian and Serbian necessary. Instructor: Andrews. 3 units.

Courses in Serbian and Croatian (SERBCRO)

701. Elementary Croatian and Serbian. Introduction to understanding, speaking, reading, and writing Croatian and Serbian. No preliminary knowledge of Croatian and Serbian necessary. Instructor: Andrews. 3 units.

702. Elementary Croatian and Serbian. Introduction to understanding, speaking, reading, and writing Croatian and Serbian. No preliminary knowledge of Croatian and Serbian necessary. Instructor: Andrews. 3 units.

Courses in Slavic and Eurasian Studies (SES)

564. Russian and Slavic Linguistics. Emphasis on synchronic linguistic theory focusing on East Slavic and Russian, but including diachronic approaches, and West and South Slavic languages. Focus on phonological, morphological, semantic and syntactic structures of Contemporary Standard Russian and modern Slavic languages. Instructor: Andrews. 3 units. C-L: Russian 564, Linguistics 564

596S. Borderland and Battleground: A Journey Through Twentieth-Century Eastern Europe. Explores through history, film, fiction, and memoirs the "extreme" political experience, hybrid ethnic identities, and stunning art and testimony of twentieth-century Central and Eastern European cultures, including Poland, Czechoslovakia, Hungary, Romania, and Yugoslavia. Traces the emergence of new nation states in the region at the end of World War I, the rise of Nazism and Stalinism, the devastating experience of World War II, and the absurdist mix of politics and daily life in Eastern Europe from 1945 until the fall of the Berlin Wall. Graduate level version of SES 386S; undergraduates may enroll only with permission of instructor. Instructor: Holmgren. 3 units. C-L: Literature 511S

674S. Orhan Pamuk and World Literature. 3 units. C-L: see Asian & Middle Eastern Studies 674S

683S. The City of Two Continents: Istanbul in Literature and Film. 3 units. C-L: see Asian & Middle Eastern Studies 683S

687. The Turks: From Ottoman Empire to European Union. 3 units. C-L: see Asian & Middle Eastern Studies 687

712. Accelerated Uzbek Language and Culture I. Accelerated study of contemporary Uzbek language and culture. Intended for students with no previous knowledge of Uzbek: speaking, reading, writing, grammar and listening comprehension and appropriate use of cultural constructs. Instructor: Staff. 3 units.

713. Accelerated Uzbek Language and Culture II. Continuation of Uzbek 10. Intermediate level of proficiency in five areas: grammar, speaking, listening comprehension, reading and writing. Language taught embedded in cultural constructs. Prerequisite: Uzbek 10 or equivalent. Instructor: Staff. 3 units.

723S. City Stops Between Europe and Asia: From Prague to Kabul. Explores the multi-layered histories and identities of cities positioned on imperial routes extending from Europe's eastern borders into Central Asia--Prague, Warsaw, Kazan, Istanbul, Bukhara/Tashkent, Kabul. Examines how these urban spaces bear the political, religious, cultural, and linguistic imprints of overlapping empires--Mongol, Ottoman, Hapsburg, Russian, and Soviet. No prerequisites. All readings in English translation and films screened with English subtitles. Instructor: Tuna. 3 units.

740S. Around the Bloc: Cold War Culture in the USSR and Eastern Europe. Drawing on oral and written history, memoirs, film, fiction, and essays in anthropology and sociology, we'll resist the black/white readings imposed by the Iron Curtain and explore the dreams, fears, ethical concerns, cultural trends, and lifestyles of Cold War baby boomers in the USSR, Poland, Czechoslovakia, and Romania. Highlighted topics include: the privileges and discontents of postwar youth, the atomic age and its mutations, adventures in socialist consumer culture, gender politics and real life, making art about the socialist state of the absurd. All texts in English translation, films screened with English subtitles. Instructor: Holmgren. 3 units.

756. Imperial Russia 1700-1917. Russian imperial history from Peter the Great to Bolshevik Revolution: 1700-1917. Focus on formation and governance of multiethnic and multi-confessional Russian empire. Traces expansion of land-locked city state (Muscovy) into world power ruling from Eastern Europe to Alaska. Questions implications of Russias world-power status. Examines institutions of governance that created this empire and held its various ethnic, religious and ideological groups together for centuries. Readings of English translations of works of Russian literature and historiographic analyses aimed at developing a sound grounding in Russian imperial history and culture. Instructor: Tuna. 3 units.

772S. The Frontiers and Minorities of the Tsarist and Soviet Empires. Introduces multi-confessional, multilingual, multicultural composition of Russian & Soviet empires with questions concerning minorities in an imperial context. Learn about construction, interaction, and manipulation of cultures and identities. Balance Tsarist & Soviet efforts to modernize and Russify minorities, such as Ashkenazi Jews, Poles, & Turkic Muslims, against negotiated transformation and cultural resilience of minorities. Recognizes cultural diversity in an imperial setting and provides better appreciation of Russian and Eurasian realities and other multicultural contexts such as America. No Russian required. Instructor: Tuna. 3 units.

773S. Between Moscow, Beijing and Delhi: Narratives of Europe and Asia. Exercise in reconstructing Eurasian history from the 13th century Mongol invasions to post-Soviet era through critical reading of eyewitness accounts--travel notes and memoirs. Reflects on political, religious, and cultural evolution, expansion, and rivalry as well as cross-cultural and trans-regional exchange. Instructor: Tuna. 3 units.

774S. Ideology and Religion in Muslim Central Eurasia. While Islam as a lived religion offers a common starting point to understand the experiences of Muslims in Central Eurasia, ideologies such as Islamism, positivism, nationalism, and socialism have informed the various powers that attempted to regiment their lives according to various blueprints for a future society since the nineteenth century. Thus, the minds and bodies of Central Eurasia's Muslims have been the subject of intense intellectual debates and social engineering interventions, and in their experiences, this course explores the modern interplays of religion and ideology as they have been mediated by individual or group interests, power dynamics, and mundane realities. Instructor: Tuna. 3 units. C-L: History 774S, Asian & Middle Eastern Studies 774S, Religion 774S

786S. Borderland and Battleground: A journey Through Twentieth-Century Eastern Europe. Explores through history, film, fiction, and memoirs the "extreme" political experience, hybrid ethnic identities, and stunning art and testimony of twentieth-century Central and Eastern European cultures, including Poland, Czechoslovakia, Hungary, Romania, and Yugoslavia. Traces the emergence of new nation states in the region at the end of World War I, the rise of Nazism and Stalinism, the devastating experience of World War II, and the absurdist mix of politics and daily life in Eastern Europe from 1945 until the fall of the Berlin Wall. Instructor: Holmgren. 3 units.

990. Directed Readings. Advanced Readings in Turkish Language and Culture. Instructor: Staff. 3 units.

Course in Turkish (TURKISH)

718. The Turks: From Ottoman Empire to European Union. Readings in cultural history and literature to examine transformations in Turkish identity from the Ottoman era to EU accession. Discussion of the "gazi thesis", the "sultanate of women", religious tolerance (millets), conversion, modernity and nationalism. Secondary topics include Sufism, Islam, gender, and historiography. Interdisciplinary focus. Taught in English. Instructor: Goknar. 3 units.

Courses in Ukrainian (UKRAIN)

701. Elementary Ukrainian. Introduction to understanding, speaking, reading, and writing Ukrainian. No preliminary knowledge of Ukrainian necessary. Instructor: Staff. 3 units.

702. Elementary Ukrainian. Introduction to understanding, speaking, reading, and writing Ukrainian. No preliminary knowledge of Ukrainian necessary. Instructor: Staff. 3 units.

Slavic, Eurasian, and East European Studies

Associate Professor Tuna, *Director*

A certificate is available in this program.

Since its establishment in 1991, the Center for Slavic, Eurasian, and East European Studies has brought together faculty and students from different departments and schools within Duke University who share a common interest in this region. The center sponsors a variety of visiting speakers, workshops, conferences, and other programs to promote research and the dissemination of knowledge about the former Soviet Union and Central and Eastern Europe.

The center offers a certificate in Slavic, Eurasian, and East European studies to students enrolled in The Graduate School, the Nicholas School of the Environment, the Duke Law School, The Fuqua School of Business, or the School of Medicine. The certificate program requires that participating Duke graduate students pursue coursework related to this region in language, literature, economics, history, political science, public policy, law, or business. A student receiving the certificate will have completed significant cross-disciplinary coursework in this area and demonstrated a mastery of at least one related Slavic language.

The center also offers a certificate in Slavic, Eurasian, and East European studies with a concentration in Russian and East European legal studies. This certificate, inaugurated in 1996, is the first of its kind offered by an American university.

Students seeking either certificate must complete five courses drawn from three different disciplines. Two of the five courses must be from a single discipline, excluding the student's major department. A sixth course of a topical nature will be offered as an interdisciplinary seminar on a yearly basis and will require a major research paper of all certificate candidates. In order to receive either certificate, students will be expected to demonstrate language proficiency in a Slavic or Eastern European language at the intermediate level. Oral and written testing will be required to demonstrate the required level of proficiency.

Requirements

The Graduate School, The Fuqua School of Business, the School of Medicine, Duke Law School, and Nicholas School of the Environment students are eligible after completion of

- five courses from three different disciplines, and an interdisciplinary course sponsored by the center (two of the five must be from a single discipline, excluding the student's major);
- demonstrated language proficiency in a Slavic or Eastern European language at the intermediate level;
- certificate with a specialization in legal studies may be received by graduate students with special interest in law/legal institutions in the former Soviet Union and Eastern Europe;
- must satisfy general requirements noted above, but with three of the five required courses drawn from a list specifically relevant to legal studies; and
- complete an interdisciplinary seminar and demonstrate language proficiency.

For further information about the center and its programs, please contact the center director, Professor Edna Andrews, Box 90260, Duke University, Durham, NC 27708-0260; or visit the website at https://slaviccenters.duke.edu/.

Sociology

Professor Read, *Chair*; Professor Lynch, *Director of Graduate Studies*; Professors Bail, Baker (Cultural Anthropology), Bonilla-Silva, Burton, Chaves, Crichlow (African and African American Studies), Cummings (Fuqua School of Business), Dupre (School of Medicine), Frankenberg (Public Policy), Gao, Gold (Psychiatry), Harris, James (Public Policy), Keister, Lynch, Merli (Public Policy), Moody, Read, and Smith-Lovin; Associate Professors Brown, Gibson-Davis (Public Policy), Hasso (Gender, Sexuality, and Feminist Studies), Healy, and Rossette (Fuqua School of Business); Assistant Professors Harrell, Rawlings, Streib, and Yang; Professor of the Practice Reeves; Assistant Professor of Practice Hamil; Professors Emeriti George, Gereffi, Land, Lin, McPherson, Morgan, O'Rand, Simpson, Smith, Spenner, Tiryakian, and Wilson; Associate Professor of Practice Emeritus Bach

A master's degree and a PhD are available in this department.

The Department of Sociology offers graduate work leading to the MA and PhD in sociology.

Applicants for admission are required to take the verbal and quantitative aptitude tests of the Graduate Record Examination.

The PhD program requires the student to take six core courses. In addition, the student is to take two professionalization seminars (Sociology 701, 702) for the exposure of frontier research issues and professional activities in sociology. The core courses include Sociology 710 (Classical Sociological Theory), Sociology 711 (Contemporary Approaches to Sociological Explanation), Sociology 722 (Social Statistics I) and Sociology 723 (Social Statistics II), Sociology 720S (Logic of Inquiry), Sociology 721S (Research Design Practicum), and two additional advanced methods courses (to be determined by the student with approval of the director of graduate studies). Qualifying areas are determined with the academic advisor, but typically include culture and cognition, health and demography, organization and economic sociology, race and inequality, religion and social change, and social networks and computational sociology. The preliminary exam consists of a defense of the dissertation proposal. A student entering with only an undergraduate degree would need to take seventeen courses to satisfy degree requirements.

Further details concerning the general departmental program, the specialties and their requirements, departmental facilities, the faculty, ongoing research, and stipends available may be obtained from the director of graduate studies.

Courses in Sociology (SOCIOL)

502S. Race, Class, and Gender in the University. 3 units. C-L: see Cultural Anthropology 502S; also C-L: History 513S

534. Topics in Population, Health, and Policy. 3 units. C-L: see Public Policy 633; also C-L: Global Health 550

541. The United States and the Asian Pacific Region. Asian Pacific region is major engine of economic growth in the 21st century likely causing major shift of power and wealth in the world. Study relationships between US and various Asian Pacific nations from the end of World War II to present. Focus on impact of wars, technological development and economic development. Examine differences in various issues such as trade, human rights, environment, territory disputes between US and a variety of Asian Pacific nations. Same

as Sociology 341, with additional work required. Instructor: Gao. Variable credit.

542S. Understanding Ethical Crisis in Organizations. 3 units. C-L: see Study of Ethics 562S; also C-L: Political Science 502S, Public Policy 558S

556S. Poverty and the Visual. 3 units. C-L: see Visual and Media Studies 570S

570S. Global Responses to the Rise of China. Issues on the impact of globalization on jobs and wages in advanced industrialized countries, the trend of regionalization in international political economy, the new strategies adopted by both advanced industrialized countries and developing countries under the WTO framework, South-North relationship in the era of globalization, the impact of outsourcing through globalization production networks on developing countries, comparative analysis of inequality, and other issues faced by developing countries today. Instructor: Gao. 3 units. C-L: Economics 550S

590. Special Topics in Sociology. Substantive, theoretical, or methodological topics vary by semester. Instructor: Staff. 3 units.

594S. Cultural (Con)Fusions of Asians and Africans. 3 units. C-L: see African & African American Studies 594S; also C-L: Cultural Anthropology 594S, Latin American Studies 594S

634S. Making Social Policy. 3 units. C-L: see Public Policy 563S; also C-L: Child Policy 634S

636S. Experimental Communities. 3 units. C-L: see Visual Arts 554S

641S. Proseminar in Medical Sociology (Special Topics). Selected topics in medical sociology: social structure and health; social behavior and health; organization and financing of health care; medical sociology (for example, social epidemiology, stress and coping, health and aging). Instructor: Burton, Brown, and Gold. 3 units.

642S. Global Inequality Research Seminar. 3 units. C-L: see Public Policy 645S; also C-L: African & African American Studies 642S, Economics 541S, Political Science 642S, Human Rights Program-Franklin Humanities Institute 642S

645S. Citizen and Subject in a Neoliberal Age. 3 units. C-L: see African & African American Studies 641S; also C-L: Cultural Anthropology 641S

647. Surviving Globalization: The Global South and the Development Imagination. 3 units. C-L: see African & African American Studies 646; also C-L: International Comparative Studies 647

651S. Social Change, Markets, and Economy in China. Introduction to recent economic, social, and institutional changes in China, with focus on recent (post 1980) periods. Up-to-date descriptive reviews, empirical data, and discussions on historical background, current status, and future perspectives. Instructor: Staff. 3 units. C-L: Economics 542S

664. Research Methods in Japanese (B). 3 units. C-L: see Japanese 650; also C-L: History 503

690. Special Topics in Sociology. Substantive, theoretical, or methodological topics vary by semester. Instructor: Staff. 3 units.

690S. Seminar in Selected Topics. Substantive, theoretical, or methodological topics. Instructor: Staff. 3 units.

699. Qualitative Methods in Sociology. This course will teach students how to use qualitative methods in sociological research. We will focus on interviewing and participant observation. Instructor: Streib. 3 units.

701. Current Debates and Professional Concerns in Sociology. A two-semester overview of the sociological research being conducted in the Department, a discussion of current controversies in the discipline, how to prepare for a professional career in sociology, the ethics of doing sociological research, the practice of teaching, how to apply for research grants. Instructor: Staff. 1.5 units.

702. Second-Year Paper Workshop. A two-semester workshop in which each student carries out a research project from beginning to end. Weekly seminars offer the opportunity for students to critique each other's work. Instructor: Staff. 1.5 units.

703. Developing a Dissertation Proposal. A two-semester workshop in which students develop their dissertation proposals. Instructor: Staff. 3 units.

710. Classical Sociological Theory. Classical sociological theory for first-year sociology graduate students. Marx, Weber, Durkheim, and other important theorists and their influences. Development of social theory through the mid-20th century. Instructor: Staff. 3 units.

711. Contemporary Approaches to Sociological Explanation. Second theory course for first-year sociology graduate students. Explanatory sociological theory from the mid-20th century to the present. Prerequisites: Sociology 710 or equivalent. Instructor: Staff. 3 units.

716S. Capitalism. 3 units. C-L: see Cultural Anthropology 716S; also C-L: Political Science 720S

720. Survey Research Methods. Theory and application of survey research techniques in the social sciences. Sampling, measurement, questionnaire construction and distribution, pretesting and posttesting, response effects, validity and reliability, scaling of data, data reduction and analysis. Instructor: Staff. 3 units.

720S. Logic of Inquiry. First in a two-course sequence. Explores sociological research methods. Focuses on basic elements shared by all sociological research: research questions, research design, measurement, sampling, and data collection. Will sharpen students' research skills, help them distinguish good from poor matches between research questions and research methods, and equip them to design and execute high quality sociological research. Consent of instructor is required. Instructor: Chaves or Keister. 3 units.

721S. Research Practicum. Second in a two-course sequence about designing and conducting social research. Students design, execute, and present original research projects that contribute to sociological knowledge. Will sharpen students' research skills by providing hands-on experience with all aspects of sociological research. Prerequisite: Sociology 720S. Instructor consent required. Instructor: Chaves or Keister. 3 units.

722. Social Statistics I: Linear Models. Introduction to regression modeling for first-year sociology graduate students; multiple

regression in matrix form; least squares and maximum likelihood; generalized linear models; regression diagnostics; model selection. Instructor: Harris, Lynch, Moody, or Vaisey. 3 units.

723. Social Statistics II: Advanced Techniques. Advanced methods for first-year sociology graduate students; content varies but may include: logit, probit, and other generalized linear models; propensity score and other forms of matching; instrumental variables; panel and multilevel data; simulations. Prerequisites: Sociology 722 or equivalent. Instructor: Lynch, Moody, or Vaisey. 3 units.

725. Basic Demographic Methods. Population composition, change, and distribution. Methods of standardizing and decomposing rates, life tables and population models, analysis of data from advanced and developing countries. Applications of computer programs for demographic analysis. Instructor: Staff. 3 units.

726S. Advanced Methods of Demographic Analysis. Mathematical methods and computer software for the analysis of population dynamics. Life table and stationary population theory; methods of life table estimation; multiple-decrement and multistate life tables; stationary population theory and its extensions; model life tables and stationary populations; two-sex models and interacting populations; hazard regression models, grade-of-membership analysis, and cohort studies. Instructor: Staff. 3 units.

728. Advanced Methods: Introduction to Social Networks. Introduction to social network analysis (SNA). History of SNA; social-theoretical foundations of modern network analysis; data collection; data management; analysis and visualization tools. Survey of current applications of SNA within the social sciences. Satisfies Sociology PhD program advanced methods requirement. Instructor: Moody or Rawlings. 3 units.

729S. Structural Equation Modeling. Basic and advanced Structural Equation Modeling (SEM) with and without latent variables. Topics include statistical theory underlying multivariate statistical modeling specific to SEM, path analysis, confirmatory (and exploratory) factor analysis, multiple group analysis, multiple indicator multiple cause (MIMIC) modeling, full SEM, and contemporary extensions to growth modeling and latent class analysis. Homework involves applying SEM software to real and simulated social science data. Recommended prerequisite: a basic statistics course and a course covering linear regression modeling. Instructor: Lynch. 3 units.

730S. Proseminar: Topics in Comparative and Historical Sociology. Selected topics in the differentiation and transformation of societies: theories of social change; globalization and comparative development; societal transformations and social institutions; culture, values, and ideas; social movements and political sociology; comparative social policies; comparative and historical sociology. Instructor: Staff. 3 units.

745S. Proseminar in Crime, Law, and Deviance (Special Topics). Selected topics in crime and the institutions of social control: theories of crime causation; human development and criminal careers; social control and the criminal justice system; sociology of law; crime, law, and deviance. Instructor: Staff. 3 units.

750S. Proseminar in Population Studies (Special Topics). Selected topics: population dynamics; mortality, morbidity, and epidemiology; urbanization and migration; demography of the labor force; demography of aging; population studies. Instructor: Burton, Lynch, or Moody. 3 units.

755S. Proseminar in Economic Sociology (Special Topics). Selected topics: basic concepts, theories, and methods; organizations and institutions; social networks and social capital; globalization and markets; occupations and work. Instructor: Gao, Keister, or Ruef. 3 units.

760S. Proseminars in Social Institutions and Processes (Special Topics). Selected topics in the sociology of institutions and social and institutional behavior: social networks; political sociology; sociology of religion; sociology of science; sociology of education. Instructor: Healy, Moody, or staff. 3 units.

765S. Proseminar: Topics in Social Stratification. Core and special topics in social stratification, including explanations for the existence, amount, and various dimensions of stratification in society; institutions that produce stratification; forces that cause the structure of stratification to vary both over time and across societies; and structures that govern social mobility within and across generations. Intergenerational mobility; social structure and the life course; social inequality and the structure of poverty; careers and labor markets; societal transformation; stratification and mobility research. Instructor: Keister or Streib. 3 units.

770S. Proseminar in Social Psychology (Special Topics). Selected topics in microsociology and social psychology, including social interaction, decision making, social exchange, group processes, intergroup relations, self and identity, social structure and personality, social networks, and application in organizations and health care. Introduction to social psychology; rational choice and social exchange; sociology of self and identity; group processes and intergroup relations; experimental research; practicum; social psychology. Instructor: Burton, George or Smith-Lovin. 3 units.

775S. Sociology of Religion. Begins with Durkheim's and Weber's different approaches to the sociology of religion. Considers a range of topics, including ritual, religious commitment, conversion, religion and social movements, secularization, social sources of religious variation, and religious influences on people, organizations, and societies. Explores current empirical and theoretical debates. Identifies significant unanswered questions that future research should address. Instructor: Chaves. 3 units. C-L: Religion 775S

776. The Social Organization of American Religion. 1 unit. C-L: see American Christianity 807

790. Selected Topics. Lecture version of Sociology 690S. 3 units.

790S. Seminar in Selected Topics. Substantive, theoretical, or methodological topics. Restricted to Sociology graduate program majors only. Instructor: Staff. 3 units.

791. Individual Research in Sociology. Students will conduct on an individual basis research designed to evaluate a sociological hypothesis of their choice. The process must be completed by preparation of a report on this research in adequate professional style. Prerequisite: Sociology 721S or consent of instructor. Instructor: Staff. 3 units.

880. Special Topics in Sociology. Substantive, theoretical, or methodological topics vary by semester. Open only to PhD students. Instructor: Staff. 1.5 units.

901. Advanced Writing Workshop. Research writing workshop required for sociology graduate students. Prerequisite: Sociology 703. Instructor: Staff. 1.5 units.

Statistical Science

Professor Reiter, *Chair*; Professor Hoff, *Director of Graduate Studies*; Professors Belloni, Berger, Carin, Clark, Clyde, Dunson, Herring, Hoff, Mattingly, Miller, Mukherjee, Reiter, West, Winkler, and Wolpert; Associate Professors Arlotto, Li, Ma, Rudin, Schmidler, Tokdar, and Wu; Assistant Professors Heller, Mak, Reeves, Steorts, Volfosky, and Xu; Professors Emeriti Burdick, Gelfand, and Sacks; Professor of the Practice Banks; Associate Professor of the Practice Çetinkaya-Rundel; Assistant Professors of the Practice Jiang, Rundel, Santo, and Tackett; Research Professor Iversen; Associate Research Professor Chan; Senior Lecturer Dasmohapatra; Adjunct Professor Cron

A master's degree and a PhD are available in this department.

The Department of Statistical Science at Duke University offers graduate study leading to the MS and PhD in statistical science. The department offered the MS in statistical and economic modeling (MSEM) until 2017; this program has been discontinued.

The PhD in statistical science offers thorough preparation in the theory and methods of statistics, with major emphases on modern, model-based statistical science, Bayesian and classical approaches to inference, computational statistics, and machine learning. Students work with world leaders in research in Bayesian statistics, methodology of statistical science, statistical computing, and a range of interdisciplinary areas. A hallmark of the program is the integration of interdisciplinary applications into teaching and research at all levels, reflecting the department's broad and deep engagements in leadership and innovation in statistical science in its intersections with many other areas (biomedical sciences, computational sciences, data and information sciences, economic and policy sciences, environmental sciences, engineering, machine learning, physical sciences, social sciences, and their intersections. The rich opportunities for students in interdisciplinary statistical research at Duke are complemented by departmental interconnections at the National Institute of Statistical Science (NISS) and Statistical and Applied Mathematical Sciences Institute (SAMSI), and opportunities for engagement in research in summer projects with nonprofit agencies, industry, and academia.

Requirements for the PhD in statistical science include study of statistics, probability, relevant areas of mathematics, computation, decision sciences, and related areas; passing the qualifying examination (covering those topics) and the doctoral preliminary examination (covering areas of possible research interest); and completing a dissertation written under the supervision of a faculty advisor.

The master's in statistical science (MSS) emphasizes core expertise in predictive modeling, Bayesian methods, machine learning, computational science and modern analytics linked to interdisciplinary applications, and into frontier areas of R&D with industry as well as academia and nonprofit organizations. In addition to defining a premier graduate educational program at the MS level, the MSS couples into the research leadership of Duke statistical science faculty. For some MSS students, the program defines a professional launchpad for careers in modern statistical science and related areas. For others, it is a bridge to future PhD studies.

For an up-to-date faculty list and description of the graduate programs in statistical science, visit the website at https://stat.duke.edu.

Courses in Statistical Science (STA)

501S. Teaching Advanced Placement Statistics. Designed for students in MAT (Master's in Education Program) who want to go on to teach statistics in high schools. Content covers advanced placement curriculum as well as discussion on the pedagogy of teaching statistical science in high schools. Typically offered only in the summer, occasionally during the academic year. Instructor consent required. Instructor: Staff. 3 units.

502. Bayesian Inference and Decision. 3 units. C-L: see Business Administration 910

503. Choice Theory. 3 units. C-L: see Business Administration 913

504. Statistical Genetics. 3 units. C-L: see Computational Biology and Bioinformatics 541

521L. Predictive Modeling and Statistical Learning. An introduction to statistical learning methods for prediction and inference. Topics include exploratory data analysis and visualization, linear and generalized linear models, model selection, penalized estimation and shrinkage methods including Lasso, ridge regression and Bayesian regression, regression and classification based on decision trees, Bayesian Model Averaging and ensemble methods, and time permitting, smoothing splines, support vector machines, neural nets or other advanced topics. The R programming language and applications used throughout. Instructor consent required. Corequisite: Statistical Science 323D or 523L and Statistical Science 360, 601, or 602L. Instructor: Staff. 3 units.

522. Study Design: Design of Surveys and Causal Studies. Investigation of study designs collecting data and their implications for statistical inference. Design and analysis of surveys of populations, including stratification, clustering, multi-stage sampling, design-based inference, considerations when analyzing convenience samples and big data. Design and analysis of causal studies including randomized experiments, blocking, fractional factorial designs, non-randomized studies, propensity score analysis. Applications involving big data, health, policy, natural and social sciences. Not open to students who have taken Statistical Science 322. Recommended prerequisite: Statistical Science 210, 521L, or an equivalent course. Instructor: Staff. 3 units.

523L. Programming for Statistical Science. Statistical programming, computation using selected languages and environments (Python, R, Matlab, and/or C/C++) and interfaces with custom code development for statistical models. Best practices and software development for reproducible results, selecting topics from: use of markup languages, understanding data structures, design of graphics, object oriented programming, vectorized code, scoping, documenting code, profiling and debugging, building modular code, and version control- all in contexts of specific applied statistical analyses. Instructor consent required. Prerequisite: Statistical Science 360, 601L, 602L, or 611 (or concurrent enrollment in any of these courses). Not open to students who have taken Statistical Science 323D. Instructor: Staff. 3 units.

531. Advanced Bayesian Inference and Stochastic Modeling. Art and science of building graphical models and stochastic simulation methods for inference and prediction. Mixture models, networks, and other latent variable probability models, i.e. hidden Markov models. Review of discrete and continuous multivariate distributions used in building graphical models, tools of linear algebra

and probability calculus. Aspects of Monte Carlo methodology and related dynamical modeling theory. Statistical computing using Matlab or R. Instructor consent required. Prerequisites: Statistics 521L, 523L, 601. Instructor: Staff. 3 units.

532. Theory of Statistical Inference. Core mathematical foundations of classical and Bayesian statistical inference. Theory of point and interval estimation and testing based on efficiency, consistency, sufficiency and robustness. Maximum likelihood, moments and non-parametric methods based on exact or large sample distribution theory; associated EM, asymptotic normality and bootstrap computational techniques. Theoretical aspects of objective Bayesian inference, prediction, and testing. Selected additional topics drawn from, for example, multiparameter testing, contingency tables, multiplicity studies. Instructor consent required. Recommended prerequisite: Statistical Science 521L, 523L, 601. Instructor: Staff. 3 units.

540L. Case Studies in Statistical and Data Science. Students apply statistical analysis skills to in-depth data analysis projects in a variety of areas of application. Students design and implement a data analysis plan based on substantive questions or hypotheses and communicate their results both technically and non-technically in oral presentations and written reports. Prerequisite: Statistical Science 360, 601, or 602. Not open to students who have taken Statistical Science 440 or Statistical Science 723. Instructor: Staff. 3 units.

561D. Probabilistic Machine Learning. Introduction to concepts in probabilistic machine learning with a focus on discriminative and hierarchical generative models. Topics include directed and undirected graphical models, kernel methods, exact and approximate parameter estimation methods, and structure learning. Prerequisite: Linear algebra, Statistical Science 250 or Statistical Science 611. Instructor: Staff. 3 units. C-L: Electrical and Computer Engineering 682D, Computer Science 571D

563. Information Theory. 3 units. C-L: see Electrical and Computer Engineering 587

571. Advanced Stochastic Modeling and Machine Learning. Art and science of building advanced probabilistic models. EM and stochastic based algorithms will be discussed in detail for inference and prediction. Topics include mixture models and latent variable models, i.e. hidden Markov models. Review of discrete and continuous multivariate distributions used in building graphical models, tools of linear algebra and probability calculus. Aspects of Monte Carlo methodology and related dynamical modeling theory and algorithms/computation. Understanding why and when models and methods work or break will be a focus. Prerequisite: Statistical Science 601 or 602L, and Statistical Science 532. Instructor: Staff. 3 units.

581. ProSeminar: Becoming a Statistical Scientist. Statistical paradigms and current directions, communication of statistical ideas and arguments, statistical ethics, overview of study designs, building a statistical network, professional societies, developing a web/social media presence, career paths. Instructor consent required. Instructor: Staff. 1 unit.

582L. DataFest. Students work in teams to solve this year's big data challenge on campus. Engages students with the data analysis process from the definition of research/analysis questions, to in-depth exploratory analysis, to formal modeling and computational developments, to drawing conclusions based on their findings. Students interact with multiple faculty and expert advisors, and develop and present their findings to a panel of professors and professionals. Prerequisite: Statistics 531, 532, 523L (or co-registration). Instructor: Staff. 1 unit.

583. Internship Writing. The aim of this course is to work with materials (report + presentation) from summer internship experience and turn them into products that are admissible for a portfolio defense. The course aims to help students produce materials that meet the bar of scientific writing without violating any non-disclosure agreements you may have signed. The course starts with an initial written piece from every student that gives a good summary of their internship project(s), then works through several rounds of revision with detailed feedback and assistance from course instructor. Instructor consent required. Instructor: Staff. 1 unit.

601L. Bayesian Statistical Modeling and Data Analysis. Principles of data analysis and modern statistical modeling. Exploratory data analysis. Introduction to Bayesian inference, prior and posterior distributions, predictive distributions, hierarchical models, model checking and selection, missing data, introduction to stochastic simulation by Markov chain Monte Carlo using a higher level statistical language such as R or Matlab. Applications drawn from various disciplines. Not recommended for students with credit for Statistical Science 360. Recommended prerequisite: Statistical Science 210, 240, or both Statistical Science 230 and 250. Instructor: Staff. 3 units.

602L. Bayesian Statistical Modeling and Data Analysis. Principles of data analysis and modern statistical modeling. Exploratory data analysis. Introduction to Bayesian inference, prior and posterior distributions, hierarchical models, model checking and selection, missing data, introduction to stochastic simulation by Markov chain Monte Carlo using a higher level statistical language such as R or Matlab. Applications drawn from various disciplines. Not open to students who have taken Statistical Science 360. Prerequisite: Statistical Science 611 or the following: Statistical Science 210 and (Statistical Science 230 or 240L) and (Mathematics 202, 202D, 212, or 222) and (Mathematics 216, 218, or 221, any of which may be taken concurrently). Instructor: Staff. 3 units.

610L. Multilevel and Hierarchical Models. Variance component models with fixed and random effects. Multilevel and hierarchical models for longitudinal and/or clustered data. Focus on model fitting and interpretation. Maximum likelihood and Bayesian inference and computation. Prerequisite: Statistical Science 360, 601, or 602L. Recommended prerequisite: R programming skills. Not open to students who have taken Statistical Science 410L. Instructor: Staff. 3 units.

611. Introduction to Mathematical Statistics. Formal introduction to basic theory and methods of probability and statistics: probability and sample spaces, independence, conditional probability and Bayes' theorem; random variables, distributions, moments and transformations. Parametric families of distributions and central limit theorem. Sampling distributions, traditional methods of estimation and hypothesis testing. Elements of likelihood and Bayesian inference. Basic discrete and continuous statistical models. Not open to students who have had Statistical Science 250/Mathematics 342. Instructor: Staff. 3 units.

612. Numerical Analysis. 3 units. C-L: see Computer Science 520; also C-L: Mathematics 565

613. Statistical Methods for Computational Biology. 3 units. C-L: see Computational Biology and Bioinformatics 540

614. Computational Structural Biology. 3 units. C-L: see Computer Science 664; also C-L: Computational Biology and Bioinformatics 550

621. Applied Stochastic Processes. 3 units. C-L: see Mathematics 541

622. Statistical Data Mining. Introduction to data mining, including multivariate nonparametric regression, classification, and cluster analysis. Topics include the curse of dimensionality, the bootstrap, cross-validation, search (especially model selection), smoothing, the backfitting algorithm, and boosting. Emphasis on regression methods (e.g., neural networks, wavelets, the LASSO, and LARS), classifications methods (e.g., CART, Support vector machines, and nearest-neighbor methods), and cluster analysis (e.g., self-organizing maps, D-means clustering, and minimum spanning trees). Theory illustrated through analysis of classical data sets. Prerequisite: Statistical Science 250. Instructor: Staff. 3 units. C-L: Computer Science 579

623. Statistical Decision Theory. Formulation of decision problems; criteria for optimality: maximum expected utility and minimax. Axiomatic foundations of expected utility; coherence and the axioms of probability (the Dutch Book theorem). Elicitation of probabilities and utilities. The value of information. Estimation and hypothesis testing as decision problems: risk, sufficiency, completeness and admissibility. Stein estimation. Bayes decision functions and their properties. Minimax analysis and improper priors. Decision theoretic Bayesian experimental design. Combining evidence and group decisions. Prerequisite: Statistical Science 732 or consent of instructor. Instructor: Staff. 3 units.

640. Causal Inference. Statistical issues in causality and methods for estimating causal effects. Randomized designs and alternative designs and methods for when randomization is infeasible: matching methods, propensity scores, longitudinal treatments, regression discontinuity, instrumental variables, and principal stratification. Methods are motivated by examples from social sciences, policy and health sciences. Prerequisite: Statistical 521L or 721. Instructor: Staff. 3 units.

641. Statistical Learning and Bayesian Nonparametrics. Nonparametric Bayesian models and methods for complex data analyses with non-linearity adjustment, flexible borrowing of information, local uncertainty quantification and interaction discovery. Focuses on computationally and theoretically efficient nonparametric regression techniques based on advanced Gaussian process models, with motivating applications in causal inference and big data genomics. Includes several illustrative examples with R codes. Basic coverage of asymptotic theory and MCMC and greedy algorithms. Prerequisite: Statistics 531, 532, 523L. Instructor: Staff. 3 units.

642. Time Series and Dynamic Models. Statistical models for modeling, monitoring, assessing and forecasting time series. Univariate and multivariate dynamic models; state space modeling approaches; Bayesian inference and prediction; computational methods for fast data analysis, learning and prediction; time series decomposition; dynamic model and time series structure assessment. Routine use of statistical software for time series applications. Applied studies motivated by problems and time series data from a range of applied fields including economics, finance, neuroscience, climatology, social networks, and others. Instructor consent required. Prerequisite: Statistics 531, 532, 523L. Instructor: Staff. 3 units.

643. Modern Design of Experiments. Classical and Bayesian design notions and techniques—experimental units, randomization, treatments, blocking and restrictions to randomization, and utility of designs. Optimal sample size determination for estimation and testing. Factorial and fractional factorial designs, response surface methods, conjoint designs, sequential designs and bandit problems used in on-line advertising. Design and modeling of complex computer experiments. Designs for multiple objectives. Computational algorithms for finding optimal designs. Prerequisite: Statistics 531, 532, 523L. Instructor: Staff. 3 units.

644L. Statistical Modeling of Spatial and Time Series Data. Introduction to Bayesian modeling for data with spatial and/or time dependence. Exploratory analysis of spatial (point referenced and areal) and time series data. Gaussian processes and generalizations. Extending hierarchical Bayesian linear models and generalized linear models. Spatial models: CAR, SAR, kriging and time series models: ARM, ARMA, dynamic linear models. Computational methods for model fitting and diagnostics. Prerequisite: Statistical Science 360 or 601/602L or equivalent. Instructor: Staff. 3 units.

650L. Theory and Methods for the Analysis of Social Networks. Introduction to basic principles of analyzing relational data. Consider deterministic and probabilistic specifications of networks and graphs, studying structural blockmodels, the Erdos-Renyi model, the exponential random graph model, the stochastic blockmodel, generalizations to latent space models and to more complex relational data. Development of these models and practical understanding of how to fit them. There is no book, lectures will be supplemented with discussions of relevant papers. Prerequisite: Statistical Science 601 or 602L. Corequisite: Statistical Science 532 or 732. Instructor: Staff. 3 units.

663L. Statistical Computing and Computation. Statistical modeling and machine learning involving large data sets and challenging computation. Data pipelines and data bases, big data tools, sequential algorithms and subsampling methods for massive data sets, efficient programming for multi-core and cluster machines, including topics drawn from GPU programming, cloud computing, Map/Reduce and general tools of distributed computing environments. Intense use of statistical and data manipulation software will be required. Data from areas such as astronomy, genomics, finance, social media, networks, neuroscience. Instructor consent required. Prerequisite: Statistics 521L, 523L; Statistics 531, 532 (or co-registration). Instructor: Staff. 3 units.

665. Statistical Programming for Big Data. This course will extend the foundation laid in software tools for data science to allow for efficient computing involving very large data sets. This course will explore the use appropriate algorithms and data structures for intensive computations, improving computational performance by use of native code compilation, use of parallel computing to accelerate intensive computations, use appropriate algorithms and data structures for massive data set, and use of distributed computing to process massive data sets. Prerequisite: Biostatistics 821 or permission of the director of graduate studies. Instructor: Staff. 2 units.

671D. Theory and Algorithms for Machine Learning. 3 units. C-L: see Computer Science 671D; also C-L: Electrical and Computer Engineering 687D

690. Special Topics in Statistics. Prerequisite: Statistical Science 611 or consent of instructor. Pass/Fail grading only. Instructor: Staff. 3 units.

690-40. Topics in Probability Theory. 3 units. C-L: see Mathematics 690-40

693. Research Independent Study. Directed reading and research for master's students. Consent of instructor and director of master's program required. Instructor: Staff. 3 units.

701S. Readings in Statistical Science. Advanced seminar on topics at research frontiers in statistical sciences. Consent of instructor required. Instructor: Staff. 1 unit.

711. Probability and Measure Theory. Introduction to probability spaces, the theory of measure and integration, random variables, and limit theorems. Distribution functions, densities, and characteristic functions; convergence of random variables and of their distributions; uniform integrability and the Lebesgue convergence theorems. Weak and strong laws of large numbers, central limit theorem. Prerequisite: elementary real analysis and elementary probability theory. Instructor: Staff. 3 units.

715. Stochastic Models. 3 units. C-L: see Business Administration 915; also C-L: Mathematics 742

721L. Linear Models. Multiple linear regression and model building. Exploratory data analysis techniques, variable transformations and selection, parameter estimation and interpretation, prediction, Bayesian hierarchical models, Bayes factors and intrinsic Bayes factors for linear models, and Bayesian model averaging. The concepts of linear models from Bayesian and classical viewpoints. Topics in Markov chain Monte Carlo simulation introduced as required. Prerequisite: Statistical Science 611 and 601 or equivalent. Instructor: Staff. 3 units. C-L: Mathematics 743L

723. Case Studies in Bayesian Statistics. Advanced Bayesian statistical modelling from an applied perspective; problems and data from a range of application areas; focus on statistical thought and practice with in-depth examination of applications; statistical topics drawn from multilevel modelling, randomization and experimental design, causal inference, meta analysis, item response models, models for categorical data, time series, model assessment and criticism, scientific communication. Instructor consent. Instructor: Staff. 3 units.

732. Statistical Inference. Classical, likelihood, and Bayesian approaches to statistical inference. Foundations of point and interval estimation, and properties of estimators (bias, consistency, efficiency, sufficiency, robustness). Testing: Type I and II errors, power, likelihood ratios; Bayes factors, posterior probabilities of hypotheses. The predictivist perspective. Applications include estimation and testing in normal models; model choice and criticism. Prerequisite: Statistical Science 611 and 831 or consent of instructor. Instructor: Staff. 3 units.

741. Compressed Sensing and Related Topics. Introduction to the basic compressed sensing problems and methodologies, including the recovery of sparse vectors and low-rank matrices using methods based on convex optimization and approximate message passing. Unified theoretical framework for the analysis of certain CS problems, drawing upon ideas from statistical decision theory, high-dimensional convex geometry, information theory, convex optimization, message passing and variational inference with graphical models, and the replica method from statistical physics. Instructor: Staff. 3 units. C-L: Electrical and Computer Engineering 741

771S. Teaching Statistics: Instruction, Pedagogy, and Curriculum Development. This course is designed to help students become better teachers and communicators of statistics, learn about and discuss pedagogy, gain experience with practice teaching, and improve via individual feedback. Course will be divided into three parts: Being a TA: office hours, computing labs, and grading; developing and leading a class: writing a syllabus, lecturing, active learning, integrating technology; preparing students for the next stage: writing teaching statements and giving talks. The course will be based primarily on discussion, practice teaching, and feedback. Counts as one of the two pedagogy courses required for The Graduate School's certificate in college teaching. Instructor: Staff. 1 unit.

790. Special Topics in Statistics. Prerequisite: Statistical Science 611 or consent of instructor. Pass/Fail grading only. Instructor: Staff. 3 units.

790-1. Special Topics in Statistics. Instructor: Staff. 1 unit.

831. Probability and Statistical Models. Theory, modeling, and computational topics in probability and statistics: distribution theory and modeling, simulation and applied probability models in statistics, generation of random variables. Monte Carlo method and integration; Markov Chain Monte Carlo methods; applied stochastic processes including Markov process theory, linear systems theory, and AR models. Latent variable probability models, i.e., mixture models, hidden Markov models, and missing data problems. Discrete and continuous multivariate distributions; linear, multinormal, and graphical models; tools of linear algebra and probability calculus. Statistical computing using Matlab/R. Prerequisite: Statistical Science 601 and 721. Recommended prerequisite: Statistical Science 732. Instructor: Staff. 3 units.

832. Multivariate Statistical Analysis. Classical and modern statistical methods for the analysis of multivariate data. Topics include: exploratory data analysis via matrix and tensor factorizations, linear and multilinear models for vector, matrix and tensor-valued data, group invariance approaches to estimation and testing, copula models for non-Gaussian data, and high-dimensional multivariate regression and covariance estimation. Prerequisite: Statistical Science 732. Instructor: Staff. 3 units.

841. Models and Methods for Categorical Data. This course covers statistical methods for analyzing categorical data. Model and theory includes: generalized linear models, including models for binary data, polytomous data (ordered and unordered), counts, contingency tables, matrix and graphical data. Classical and Bayesian inference in these models involves: latent variable representations, conditional likelihood, profile likelihood, and iterative algorithms. More advanced methods include: analysis of repeated measurements, data with cluster structure, nonparametric analysis, adaptive testing in contingency tables, multiple testing and data analysis in high-dimensions. Prerequisite: Statistical Science 521L or 721 and Statistical Science 532 or 732, or consent of instructor. Instructor: Staff. 3 units.

851. Statistical Consulting Workshop. Students address and develop solution approaches to diverse ranges of statistical consulting problems in collaboration with faculty and researchers from many different fields. Students meet weekly to discuss projects, consult with faculty and disciplinary investigators, present their progress reports and eventual solutions, and work collaboratively in a vertically-integrated educational context. May be taken more than once. Consent of instructor required. Instructor: Staff. 3 units.

863. Advanced Statistical Computing. Advanced numerical methods and algorithms for statistical computing, emphasizing

techniques relevant to modern Bayesian statistical research. Topics drawn from: numerical linear algebra, optimization, advanced Monte Carlo simulation and integration, approximate Bayesian computation, variational methods, belief propagation, distributed computing, and other areas of current research. Prerequisite: Statistical Science 831, 832. Instructor: Staff. 3 units.

941. Bayesian Nonparametric Models and Methods. Modern nonparametric approaches to statistical analysis. Infinite dimensional Bayesian models: data analysis, inference and prediction. Models of curves, surfaces, probability distributions, partitions and latent feature spaces; nonparametric density estimation, regression and classification; hierarchical, multivariate and functional data analysis models; theory of estimation in function spaces. Methodology of probabilistic process models: Dirichlet, Gaussian, basis/kernel expansion, splines, wavelets, support vector machines and other local regression models. Interfaces of Bayesian:non-Bayesian methods and additional methodological topics. Prerequisite: Statistical Science 732 and 831. Instructor: Staff. 3 units.

942. Time Series and Forecasting. Advanced topics in time series modelling and forecasting in a reading/seminar-style format. Topics include dynamic state-space models and their applications, Bayesian learning and forecasting, statistical model developments motivated by forecasting applications in many fields, and advanced topics interfacing with current research frontiers. Instructor consent required. Prerequisite: Statistical Science 732 and 831. Recommended prerequisite: Statistical Science 642. Instructor: Staff. 1 unit.

944. Spatial Statistics. Modeling data with spatial structure; point-referenced (geo-statistical)data, areal (lattice) data, and point process data; stationarity, valid covariance functions; Gaussian processes and generalizations; kriging; Markov random fields (CAR and SAR); hierarchical modeling for spatial data; misalignment; multivariate spatial data, space/time data specification. Theory and application. Some assignments will involve computing and data analysis. Consent of instructor required. Instructor: Staff. 3 units.

961. Stochastic Processes. Conditional probabilities and Radon-Nikodym derivatives of measures; tightness and weak convergence of probability measures, measurability and observability. Markov chains, Brownian motion, Poisson processes. Gaussian processes, birth-and-death processes, and an introduction to continuous-time martingales. Prerequisite: Statistical Science 711 and 732. Instructor: Staff. 3 units.

993. Independent Study. Directed reading and research. Consent of instructor and director of graduate studies required. Instructor: Staff. Variable credit.

994. Independent Study. Directed reading and research. Consent of instructor and director of graduate studies required. Instructor: Staff. Variable credit.

995. Internship. Students gain practical experience in statistical applications by taking a summer internship in industry or government. Requires prior consent from the student's advisor and the director of graduate studies. A final report acceptable to the advisor outlining work activity, statistical aspects of the internship, and possible follow-up projects is required. May be repeated with consent of the advisor and the director of graduate studies. Instructor: Staff. 1 unit.

Structural Biology and Biophysics

Professor Oas, *Director* (Biochemistry); twenty-nine participating faculty members in seven departments

The Structural Biology and Biophysics Program is not currently accepting new students.

A certificate and a PhD are available in this program.

The Structural Biology and Biophysics Program brings together an interdisciplinary group of chemists, biochemists, physicists, computational biologists, cell biologists, biomaterials scientists and biomedical engineers to interact and discuss problems of common interest. These include physical and computational studies of biological macromolecules and their interactions, where the details of molecular structure are critical to understanding the biological problem in question. The focus is on understanding molecular structure/function at atomic resolution; the breadth extends to detecting molecular events and describing structural relationships in a chemically meaningful way, and relating atomic-level with higher-order structures. There is a commonality in the intellectual approaches and experimental techniques. Research problems addressed within the University Program in Structural Biology and Biophysics include: 3-D structure determination by crystallography and NMR; molecular assemblies studied by various diffraction, spectroscopy, and microscopy techniques; protein folding; molecular modeling and design studies and their direct experimental testing; and functional studies in biochemistry, genetic mechanisms, drug interactions, membrane systems, and so on, for which the details of molecular geometry are central to interpreting the experiments.

Participating students may receive a certificate from the Structural Biology and Biophysics Program in addition to the doctoral degree from their home department. Requirements for the certificate ordinarily will include the core courses, lab rotations with structural biology and biophysics faculty, presenting and attending seminars, and an appropriate thesis topic and committee. However, the curriculum can be tailored for students with special interests and backgrounds.

Certificate Requirements

- Complete a certificate form from SBB and have it signed by the director of graduate studies. Submit to the department early in the semester.
- Required courses in SBB curriculum:
  - Structural Biochemistry
  - Structural Biology and Biophysics 681 (Physical Biochemistry)
  - Biochemistry 695 (Structural Methods)
  - Structural Biology and Biophysics 622 (Structure of Biological Macromolecules)
  - Structural Biology and Biophysics 546S (Structural Biology & Biophysics Seminar)
- Lab rotations with structural biology and biophysics faculty.
- Presenting and attending weekly seminar series.
- An appropriate thesis topic, and have one program faculty member on their thesis committee.

For further information about the Structural Biology and Biophysics Program, visit http://sbb.duke.edu/.

Courses in Structural Biology and Biophysics (SBB)

546S. Structural Biology and Biophysics Seminar. Weekly seminars are presented by program students, beyond their first year, faculty members, or guest speakers. (Required of all SBB Students.) Instructor: Oas. 1 unit.

622. Structure of Biological Macromolecules. 3 units. C-L: see Biochemistry 622; also C-L: Computational Biology and Bioinformatics 622

658. Structural Biochemistry I. 2 units. C-L: see Biochemistry 658; also C-L: Cell and Molecular Biology 658, Cell Biology 658, University Program in Genetics 658, Computational Biology and Bioinformatics 658

659. Structural Biochemistry II. 2 units. C-L: see Biochemistry 659; also C-L: Cell Biology 659, Computational Biology and Bioinformatics 659, University Program in Genetics 659

682T. Advanced Physical Biochemistry. Transient kinetics, computational methods, multidimensional NMR, x-ray crystallography, thermodynamics of association. Prerequisite: Structural Biology and Biophysics or consent of instructor. Instructor: Oas. 3 units.

Other Graduate Level Courses

Following are other graduate level courses that are not part of a specific graduate department or program but nonetheless available for graduate students.

Arts & Sciences IDEAS Themes and University Courses

Arts & Sciences Themes and University Courses (ARTS&SCI)

790. University Course (Special Topics). Interdisciplinary course on topics of social relevance, sponsored by the Dean of Arts & Sciences. Course is paired with ARTS&SCI 390. Graduate students attend class together with undergraduates, but require sponsorship by a faculty member in their home department or school to assign additional graduate level work, evaluate their papers, and assign a grade. Topics vary each year. (Note: as an alternative, graduate students may choose to register for this course directly with their faculty sponsor as an Independent Study.) Instructor: Patton. 3 units.

795. Bass Connections: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing social issues. Teams may also include postdoctoral fellows, visiting fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires substantive final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 3 units.

795-1. Bass Connections: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing social issues. Teams may also include postdoctoral fellows, visiting fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 1.5 units.

796. Bass Connections: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing social issues. Teams may also include postdoctoral fellows, visiting fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires substantive final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 3 units.

796-1. Bass Connections: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing sociFasianal issues. Teams may also include postdoctoral fellows, visiting fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 1.5 units.

Biomedical Research Training

Biomedical Research Training Courses (BIOTRAIN)

720. Grant Writing for Biomedical Scientists. Introduction to scientific grant writing for second- (or third-) year PhD students. This course contains lecture-based and active learning sessions. Content includes lectures combined with class discussions on grant agencies, format and structure of grant applications, concepts in peer review, best practices in articulating study design and data outcomes, rigor and reproducibility in a research plan, and crafting biological significance and training statements. Students write an NIH-style proposal and actively participate in topical study sections to receive oral and written critiques of their proposals and

to provide constructive feedback of others' proposals. Open only to second- or third-year students in biomedical PhD programs. Instructor: Sullivan and staff. 3 units.

750. Introduction to Responsible Conduct of Research Concepts. Responsible Conduct of Research (RCR) and Rigor and Reproducibility (R&R) training is essential to graduate biomedical research training. In this combined Orientation and RCR course, students will be introduced to fundamental concepts in RCR and learn about resources to enhance their training experience. Topics include: expectations of a graduate student; concepts in professionalism; best practices in mentoring; self-awareness and wellness; history of ethics and inherent bias; reporting professional misconduct; and diversity, inclusion, and cultural awareness. This one day on-site course offered at the start of fall semester is required for all entering first-year biomedical PhD students. Open only to first-year students in biomedical PhD programs. Instructor: Sullivan. 1 unit.

753. Data Management and Quality for Biomedical PhD Students. Data Management and Quality for Biomedical PhD Students is offered via Duke LMS (Learning Management System). In Years 2 and 3, PhD students in the School of Medicine are required to take this course comprised of 3 online interactive modules. Each module is accompanied by an assessment. This course is presented with interactive graphics, text-based activities, short videos, and discipline specific scenarios. Data Management and Quality for Biomedical PhD Students includes 3 modules: 1) Research Quality and Reproducibility; 2) Data Management; 3) Data and Resource Sharing. This course is required for all biomedical PhD students in year 2 or 3.. 0 units.

755. The Responsible Scientist Teaching Assistant. School of Medicine PhD students in Years 4+ may earn Responsible Conduct of Research (RCR) credit replacing one of two required RCR Forums by serving as teaching assistants in BIOTRAIN 751: The Responsible Scientist I. Participation includes distribution of questions/case studies prior to small group meetings and facilitating discussions with the faculty small group leader. Instructor: Staff. 0 units.

Brain & Society

Brain & Society (BRAINSOC)

795T. Bass Connections in Brain & Society Research Team. Tutorial course for Bass Connections yearlong project team. Topics vary by semester and section. Teams of graduate and undergraduate students work with faculty to build connections between neuroscience and socially challenging questions in healthcare, the humanities, policy, economics, ethics and law. Teams may include external partners. Work may run in parallel with or contribute to ongoing faculty-led research. Teams participate in seminars, data collection and analysis, lab work, field work, and other relevant learning or research experiences. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 4 units.

796T. Bass Connections in Brain & Society Research Team. Tutorial course for Bass Connections yearlong project team. Topics vary by semester and section. Teams of graduate and undergraduate students work with faculty to build connections between neuroscience and socially challenging questions in healthcare, the humanities, policy, economics, ethics and law. Teams may include external partners. Work may run in parallel with or contribute to ongoing faculty-led research. Teams participate in seminars, data collection and analysis, lab work, field work, and other relevant learning or research experiences. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 4 units.

Documentary Studies

Courses in Documentary Studies (DOCST)

511. Documentary and East Asian Cultures. 3 units. C-L: see Asian & Middle Eastern Studies 511; also C-L: International Comparative Studies 513

540S. Memory and Documentary Cinema in Latin America. 3 units. C-L: see Romance Studies 540S; also C-L: Visual and Media Studies 540S, Literature 544S, Latin American Studies 540S

590. Special Topics in Documentary Studies. Selected topics in methodology, theory, or area in lecture format. Instructor: Staff. 3 units.

590S. Special Topics in Documentary Studies. Selected topics in methodology, theory, or area in seminar format. Open only to graduate students in the MFAEDA program. Instructor: Staff. 3 units.

620S. Film-philosophers/Film-makers. 3 units. C-L: see Literature 620S; also C-L: Visual and Media Studies 622S, Theater Studies 620S, English 620S

630. Projections in Time: The Still and Moving Image. 3 units. C-L: see Visual and Media Studies 629

640S. Expanded Cinema: Cinema Outside the Movie Theater. 3 units. C-L: see Visual and Media Studies 640S; also C-L: Literature 545S

705S. The Documentary Experience: A Video Approach (A). A documentary approach to the study of local communities through video production projects assigned by the course instructor. Working closely with these groups, students explore issues or topics of concern to the community. Students complete an edited video as their final project. Not open to students who have taken this course as Film/Video/Digital 105S. Open only to graduate students in the MFAEDA program. Consent of instructor required. Instructor: Hawkins. 3 units.

706S. Medicine and the Vision of Documentary Photography. The intersection of documentary photography and the medical community. Open only to graduate students in the MFAEDA program. Consent of instructor required. Instructor: Moses. 3 units.

710S. The Short Audio Documentary. Introductory to intermediate public radio-style audio documentary production. Includes instructor-supervised fieldwork with an audio recorder in a variety of settings using creative approaches; students produce four short

pieces (3-4 minutes long) in varying styles (journalistic, narrative, artistic) for posting on class site and public websites. Open only to graduate students in the MFAEDA program. Instructor: Biewen. 3 units.

711S. Documentary Writing Workshop. Workshop in the art and practice of writing in the long-form traditions of narrative nonfiction, literary journalism, and documentary writing. Write, share, and refine one major work of narrative nonfiction throughout the semester. Discuss research methods and resources, especially those useful for creative writers. Intended for advanced writers who would like to work on ambitious nonfiction work in an intensely creative and supportive workshop. Open only to graduate students in the MFAEDA program. Instructor: Murrell. 3 units.

714S. Introduction to Black and White Photography. Foundation class in photography utilizing black and white film and a wet darkroom. Shoot, process, and print individual student work throughout the semester. Emphasis on continual visual exploration of meaning and metaphor in the form of regular assignments, slide lectures of important historic and contemporary photographic work, and critiques of each others work. No textbooks are required, though students will need to budget a comparable amount for supplies and equipment. Open only to graduate students in the MFAEDA program. Instructor: Sharp. 3 units.

715S. Environmental Issues & the Documentary Arts. Survey how filmmakers, authors, photographers, and other artists have brought environmental issues to the public's attention in the last century, and in some cases instigated profound societal and political change. Examine the nebulous distinctions between persuasion and propaganda, agenda and allegory, point of view and content. Evolve as a viewer of the environment and a maker of documentary art. Initiate your own projects to address and/or depict environmental issues in one form of a broad range of media. Open only to graduate students in the MFAEDA program. Instructor: Espelie. 3 units.

716S. Activating the Archive: Archival Research as Documentary Practice. Introduce students to methods of archival research and investigate its use as a tool for activism within documentary practice. Using Duke's Rubenstein Rare Book & Manuscript library students will gain practical experience to effectively locate, retrieve, handle, document and analyze primary source materials. This knowledge will be applied to produce original written and multimedia documentary projects that rethink notions of history, identity, memory, and loss. Explores individual and open source archives, as well as works by contemporary artists and documentarians who mediate archival materials and structures. Emphasis on the archive as a site of discovery and construction. Open only to graduate students in the MFAEDA program. Instructor: McCarty. 3 units.

717S. Documentary Photography and the Southern Culture Landscape. Emphasis on the tradition and practice of documentary photography as a way of seeing and interpreting cultural life. The techniques of color and black-and-white photography—exposure, development, and printing—diverse ways of representing the cultural landscape of the region through photographic imagery. The role issues such as objectivity, clarity, politics, memory, autobiography, and local culture play in the making and dissemination of photographs. Open only to graduate students in the MFAEDA program. Instructor: Rankin. 3 units.

720S. Documenting Black Power: Writing the History of the African American Freedom Struggle. Documentary writing course exploring the African American Freedom Struggle in the United States from the Civil War era to the present. Focus on the American South and black social movements from World War II until 1980. Students engage wide ranging archival material including documentary research, traditional historiography, interviews, memoirs, fiction, poetry, music and film. Students write weekly essays and a final documentary history project on a topic of their choosing. Open only to graduate students in the MFAEDA program. Instructor: Tyson. 3 units.

724S. Children's Self Expression: Literacy Through Photography. Children's self-expression and education through writing, photograph and documentary work. Focus on reading and critical interpretation of images. The history, philosophy, and methodology of Literacy Through Photography. Includes internship in an elementary or middle school classroom. Required participation in service learning. Open only to graduate students in the MFAEDA program. Consent of instructor required. Instructor: Hyde. 3 units.

726. The South in Black and White. Focus on present-day and historical documentary traditions in American South, with an emphasis on call and response between black and white cultures. The arts and humanities as embedded in particular histories and cultures found in the South, and as performed in music and theater; and portrayed in documentary films, civil rights photography, Southern literature, and historical and autobiographical writing. Includes historical texts, oral histories and testimonies of living persons, along with documentary films, photographs, and writings from people in Durham and elsewhere in the region. Instructor: Tyson. 3 units.

726S. The South in Black and White. Seminar with focus on present-day and historical documentary traditions in American South, with an emphasis on call and response between black and white cultures. The arts and humanities as embedded in particular histories and cultures found in the South, and as performed in music and theater; and portrayed in documentary films, civil rights photography, Southern literature, and historical and autobiographical writing. Includes historical texts, oral histories and testimonies of living persons, along with documentary films, photographs, and writings from people in Durham and elsewhere in the region. Instructor: Tyson. 3 units.

735S. Introduction to Audio Documentary. Recording techniques and audio mixing on digital editing software for the production of audio (radio) documentaries. Various approaches to audio documentary work, from the journalistic to the personal; use of fieldwork to explore cultural differences. Stories told through audio, using National Public Radio-style form, focusing on a particular social concern such as war and peace, death and dying, civil rights. Open only to graduate students in the MFAEDA program. Instructor: Biewen. 3 units.

736S. Color Photography: Fieldwork and Digital Color. Field-based course examining color photography as a documentary tool. Students learn about aesthetic and technical foundations of color photography using recent digital technology. Class-conducted intensive examination of the work of historic and contemporary color documentary photographers. Advanced techniques in film scanning, Photoshop, and color pigment printing using Arts Warehouse multimedia classroom. Completion of semester-long color photographic project, and final project consisting of production of a series of color pigment prints. Open only to graduate students in the MFAEDA program. Consent of instructor required. Instructor: Harris. 3 units.

741S. Politics of Food: Land, Labor, Health, and Economics. Explores the food system through fieldwork, study, and guest

lectures that include farmers, nutritionists, sustainable agriculture advocates, rural organizers, and farmworker activists. Examines how food is produced, seeks to identify and understand its workers and working conditions in fields and factories, and, using documentary research conducted in the field and other means, unpacks the major current issues in the food justice arena globally and locally. Fieldwork required, but no advanced technological experience necessary. At least one group field trip, perhaps to a local farm or farmers market, required. Open only to graduate students in the MFAEDA program. Instructor: Thompson. 3 units.

744S. Our Culinary Cultures. Documentary approach to the world of food using fieldwork research. Topics of food and its preparation examined through deep stories of how food is raised, prepared, and presented in order to explore how the myriad ways in which what we eat reveal key biographical, economic, religious, and other truths about our cultures. Introduces students to the history of food writing and the concept of food in general as a nonverbal tool of communication. Photography, audio, and documentary writing employed. Open only to graduate students in the MFAEDA program. Instructor: Alexander. 3 units.

745S. Photography in Context. Uses the Duke Library Photography Archive as a resource to challenge students to think critically about photography. Considers how photography offers insights into areas of academic study such as social change, sexual identity, and regional culture, and how images have shaped collective understanding of these issues. Focuses on analyzing and contextualizing bodies of photographic work, the historical moment in which the pictures were made, personal history and artistic sensibility of the photographer, tools of the medium, along with considering personal responses to images and the ways in which all factors come together. Open only to graduate students in the MFAEDA program. Instructor: Sartor. 3 units.

747S. Visual Culture of Black Appalachia: Race, Place and Resilience. Introduces culture and history of African American communities in Appalachia. Visual culture and artistic media produced by Appalachians of African descent are used as nodal points through which to explore economic, political, and social forces that have shaped African American communities in Appalachia, and also engaged as forms of creative expression responding to these same forces. As a final project for this course, students contribute to an ongoing, collaborative research project, titled "Mapping Affrilachia," which aims to locate and archive institutions and other sites of African American cultural production in Appalachia and to give voice to black Appalachian artists and communities. Instructor: Cochran. 3 units. C-L: African & African American Studies 747S, Art History 747S

750S. Documentary Engagement Through Field-Based Projects. Documentary photography as a tool for social engagement in preparation for intensive field-based projects. Students study documentary photographers while planning and refining their own documentary projects through which they will address societal issues locally, nationally, or abroad. Students learn and refine valuable technical skills such as Photoshop, inkjet printing, and web-based methods in order to complete a preliminary documentary project by the end of the semester. Open only to graduate students in the MFAEDA program. Consent of instructor required. Required participation in service learning. Instructor: Harris. 3 units.

751S. Documenting Black Experiences. Interpretations of the black diaspora in documentary film from slavery to the present. Interdisciplinary study of black religions, cultures, histories, aesthetics, politics, and their representations, both globally and in the US. Students will view and study a variety of films and approaches to film and study film's evolution through numerous lenses from early ethnographic film to recent works by indigenous filmmakers, and understand the politics of representation, from D. W. Griffith to Spike Lee; read relevant works in the genres represented; and hear from guest critics, scholars of African and African American history and culture, and filmmakers. Open only to graduate students in the MFAEDA program. Instructor: Tyson. 3 units.

752S. Documentary Publishing from Gutenberg to the Web: History and Practice. Publishing course leading to publication of Vanishing Point Magazine (http://vanishingpointmag.com); grounded in cultural, technical, and aesthetic history of documentary periodicals, from 16th century Venetian avvisi through 18th century English gentlemen's magazines through mid-20th century "Golden Age" of American magazines, to current age of digital documentary publication; speakers and advisors from publishing industry; wide readings in international history of periodicals and documentarism; production of Vanishing Point as conceived, created, edited, designed and built by students in accordance with professional standards and practices. Open only to graduate students in the MFAEDA program. Instructor: Murrell. 3 units.

754S. Web Design and Narrative: Artists, Documentarians, Art Historians, and Entrepreneurs. Professional practices course for students in creative fields without a computer science background: for artists and documentarians to create robust web-based portfolios; for art historians to showcase curatorial and scholarly projects; for entrepreneurs to demonstrate ideas, concepts, and products to the public. Develop customized, individual websites using CMS platforms. Hone and workshop artistic/curatorial/product statements. Develop teaching philosophies, exhibition imagery, and video documentation of artistic, curatorial, or product talks. Publish a blog magazine on arts and innovation topics. Guest speakers visit the course on a regular basis to review the students' work. Open only to graduate students in the MFAEDA program. Instructor: Sims. 3 units.

757S. Editing for Film and Video. 3 units. C-L: see Visual and Media Studies 757S; also C-L: Information Science + Studies 757S

760S. Multimedia Documentary: Editing, Production, and Publication. Edit and shape fieldwork material into a Web-based multimedia presentation. Learn current technologies and techniques for multimedia publications. Examine unique storytelling strategies for on-line presentations and compare this medium to traditional venues for documentary work such as exhibitions, books, and broadcast. Open only to graduate students in the MFAEDA program. Instructor consent required. Instructor: Sims. 3 units.

761S. Photographic Memory: Photo Albums, Photobooks, & Zines. Examine the history and uses of photo albums, zines, and self-published photobooks as a means to memorialize and document underrepresented communities, cultural movements, customs, and personal experiences. View, handle, and analyze examples of all three formats from material in Rubenstein Rare Book & Manuscript library. Produce photo album, zine, and photo book using photographs and ephemera from personal archives. The interplay of text and image, methods for sequential storytelling, basic layout and design techniques, as well as methods for production distribution. Emphasis on photographic books as an accessible and democratic storytelling medium. Open only to graduate students in the MFAEDA program. Instructor: McCarty. 3 units.

765S. The Documentary Turn: Southern Culture. In the 20th century, oral history, photography, film and ethnographies

brought into existence narratives that would never otherwise have existed. Documentary as a discipline was central to bearing witness. "The Documentary Turn: Southern Cultures" offers an ongoing conversation focused on the proposition of the "documentary turn" in the 21st century. Information flows and new technologies have changed the documentary enterprise in fundamental ways that open new possibilities and challenge continuing conventions. The rise of digital platforms, crowd sourced communications, and viral information test the very nature of what documentary practices entail. Open only to graduate students in the MFAEDA program. Instructor: Hogan. 3 units.

766S. Human Rights and Documentary: Aesthetics, Ethics, History. Course examines how artists, filmmakers, and journalists have used images to address complex human rights challenges in past and present. Engaged complex ethical and legal questions that arise when documenting human rights issues, e.g., rights of people photographed, written about, or filmed, vs rights of photographers, writers, filmmakers. Learn historical and contemporary strategies for image makers to improve the society in which they live. Learn methods (visual, audio, writing) to document non-traditional political actors work in human rights fields. Apply knowledge and skills developed to address key issues in human rights policy in a thoughtful, clear way orally, visually, and written. Open only to graduate students in the MFAEDA program. Instructor: Hogan. 3 units.

768S. The View Camera: Black and White Large Format Photography. Advanced, production-based photography course introduces students to the 4 x 5 large format view camera and its role in the documentary tradition. Learn to operate a view camera and attendant processes and materials to develop black and white sheet film and make silver gelatin contact prints from 4 x 5 negatives. Begins with focus on black and white negatives and contact prints. After demonstration of proficiency, students may optionally work in color film. Students produce a final portfolio of prints from their work throughout the semester. Class meetings consist of lectures, demonstrations, darkroom work, and critique of both process and final images. Instructor: Rankin. 3 units.

775S. The Documentary Essay: Exploration, Research, and the Peripatetic Tradition in Documentary Writing. Writing workshop course exploring the intersection of documentary fieldwork methods and the exploratory traditions and practices of the essay. Grounded in the recognition that the documentary essay engages the world first, seeking knowledge and understanding, gathers the material of art by direct experience. Out-of-class exploration emphasized through careful exploration of the special collections of Duke University; and by pursuing a common subject as a class. Wide readings in documentary essays, workshop discussion of student work, and the eventual goal of publication in the new CDS student documentary magazine. This is a graduate level pairing with 112S. Open only to graduate students in the MFAEDA program. Instructor: Murrell. 3 units.

779S. Docu-Poetry: Real Life Truths Outside and Inside the Poetic Narrative. Investigates written and oral poetry as a mode of documentary storytelling. Engage with contemporary and historical poetry examining real-life, historical events. Investigate relationship between history, documentary, and poetry. Write poems based on research with multiple forms of archival source material and critical interpretation thereof. Open only to graduate students in the MFAEDA program. Instructor: Green. 3 units.

790S. Advanced Special Topics in Documentary Studies. Advanced selected topics in methodology, theory, or area in seminar format. Open only to graduate students in the MFAEDA program. Instructor: Staff. 3 units.

791. Independent Study in Documentary Studies. Supervision and guidance of individual topics at the graduate level. Consent of Director of the Center for Documentary Studies required. 3 units.

850S. Deleuze: Cinema and Philosophy. 3 units. C-L: see Literature 850S; also C-L: Visual and Media Studies 850S, English 860S, Romance Studies 850S, Visual Arts 850S, Computational Media, Arts & Cultures 85

Education

Courses in Education (EDUC)

514. Technology, Society, and Schools. Role of technology in schools and society. Introduction for preservice teacher candidates to technology tools including Photoshop, web design, and digital storytelling. Emphasis on integrating technology into instruction and utilizing technology to become educational leaders. Includes elements of design through completion of online portfolio. Designed to meet the North Carolina Department of Public Instruction technology requirements for teaching licensure. Consent of instructor required. Instructor: Staff. 2 units.

518S. Approaches and Practices in Second Language Pedagogy. 3 units. C-L: see Asian & Middle Eastern Studies 518S; also C-L: Linguistics 518S

525. Global Engagement and Career Development through Service-Learning. In this half-credit course students will examine the research literature on cultural competence and engage with people of diverse cultural backgrounds through various cultural and language exchange programs offered at Duke. One goal this half-credit course is to expose students to differences in cultural norms and social systems. The readings and experiential activities are designed to enable the students to examine their own cultural lenses and assumptions and increase their intercultural competency to be true global citizens, well prepared for the increasingly globalized society and job market. Instructor consent is required. Instructor: Jeong. 2 units.

542S. Schooling and Social Stratification. 3 units. C-L: see Public Policy 542S; also C-L: African & African American Studies 549S

590. Special Topics. Selected topics in education. Instructor: Staff. 3 units.

591. Independent Study. Directed readings in a field of special interest under the supervision of a faculty member, the central goal of which is a substantive paper or project on a previously approved topic. Consent of instructor and director of graduate studies required. Instructor: Staff. 3 units.

620. Nature and Needs of the Gifted Learner: Introduction to Characteristics and Educ/Affective Needs. Introduction to characteristics and unique educational and affective needs of gifted learners. Analysis of philosophical considerations, historical perspectives, definitions and types of giftedness, incidence, and evaluation procedures. Cultural comparisons of the manifestations of

giftedness, ways of reversing underrepresentation of minority students in programs for the gifted, and affective social-emotional topics/issues relating to giftedness. This course is a post-bacc, non-degree course not open to Duke undergraduates. Consent of instructor required. Instructor: Stephens. 3 units.

622. Differentiating Curriculum for the Gifted Learner: Program Planning and Curriculum Development. Organize and deliver appropriate curriculum for gifted and talented students. Focus on program planning, exemplary program models, development of differentiated curriculum with appropriate modifications to content, process, product and learning environment. Instructor: Stephens. 3 units.

623. Practicum and Seminar in Gifted Education. Supervised practicum with gifted learners in a differentiated education program. Students plan, develop, and evaluate educational experiences, with a special emphasis on the social and emotional development of gifted learners. Instructor consent required. Instructor: Stephens. 3 units.

651. Directed Activities. Internship experiences at an advanced level under supervision of appropriate staff. Prerequisite: consent of instructor. Instructor: Staff. 3 units.

690S. Selected Topics Seminar. May be repeated. Consent of instructor required. Instructor: Staff. 3 units.

758S. Bass Connections: Digital Durham. 3 units. C-L: see Information Science + Studies 758S; also C-L: Computational Media, Arts & Cultures 758S, History 758S

791. Graduate Independent Study. Directed readings in a field of special interest under the supervision of a faculty member, the central goal of which is a substantive paper or project on a previously approved topic at the graduate level. Instructor: Staff. 1 unit.

794S. Research Synthesis and Meta-Analysis (G). Recent developments in research synthesis in the behavioral and medical sciences. Topics include: problem formulation; scientific communication; methods for locating research; problems in retrieving data from secondary sources; judging the quality of research; effect size estimation; analyzing variance in effect sizes across studies. Prerequisites: Statistics through analysis of variance. Consent of instructor required. Instructor: Cooper. 3 units. C-L: Psychology 769S

795T. Bass Connections Education & Human Development Research Team. Tutorial course for Bass Connections yearlong project team. Topics vary depending on semester and section. Teams of undergraduate and graduate students work with faculty to explore factors that contribute to positive outcomes across the human lifespan, including influences on education, health, and human flourishing. Teams may also include external partners. A team's work may run in parallel with or contribute to an ongoing research project. Teams will participate in seminars, data collection and analysis, field work, and other relevant learning experiences. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 4 units.

796T. Bass Connections Education & Human Development Research Team. Tutorial course for Bass Connections yearlong project team. Topics vary depending on semester and section. Teams of undergraduate and graduate students work with faculty to explore factors that contribute to positive outcomes across the human lifespan, including influences on education, health, and human flourishing. Teams may also include external partners. A team's work may run in parallel with or contribute to an ongoing research project. Teams will participate in seminars, data collection and analysis, field work, and other relevant learning experiences. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 4 units.

790. Special Topics in Education and Human Development. Topics vary by semester. Check individual semester offerings for additional prerequisites. Instructor permission usually an option. Instructor: Staff. 3 units.

790S. Special Topics in Education and Human Development. Topics vary by semester. Check individual semester offerings for prerequisites. Instructor consent may be required. Instructor: Staff. 3 units.

795. Bass Connections: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing social issues. Teams may also include postdoctoral fellows, visiting fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 3 units.

795-1. Bass Connections: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing social issues. Teams may also include postdoctoral fellows, visiting fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 1.5 units.

796. Bass Connections: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing social issues. Teams may also include postdoctoral fellows, visiting fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 3 units.

796-1. Bass Connections: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing social issues. Teams may also include postdoctoral fellows, visiting fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 1.5 units.

Energy

Courses in Energy (ENERGY)

5520. Resource & Environmental Economics I. 1.5 units. C-L: see Environment 520; also C-L: Economics 530, Public Policy 576

520D. Resource & Environmental Economics I. 1.5 units. C-L: see Environment 520D; also C-L: Economics 530D, Public Policy 575D

524. Water Quality Health. 3 units. C-L: see Earth and Ocean Sciences 524; also C-L: Environment 524, Global Health 534

590. Special Topics in Energy. Content to be determined each semester. May be repeated. Instructor: Staff. 3 units.

590-1. Special Topics in Energy. Topics vary by semester. Instructor: Staff. 1.5 units.

590S. Advanced Topics in Energy. Selected topics vary by semester. Instructor: Staff. 3 units.

620. Energy Finance. Exploration of energy financing and investment decisions as they relate to energy companies and energy-related projects. Key topics include discount rates, discounted cash flows, valuation approaches, option pricing, real options, energy derivatives, project finance, energy specific taxation, and risk management. Prerequisites: College-level calculus, Introductory Micro/Macroeconomics (Economics 101 Economic Principles or equivalent), and either Economics 572, Environment 782, or Engineering Management 530. 3 units.

630. Transportation and Energy. 3 units. C-L: see Environment 630

630D. Transportation and Energy. 3 units. C-L: see Environment 630D

631. Energy Technology and Impact on the Environment. 3 units. C-L: see Environment 631

631D. Energy Technology and Impact on the Environment. 3 units. C-L: see Environment 631D

635. Energy Economics and Policy. 1.5 units. C-L: see Environment 635

635D. Energy Economics and Policy. 1.5 units. C-L: see Environment 635D

638. Environmental Life Cycle Analysis & Decision. 3 units. C-L: see Environment 638

711. Energy and Environment. 3 units. C-L: see Environment 711

713A. Clean Energy Field Trip. 1 unit. C-L: see Environment 713A

715L. Understanding Energy Models and Modeling. 3 units. C-L: see Environment 715L

716L. Modeling for Energy Systems. 3 units. C-L: see Environment 716L

727. Energy Law. 3 units. C-L: see Law 327

729S. The Water-Energy Nexus. 1 unit. C-L: see Earth and Ocean Sciences 729S

790. Special Topics in Energy. Topics vary by semester. Instructor: Staff. Variable credit.

790-1. Special Topics in Energy. Topics vary by semester. Instructor: Staff. 1.5 units.

795. Connections in Energy: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing energy issues. Teams may also include postdoctoral fellows, visiting energy fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires substantive paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 3 units.

795-1. Connections in Energy: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing energy issues. Teams may also include postdoctoral fellows, visiting energy fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 1.5 units.

795A. Connections in Energy: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing energy issues. Teams may also include postdoctoral fellows, visiting energy fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires substantive paper or product containing significant analysis and interpretation. Instructor consent required. Taught in Beaufort at Duke Marine Lab. Instructor: Staff. 3 units.

795T. Bass Connections Energy & Environment Research Team. Tutorial course for Bass Connections yearlong project team. Topics vary depending on semester and section. Teams of undergraduate and graduate students work with faculty to address critical energy and environmental challenges. Teams may also include postdoctoral fellows and experts from business, government, and the nonprofit sector. A team's work may run in parallel with or contribute to an ongoing research project. Teams will participate in seminars, data collection and analysis, lab work, field work, and other learning experiences relevant to the project. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 3 units.

796. Connections in Energy: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing energy issues. Teams may also include postdoctoral

fellows, visiting energy fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires substantive paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 3 units.

796-1. Connections in Energy: Interdisciplinary Team Projects. Teams of undergraduate and graduate students work with faculty supervisors to identify, refine, explore and develop solutions to pressing energy issues. Teams may also include postdoctoral fellows, visiting energy fellows, and other experts from business, government, and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, lectures, field work and other learning experiences relevant to the project. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 1.5 units.

796T. Bass Connections Energy & Environment Research Team. Tutorial course for Bass Connections yearlong project team. Topics vary depending on semester and section. Teams of undergraduate and graduate students work with faculty to address critical energy and environmental challenges. Teams may also include postdoctoral fellows and experts from business, government, and the nonprofit sector. A team's work may run in parallel with or contribute to an ongoing research project. Teams will participate in seminars, data collection and analysis, lab work, field work, and other learning experiences relevant to the project. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 3 units.

811. Business and Environment. 3 units. C-L: see Environment 811

811D. Business and Environment. 3 units. C-L: see Environment 811D

830. Building Energy on Campus: Evaluating Efficiency and Conservation Measures at Duke. 3 units. C-L: see Environment 830

835. Environmental Law. 3 units. C-L: see Environment 835

891. Topics in Environmental Regulation. 1.5 units. C-L: see Environment 891

910. Environment and Energy Economics. 3 units. C-L: see Public Policy 910

Energy Engineering

Course in Energy Engineering (ENRGYEGR)

531. Power Electronic Circuits for Energy Conversion. 3 units. C-L: see Electrical and Computer Engineering 531

Ethics

Courses in Ethics (ETHICS)

510S. Adversarial Ethics. 3 units. C-L: see Philosophy 510S; also C-L: Political Science 585S

555S. The Politics of Market Competition in a Global Economy. 3 units. C-L: see Political Science 555S; also C-L: Public Policy 555S

560S. Organized Compassion: History and Ethics of Humanitarianism. Explores philosophical and theological conceptions of compassion, and the history and ethics of the ways in which compassion for distant strangers has been organized into humanitarian institutions, from 19th-century anti-slavery movements to the International Committee of the Red Cross to the current international humanitarian order of UN agencies and countless NGOs like Médecins Sans Frontières, Save the Children, Oxfam, Care, Catholic Relief Services, and so on. Drawing on history, it will introduce students to the current landscape of humanitarian organizations and, through case studies, to the ethical quandaries the institutions face in the contemporary world. Instructor: Toole. 3 units. C-L: Global Health 541S, Human Rights Program-Franklin Humanities Institute 560S

561. History of Poverty in the United States. A history of poverty and poverty policy in the United States from the colonial era to the present. The changing experience of poverty, efforts to analyze and measure poverty, and attempts to alleviate or eliminate it. Attention paid to the reasons for the durability of poverty in a wealthy nation and to the forces shaping the contours of anti-poverty policy. Instructor: Staff. 3 units. C-L: History 546, Public Policy 528, Human Rights Program-Franklin Humanities Institute 561

562S. Understanding Ethical Crisis in Organizations. This course examines the causes and consequences of ethical crisis across business, military, higher education and religious institutions. Emphasis is on identifying why certain organizations are more prone to ethical problems and certain organizations better able to manage them. A core goal is to develop real-world solutions to ethical challenges organizations face in contemporary societies worldwide. Instructor: Pickus. 3 units. C-L: Political Science 502S, Sociology 542S, Public Policy 558S

565S. Attending to Persons in Pain. In this class, we aim to understand the roots of the various ways we attend to persons in pain today, and so to develop greater conceptual clarity and historical perspective on the diverse frameworks in which we encounter persons in pain. At the same time, we seek to nurture a recognition that attending to persons in pain threatens modes of control over that person's reality and our own. Therefore, in this class we seek to foster an understanding that attending to persons in pain today, whatever the setting, is a fragile and fraught enterprise that nevertheless continually calls for creative and faithful responses. Instructor: McCarty. 3 units.

578S. Contemporary Theories of Democracy. 3 units. C-L: see Political Science 578S

590. Special Topics in Ethics. Topics vary by semester. Instructor: Staff. 3 units.

590S. Special Topics in Ethics. Topics vary. Instructor: Staff. 3 units.

646S. Strategic Storytelling: Narratives for Development. 3 units. C-L: see Public Policy 646S; also C-L: International Comparative Studies 646S

795. Preventing Sexual Misconduct on University Campuses. This Bass Connections project's goals are to summarize the problems and practices in sexual harassment intervention and training by conducting a review of the literature; examine the potential role of courage and self-awareness, as well as the ways these characteristics could be developed in individuals and incorporated into interventions; and to develop designs that utilize these insights. For graduate students, regular participation will be complimented with mentorship of undergrads, additional meetings with faculty, and summary presentations of research findings to the larger group. They will also be evaluated on the basis of the quality of their research based on their year and program. Instructor consent required. Instructor: Anisman-Razin, Shanahan, Sitkin. 3 units.

796. Moral Economy of Markets: Constituting and Resisting Relations of Power. This Bass Connections project will explore experiences and narratives especially of those thrown into various states of vulnerability, objectification and precarity by the voracious spread of market logic. For graduate students, regular participation in all project meetings will be complimented with mentorship of undergraduates, additional meetings with the faculty directors of the project, and summary presentations of research findings to the larger project group. They will also be evaluated on the basis of the quality of their research based on their year (1st year vs. 4th year) and program i.e. whether they are PhD or master's level. Instructor consent required. Instructor: Philipsen, Crichlow. 3 units.

797S. Designing Ethics: Exploring the Integration of Ethics into Engineering Curricula. Many engineering challenges contain thorny moral questions, yet ethical considerations are often secondary. In fact, nationwide ethics is rarely addressed in standard engineering disciplinary courses at Duke or elsewhere. This course seeks provide a blueprint and testing ground for addressing this gap. Students will work to research best practices from the educational and private sectors. Incorporating those insights with a study of the landscape of Engineering design education at Duke, students will design interventions that may be deployed in Duke Engineering classes. Graduate students will take a leadership role in the classroom and on projects. Instructor consent required. Instructor: Ferney, Saterbak, Shanahan. 3 units.

890S. Special Topics in Ethics. Topics vary by semester. Instructor: Staff. 3 units.

893. Research Independent Study. Individual research in field of special interest under the supervision of a faculty member, the central goal of which is a substantive paper or written report containing significant analysis and interpretation of a previously approved topic. Instructor consent required. Instructor: Shanahan. 3 units.

947S. Comparative Religious Studies (Case Study of Judaism, Christianity & Islam). 3 units. C-L: see Religion 947S

Health Policy

Health Policy (HLTHPOL)

795. Bass Connections COVID-19 Research Team. Bass Connections Year-long Project Team. Topics vary depending on semester and section. Teams of undergraduate and graduate students work with faculty to enter into research related to the COVID-19 pandemic. Teams may also include postdoctoral fellows and experts from business, government and the non-profit sector. A team's work may run in parallel with or contribute to an on-going research project. Teams will participate in seminars, data collection and analysis, field work and other learning experiences relevant to the project. Requires final paper or product containing significant analysis and interpretation. Instructor consent required. Instructor: Staff. 3 units.

Human Rights Program—Franklin Humanities Institute

Courses in Human Rights (RIGHTS)

527S. Islam and Human Rights. 3 units. C-L: see Religion 527S

539S. Queer China. 3 units. C-L: see Asian & Middle Eastern Studies 539S; also C-L: Cultural Anthropology 539S, Gender, Sexuality, and Feminist Studies 502S, Literature 539S, Visual and Media Studies 539S

560S. Organized Compassion: History and Ethics of Humanitarianism. 3 units. C-L: see Study of Ethics 560S; also C-L: Global Health 541S

561. History of Poverty in the United States. 3 units. C-L: see Study of Ethics 561; also C-L: History 546, Public Policy 528

603. The Palestinian-Israeli Conflict in Literature and Film. 3 units. C-L: see Asian & Middle Eastern Studies 603; also C-L: Jewish Studies 683

642S. Global Inequality Research Seminar. 3 units. C-L: see Public Policy 645S; also C-L: African & African American Studies 642S, Economics 541S, Sociology 642S, Political Science 642S

660. Global Mental Health. 3 units. C-L: see Global Health 660; also C-L: Psychology 611, Cultural Anthropology 611

Innovation and Entrepreneurship

Courses in Innovation and Entrepreneurship (I&E)

510. Social Innovation Practicum. In the Social Innovation Practicum, students will engage with social entrepreneurs and other

practitioners to learn about and support the design, development, validation, assessment, and scaling up of innovative, sustainable approaches to addressing critical social and environmental problems in Durham and around the world. Working in multidisciplinary teams, students will gather and analyze data, develop recommendations, formulate implementation plans, and provide other capacity-building support to clients that may include domestic and international social entrepreneurs, social enterprises, funders, public sector innovators and policy makers, and corporate social impact managers. Instructor: Bloom, Nash. 3 units. C-L: Public Policy 511

590. Special Topics in Innovation & Entrepreneurship. Selected topics in innovation and entrepreneurship. Consent of instructor is required. Instructor: Staff. 3 units.

710. Research and Technology Translation. This course focuses primarily on the innovative and entrepreneurship aspects of translating research and technology developments out of the lab and research center and launching new products or starting new companies. The dark reality is that most ventures fail. Sometimes there is not much you can do to prevent failure; however, you can reduce the chance of failure by learning from others' experience and your own experience. This course leverages the experiences of others who have failed and succeeded so you can increase your chances of success. This course will cover many topics typically taught in technical leadership programs and graduate professional programs. Instructor: Azhar. 3 units.

720. Design in Healthcare 1. The course guides students through the process of human-centered design with the goal of developing a solution to a real-world, unmet need in healthcare. Students will learn to: 1) identify unmet, underserved and unarticulated needs using human-centered qualitative contextual primary research methods such as ethnographic research; 2) apply commercial business criteria in order to select viable business opportunities; 3) use creative and research-based processes to generate and/or identify potential solutions; and 4) document their design process in accordance with regulations. The course blends taught content with practical field application and team-based project execution. Instructor consent required. Instructor: Knight, Richardson, Fearis, Makhulu. 3 units.

721. Design in Healthcare 2. The Design in Healthcare 2 course is an experiential program and continuation of Design in Healthcare 1. It requires extensive team interaction and the direct application of skills in the process of preparing a medical device technology for development and eventual commercialization. Teams work through a development strategy to determine what work will be required to bring their technology forward, and the funding requirements and timing to raise capital at key milestones. The course concludes with an investor pitch to an outside panel of seasoned CEOs, VCs, and other members of the community. Prerequisite: Innovation & Entrepreneurship 720. Instructor consent required. Instructor: Knight, Richardson, Fearis, Makhulu. 3 units.

748. New Ventures 1: Opportunity Evaluation. New Ventures 1 guides students through the earliest, foundational stage of venture formation. Students enter with an interest in starting a venture, and, possibly—though not required—a vague idea for a project, and we'll spend the semester identifying and clearly defining a specific opportunity for launching a potential product, company, service, organization, and/or nonprofit. Instructor: Dinin. 3 units.

750. New Ventures 2: Strategy Development. Student teams develop core elements of a strategy for a technology or business idea; detail will be suitable for a business plan document for a company seeking initial investment; strategy will serve as a foundation for a first operating plan for company. Instructor consent required. Instructor: Fjeld, Dinin. 3 units.

752. New Ventures 3: Operating Plan. Students develop full operating plans for a new venture, including a finance plan; detail will be suitable for a business plan document for a company seeking initial investment; plan should be fundable upon completion; teams follow a structured process in doing their analysis and making recommendations; students work with faculty advisors and business mentors. Students should have completed New Ventures 2: Strategy Development. Instructor consent required. Instructor: Fjeld, Dinin. 3 units.

790. Special Topics. Selected topics in innovation and entrepreneurship. Consent of instructor is required. Instructor: Staff. 3 units.

790L. Special Topics. Selected topics in innovation and entrepreneurship. Consent of instructor is required. Instructor: Staff. 3 units.

791. Independent Study. Individual non-research directed independent study in a field of special interest on a previously approved topic taken, under the supervision of a faculty member, and resulting in an academic and/or artistic product. Instructor consent required. Instructor: Staff. 3 units.

800. Business and Organization Fundamentals for Entrepreneurial Action. Graduate students often have expertise in particular domains, but little business experience. Attaining business experience can take years and is often hard to navigate. Using entrepreneurship as a backdrop, this course provides a broad overview of business, including practical business fundamentals and theoretical frameworks for critical thinking. The course achieves this through theoretical frameworks, experiential education, and an analysis of competing companies. Students will experience the early stages of a typical startup, examine theoretical basis for startup success, understand managing and operating within an organization, and conduct a business analysis of competing companies. Instructor: Rhee, Fjeld. 3 units.

835. Innovations in Drug Development. 4 units. C-L: see Pharmacology and Cancer Biology 835

International Comparative Studies

Courses in International Comparative Studies (ICS)

5503S. Cartographies of Gender and Sexuality in Middle East. 3 units. C-L: see Gender, Sexuality, and Feminist Studies 503S; also C-L: Asian & Middle Eastern Studies 527S

504S. The Black Radical Tradition: COVID-19, #JusticeForGeorgeFloyd, and the Movement for Black Lives. 3 units. C-L: see African & African American Studies 503S; also C-L: Religion 503S, Cultural Anthropology 503S, Political Science 589S

505S. Race in Comparative Perspective. 3 units. C-L: see Political Science 505S

506. Politics of United States Foreign Policy. 3 units. C-L: see Public Policy 506; also C-L: Political Science 547

509S. Contemporary Dance History. 3 units. C-L: see Dance 665S; also C-L: History 554S

510S. Global Africa. 3 units. C-L: see Cultural Anthropology 561S; also C-L: African & African American Studies 510S, History 561S, Political Science 527S

511S. Political Participation: Comparative Perspectives. 3 units. C-L: see Political Science 509S

512S. Current Issues in International and Development Economics. 3 units. C-L: see Economics 568S

513. Documentary and East Asian Cultures. 3 units. C-L: see Asian & Middle Eastern Studies 511; also C-L: Documentary Studies 511

514S. Assisting Development. 3 units. C-L: see Public Policy 515S; also C-L: Political Science 546S

515S. Interethnic Intimacies: Production and Consumption. 3 units. C-L: see Asian & Middle Eastern Studies 515S; also C-L: Literature 515S, Visual and Media Studies 515S, Gender, Sexuality, and Feminist Studies 505S

521S. International Environmental Regimes. 3 units. C-L: see Political Science 545S; also C-L: Public Policy 581S

525S. Culture, Power, History. 3 units. C-L: see Cultural Anthropology 525S

527S. Music in Literature and Philosophy. 3 units. C-L: see German 580S; also C-L: English 580S

529S. Race and Ethnicity. 3 units. C-L: see Public Policy 529S; also C-L: African & African American Studies 551S

531S. Camera Asia. 3 units. C-L: see Art History 535S; also C-L: History 530S

537S. Post War Europe, 1945-1968: Politics, Society, and Culture. 3 units. C-L: see History 537S; also C-L: Political Science 515S

539S. Atlantic Constellations: Migration, Exile, Second Slavery. 3 units. C-L: see Spanish 539S; also C-L: History 542S

541S. Jews and the End of Theory. 3 units. C-L: see Asian & Middle Eastern Studies 541S; also C-L: Jewish Studies 541S, Literature 580S

543S. Piracy and European Imperial Expansion in the Atlantic Basin, 1492-1730. 3 units. C-L: see History 543S

561. 9/11: Causes, Response & Strategy. 3 units. C-L: see Public Policy 561; also C-L: Political Science 544

577. Environmental Politics. 3 units. C-L: see Environment 577; also C-L: Public Policy 577

580S. Water Cooperation and Conflict. 3 units. C-L: see Public Policy 580S; also C-L: Global Health 533S, Environment 543S

590. Special Topics in International Comparative Studies. Topics vary from semester to semester, focusing either on specific world regions or particular comparative/global issues. Instructor: Staff. 3 units.

598. Economic Growth and Development Policy. 3 units. C-L: see Public Policy 598

605. East Asian Cultural Studies. 3 units. C-L: see Asian & Middle Eastern Studies 605; also C-L: Cultural Anthropology 605, Literature 571

613S. Third Cinema. 3 units. C-L: see Literature 613S; also C-L: African & African American Studies 530S, Latin American Studies 613S, Visual and Media Studies 611S

615S. The #Selfie. 3 units. C-L: see Literature 615S; also C-L: Visual and Media Studies 615S, Gender, Sexuality, and Feminist Studies 615S

646S. Strategic Storytelling: Narratives for Development. 3 units. C-L: see Public Policy 646S; also C-L: Study of Ethics 646S

647. Surviving Globalization: The Global South and the Development Imagination. 3 units. C-L: see African & African American Studies 646; also C-L: Sociology 647

664S. Leaders, Nations, and War. 3 units. C-L: see Political Science 664S

Jewish Studies

Courses in Jewish Studies (JEWISHST)

519S. Andalusia: Muslim, Jewish, Christian Spain. 3 units. C-L: see Asian & Middle Eastern Studies 519S; also C-L: Religion 519S, Romance Studies 519S

541S. Jews and the End of Theory. 3 units. C-L: see Asian & Middle Eastern Studies 541S; also C-L: Literature 580S, International Comparative Studies 541S

550. Archaeology of Palestine in Hellenistic-Roman Times. 3 units. C-L: see Religion 550

555S. Art and the Holocaust: Architecture, Art, and Cultural Politics during the Nazi Period. 3 units. C-L: see Visual and Media Studies 525S; also C-L: German 565S, History 531S

601S. Introduction to Jewish Studies. An introduction to the topics and methods that are characteristic of Jewish studies as an academic and scholarly rubric in the contemporary university. The course engages both the history of Judaism as a religious culture and the history of Jewish Studies. Co-taught with faculty from UNC. Weekly meetings will alternate between Duke and UNC campuses. Instructor: Lieber. 3 units. C-L: Religion 613S, History 601S

606S. Hebrew Biblical Texts. 3 units. C-L: see Religion 606S

607. Hebrew Prose Narrative. 3 units. C-L: see Religion 607

608. Classical Hebrew Poetry. 3 units. C-L: see Religion 608

609. Rabbinic Hebrew. 3 units. C-L: see Religion 609

610. Readings in Hebrew Biblical Commentaries. 3 units. C-L: see Religion 610

683. The Palestinian-Israeli Conflict in Literature and Film. 3 units. C-L: see Asian & Middle Eastern Studies 603; also C-L: Human Rights Program-Franklin Humanities Institute 603

730S. A Cultural and Spatial Analysis of the Ghetto: Venice, Nazi Occupied Europe, Chicago. 3 units. C-L: see Art History 730S; also C-L: German 730S, History 730S

Latino/a Studies in the Global South

Courses in Latino/a Studies in the Global South (LSGS)

690. Special Topics in Latino Studies in the Global South. A comparative approach to Latino Studies in the Global South that draws on the methods and materials of other disciplines. Focus on interdisciplinary study. Contents vary with instructors. Instructor: Staff. 3 units.

Linguistics

Courses in Linguistics (LINGUIST)

501. Cognitive and Neurolinguistics. The interrelationship between language and brain as described and analyzed in cognitive and neurolinguistics. Topics include localization theories, hemispheric dominance in language, language disorders, invasive and noninvasive scanning and imaging technologies (including ERP, EEG, fMRI, MEG), encoding and decoding of language at the phonological, morphological, syntactic, and semantic levels. Readings include scholarship from theoretical and cognitive linguistics, neurolinguistics, neurobiology, neuropsychiatry, and neuropsychology. Major research project required in form of research paper, laboratory or imagining experiment, or IRB document. Instructor: Andrews. 3 units. C-L: Russian 510, Neuroscience 501S

502S. Language, Brain, and Human Behavior. Explores the intersection of cognition and language by looking at a variety of theories of language, including: traditional models that vary according to how much the capacity for language is attributed to "the genes" or to "the environment" and newer models that question and redescribe traditional definitions of terms such as "nature," "nurture," "genetic code," and "language." How traditional and new models of language interpret the capacity for language in its relationship to the neurosciences, the cognitive sciences, and the social sciences. Instructor: Tetel. 3 units. C-L: Psychology 670S

503S. Language Evolution and Acquisition. Both the phylogeny and ontogeny of language, i.e., both the wide and growing variety of scripts for the evolution of language in the human species and the various approaches to the emergence of language in the individual. The emergence of language in the individual and the particular language(s) the individual is exposed to, making linguistic relativity an important topic. Instructor: Tetel. 3 units. C-L: English 503S

506S. Semiotics and Linguistics (DS4). 3 units. C-L: see Russian 506S

510. Brain and Language. The relationship of brain and language is explored through a variety of methodologies and approaches, including studies of first and second language acquisition across cultures, multilingualism, language disorders. Neuroimaging studies (including electrophysiological and hemodynamic techniques) are central to understanding current neurobiological, neurophysiological and neurolinguistic perspectives of representation of language(s) in the brain. Readings and case studies focus on the latest theoretical contributions to the field. IRB certification and data collection are required. Instructor: Andrews. 3 units. C-L: Psychology 575, Neuroscience 510

512. Structure of French. 3 units. C-L: see French 512

512S. Topics in Spanish Linguistics. 3 units. C-L: see Spanish 512S

518S. Approaches and Practices in Second Language Pedagogy. 3 units. C-L: see Asian & Middle Eastern Studies 518S; also C-L: Education 518S

528S. Recent and Contemporary Philosophy. 3 units. C-L: see Philosophy 628S

560. History of the German Language. 3 units. C-L: see German 560; also C-L: Medieval and Renaissance Studies 607

561S. Second Language Acquisition and Applied Linguistics. 3 units. C-L: see German 561S

562S. Old Norse: Introduction to the Language of Viking Scandinavia. 3 units. C-L: see German 510S; also C-L: Medieval and Renaissance Studies 609S

564. Russian and Slavic Linguistics. 3 units. C-L: see Slavic and Eurasian Studies 564

590. Special Topics. Study of theoretical and applied linguistics. Contrast and comparison of both theoretical approaches and language groups is required. Topics to be announced. Instructor: Staff. 3 units.

590S. Special Topics in Linguistics. Same as Linguistics 590 except instruction is provided in a seminar format. Instructor: Staff. 3 units.

595. Language, Music and Dementia: Neuroscience Approaches. Exploration of the neuroscience data on cognitive processing of languages and music in healthy subjects and pathology. Specific attention given to the interaction of language(s) and music in the

brain, music therapy and dementia, and multilingualism and dementia. Topics include the role of languages and music in building cognitive reserve, linguistic breakdown and cognitive decline in healthy aging and dementia, cross-cultural studies of pitch and timbre perception across languages of the world, possible benefits of multilingualism in healthy aging, interactions of singing and memory, integration of auditory and visual neural systems in language and music. Instructor: Andrews, Linnartz. 3 units. C-L: Neuroscience 595, Music 595

890. Special Topics in Linguistics. Advanced study of linguistic theory. Topics to be announced. Instructor: Staff. 3 units.

890S. Special Topics in Linguistics. Same as Linguistics 890 except instruction is provided in a seminar format. Instructor: Staff. 3 units.

990. Directed Readings in Linguistics: Special Topics. Directed readings in linguistics on special topics. Instructor consent required. Instructor: Staff. 3 units.

Modeling Biological Systems

Course in Modeling Biological Systems (MBS)

573S. Modeling of Biological Systems. 3 units. C-L: see Mathematics 573S; also C-L: Computational Biology and Bioinformatics 573S

Neuroscience

Courses in Neuroscience (NEUROSCI)

500S. The Cinematic Depiction of Psychopathology. 3 units. C-L: see Psychology 500S

501S. Cognitive and Neurolinguistics. 3 units. C-L: see Linguistics 501; also C-L: Russian 510

502. Neural Signal Acquisition (GE, IM, EL). 3 units. C-L: see Biomedical Engineering 502

503. Computational Neuroengineering (GE, EL). 3 units. C-L: see Biomedical Engineering 503

504. Fundamentals of Electrical Stimulation of the Nervous System (GE, EL). 3 units. C-L: see Biomedical Engineering 504

507. Neuronal Control of Movement (GE, EL). 3 units. C-L: see Biomedical Engineering 517

510. Brain and Language. 3 units. C-L: see Linguistics 510; also C-L: Psychology 575

511L. Intermediate Bioelectricity (GE, EL). 4 units. C-L: see Biomedical Engineering 511L

515. Neural Prosthetic Systems (GE, EL, IM). 3 units. C-L: see Biomedical Engineering 515

533. Essentials of Pharmacology and Toxicology. 4 units. C-L: see Pharmacology and Cancer Biology 533; also C-L: Molecular Cancer Biology 533

555S. Topics in Philosophy of Mind. 3 units. C-L: see Philosophy 555S

560. Molecular Basis of Membrane Transport (GE, EL, MC). 3 units. C-L: see Biomedical Engineering 560

567. Theoretical Neuroscience. 3 units. C-L: see Physics 567

584S. Hormones, Brain, and Cognition. 3 units. C-L: see Psychology 684S

590. Special Topics in Neuroscience. Topics vary by semester. Instructor: Staff. 3 units.

590S. Special Topics in Neuroscience. Topics vary by semester. Undergraduate as well as Graduate/ Professional students. Instructor: Staff. 3 units.

595. Language, Music and Dementia: Neuroscience Approaches. 3 units. C-L: see Linguistics 595; also C-L: Music 595

686S. Principles of Neuroimmunology. 3 units. C-L: see Psychology 686S

740L. Fundamentals of Bioelectric Engineering. 4 units. C-L: see Biomedical Engineering 740L

751. Neuroscience Bootcamp. Neuroscience Bootcamp is a two week immersive lecture, discussion and laboratory course for graduate students in the Neurobiology Graduate Program and the Cognitive Neuroscience Admitting Program, and graduate students in allied programs at the discretion of the instructors. The Duke Neuroscience Bootcamp is designed to (1) provide a common knowledge base of neuroscience fundamentals; (2) demystify the tools of the discipline - providing hands-on experience with techniques that are commonly used to explore cellular/molecular, circuits and cognitive neuroscience; and (3) introduce new students to a wide variety of Duke faculty and helpful resources for ensuring a successful graduate career. Instructor: Glickfeld, Grandl, Egner. 2 units. C-L: Neurobiology 751

755. Interdisciplinary Program in Cognitive Neuroscience (IPCN) Independent Research Rotation. Students will be involved in a research apprenticeship with a faculty member for hands-on experience with research efforts. Instructor: Staff. Variable credit.

773S. Reward and the Brain. 3 units. C-L: see Psychology 773S

780S. Foundations of Behavioral and Computational Neuroscience. 3 units. C-L: see Psychology 780S

Science & Society

Courses in Science & Society (SCISOC)

502S. Communicating Science & Bioethics. Examination of the challenges and best practices for communicating scientific and bioethical issues to the public, journalists, and policymakers. Explores historical and cultural factors that influence public understanding of and attitudes toward scientific and bioethical issues. Students will draw on communication case studies from a variety of disciplines (genetics, neuroscience, law, bioethics) and their own academic interests as a context for developing writing and speaking skills essential for clear communication of complex topics to non-specialists. Instructor: Weintraub. 3 units. C-L: Bioethics and Science Policy 502S

519. Introduction to International Organizations and Technology Policy. This course will explore efforts by international organizations to shape and promote digital technology policy. Students will evaluate case studies and ongoing initiatives, including those by the United Nations, Organization for Economic Cooperation and Development, World Economic Forum, G7, and G20, to develop policy solutions that help address concerns and ensure that the digital transformation benefits society as a whole. Instructor: Lynch, Perault. 3 units. C-L: Public Policy 519

549S. Histories of Science and Technology. 3 units. C-L: see History 549S; also C-L: Global Health 549S

559. Foundational Statistics for Social Science Researchers. Foundational knowledge in statistical procedures are necessary for interpreting and describing the results of research within science. This course is designed to provide the foundational knowledge of research methodologies and the statistical concepts and tools that will allow one to understand scholarly research. Specifically, in this course you will learn the theoretical and practical use of several descriptive and inferential statistical procedures, as well as how to design strong methodological experiments. Additionally, this course will allow you to conduct basic data analysis and prepare you to better understand research as a whole. Instructor: Krenzer. 3 units.

590. Special Topics in Science & Society. Topics will vary. Instructor: Staff. 3 units.

590S. Special Topics in Science & Society. Topics will vary. Instructor: Staff. 3 units.

606S. Robots in Society. From drones to self-driving cars, robotic technologies are developing faster than society's ability to fully grasp their impact. Well-designed technology has the ability to make us safer and improve our productivity, but how does the complex relationship between innovators, policy-makers and the public influence how soon we can realize the benefits? Class is a mix of students from different backgrounds representing different stakeholder perspectives. Instructor: Staff. 3 units.

612. Ethics and Policy in Genomics. Survey of ethical, social, economic, and legal issues in genomics. Introduction to ethical reasoning and examination of selected issues calling for such analysis, including: (1) special procedures for research involving human participants, (2) respect for privacy and confidentiality of genetic information; (3) historical and political background of health research funding, and (4) public-private research interactions such as intellectual property and conflict of interest. Instructor: Staff. 3 units. C-L: Public Policy 634, Computational Biology and Bioinformatics 612

613S. Technology Policy for the New Administration: Antirust, Speech and Other Emerging Issues. 3 units. C-L: see Public Policy 613S

627. Molecular Ecology. 3 units. C-L: see Environment 627; also C-L: Biology 627

641S. Cancer in Our Lives: Film, Narrative, Fiction, History and Politics. 3 units. C-L: see Public Policy 641S

680S. Ethical Foundations of Innovative Technology Policy. As science and technology continue to progress at an unparalleled pace, law, ethics and policy struggle to provide regulation and oversight. This course will consider the ethical foundations which can guide the development of public policy concerning innovative technologies, including gene editing, artificial intelligence, augmented and virtual reality, neuroscience and others not yet conceived. Instructor: Perault. 3 units. C-L: Public Policy 680S

698. Research Based Independent Study within Science & Society. Individual research in a Science & Society topic of special interest, under the supervision of a faculty member, the major product of which is a substantive paper or written report containing specific analysis and interpretation of a previously approved topic. Open to all qualified students with consent of supervising instructor. May be repeated. Instructor: Staff. Variable credit.

702. Science Communication for Scientists. This course provides students in the sciences with practical training in the communication of scientific research to non-scientists, and helps them develop skills essential to doing meaningful outreach. Topics covered include the empirical benefits of communicating science; development of speaking, writing, and storytelling practices for diverse audiences; answering difficult, controversial, and critical questions from the media; and tweeting, blogging, and presenting research to engage non-scientists (including the lay public and policy-makers). Instructor: Weintraub. 2 units. C-L: Bioethics and Science Policy 702

709S. Science, Medicine, and the Body. 3 units. C-L: see Cultural Anthropology 709S; also C-L: Gender, Sexuality, and Feminist Studies 709S, Global Health 709S, Literature 709S

750. Genomics of Microbial Diversity. 3 units. C-L: see Environment 750

799S. Topics in Ecological Genomics. 1 unit. C-L: see Environment 799S

Theater Studies

Courses in Theater Studies (THEATRST)

520A. Theater in London: Text. A survey of drama from the Elizabethan period to the present based on performances offered by

the Royal Shakespeare Company, Royal National Theatre, and other theaters in London and Stratford-Upon-Avon. Twenty plays will be seen and studied. Instructor consent required. Instructor: Staff. 3 units. C-L: English 583

521S. Moliere: The Phenomenon of Laughter. 3 units. C-L: see French 525S; also C-L: Medieval and Renaissance Studies 601S

530S. Translation Studies and Workshop. Through reading texts about translation and by doing an independent project translating part of a play, students develop skills in translation theory and practice, culminating in a public staged reading of their work. Each student chooses a different play, in source language of his/her own choice, and translates into English. Readings are seminal texts in translation studies covering topics such as globalization, adaptation, the translator's role, gender in translation, and postcolonialism to explore transmission of text/performance across cultures. Course is for graduate students and undergraduates. Enrollment limited. No previous translation experience required. Instructor: Conceison. 3 units. C-L: Romance Studies 520S, Asian & Middle Eastern Studies 502S

533S. Performance Studies. Introduction to theatrical transformations of traditional notions of drama into the broader category of performance, and to the performative field that seeks to understand them. Topics include the crossing of formal boundaries, the development of new technical possibilities, the role of uncertainty in the process of making a performance, and the purposes of performance, which range from the social to the spiritual and from the political to the personal. Theoretical readings and performances including works by Wagner, Artaud, Brecht, Benjamin, Chaplin, O'Neill, Stanislavski, Barthes, and Anderson. Instructor: Staff. 3 units. C-L: Literature 520S

535S. AfroFuturism. 3 units. C-L: see African & African American Studies 620S; also C-L: Dance 535S, Visual and Media Studies 524S

540A. Theater in London: Performance. Understanding the growth of a play from the script to final production, with focus on shows playing in London. Includes backstage theater tours, scene work, observations, audition workshops with theater practitioners, and supervised projects. Instructor consent required. Instructor: Staff. 3 units. C-L: English 584

590. Advanced Special Topics in Dramatic Literature (Lecture). Topics vary by semester. Consent of instructor **required. Instructor: Staff.** 3 units.

590S-1. Advanced Special Topics in Dramatic Literature (Seminar). Instructor: Staff. 3 units.

620S. Film-philosophers/Film-makers. 3 units. C-L: see Literature 620S; also C-L: Visual and Media Studies 622S, English 620S, Documentary Studies 620S

671S. Thinking Digital Cinema. 3 units. C-L: see Literature 614S; also C-L: Visual and Media Studies 614S

691. Independent Study. Individual directed study on advanced graduate level under supervision of a faculty member resulting in an academic or artistic product. Consent of instructor required. Instructor: Staff. 3 units.

Writing

Course in Writing (WRITING)

591. Independent Study. Directed study in a field of special interest in Writing Studies on an approved topic under the direction of a faculty member, resulting in a substantive written product. Consent of instructor required. Instructor: Staff. 3 units.

Programs at Duke Kunshan University

Duke Kunshan University is a partnership of Duke University and Wuhan University to create a world-class university offering a range of academic programs and conferences for students from China and throughout the world. Duke Kunshan University is located in Kunshan, Jiangsu province, China.

The state-of-the-art campus covers two hundred acres in Kunshan's Yangcheng Lake Science and Technology Park. Located in close proximity to both Shanghai and Suzhou, and connected to both by high-speed rail, the city of Kunshan is a center for business and high-tech research and manufacturing and has one of the fastest growing economies in China.

Duke Kunshan University welcomed its first graduate students in August 2014. Initial offerings include two graduate master's degree programs.

Global Health

Professor Yan, *Director of Graduate Studies*

A MS degree is available in this program.

The master of science in global health (MSc-GH) is administered by Duke Kunshan University, with support from the Duke Global Health Institute. A guiding principle of the degree program is the recognition that a multidisciplinary and multi-sectoral approach to health is essential, as health is influenced by a multitude of factors, including, but not limited to: individual behaviors; family and childhood dynamics; community characteristics; economic status; gender; genetics; country laws and politics; the environment; and the availability, accessibility, and quality of education, health care, nutrition, water, housing, and other basic goods.

Program Requirements

The thirty-eight-unit curriculum includes six core courses, five electives, a ten-week (minimum) field experience to apply learned research methods, and a research-based scholarly thesis. It is designed as a three-to-four-term program.

The six core courses are:

- Global Health 701K (Global Health Challenges)
- Global Health 702K (Global Health Research: Design and Practice)
- Global Health 705K (Biostatistics and Epidemiology for Global Health Science I)
- Global Health 707K (Biostatistics and Epidemiology for Global Health Science II)
- Global Health 740K (Ethics for Global Health Research)
- Global Health 750K (Health Systems in Developing Countries)

Students will select from a list of approved elective courses. Students are also required to complete a fieldwork experience of at least ten weeks, approved by the director of the MSc-GH program, and a research-based scholarly thesis.

Courses in Global Health (GLHLTH) at Duke Kunshan University

571K. Introduction to Maternal and Child Health. Provides global perspectives on maternal and child health research, practice, and policy. Utilizes case analysis to examine health challenges facing women, children, health providers, and policymakers in some of the world's most disadvantaged communities. Addresses maternal health, infant health, and early childhood development. Special focus on low- and middle-income countries. Discussion includes: data and measurement, health system challenges, public health interventions and programs, policy and advocacy. Topics include: reproductive health, delivery and postnatal care, nutrition, immunization. Designed for graduate and advanced undergraduate students. Taught at Duke Kunshan University. Instructor: Staff. 3 units.

581K. Global Environmental Health Problems: Principles and Case Studies. 3 units. C-L: see Environment 581K

637K. Population and Environmental Dynamics Influencing Health. Examination of population, health and environment (PHE) dynamics with focus on interactions in developing or transition economies. Theoretical and empirical approaches governing PHE dynamics from multidisciplinary perspectives, including geography, public health /epidemiology, demography, and economics. Students will obtain experience in design and analysis of PHE studies, and epidemiology of vector-born, chronic and enteric infections. Taught at Duke Kunshan University. Instructor: Pan. 3 units. C-L: Environment 637K

641K. Non-Communicable Diseases in Low and Middle Income Countries: Trends, Causes, Prevention Strategies. Provides global overview of recent (mid-20th century to present) trends in non-communicable disease (NCD) epidemiology and strategies for prevention and control of these diseases, with particular emphasis on China and comparisons between China and other countries. Focuses on four major NCD categories as separate modules: cardiovascular, diabetic, oncologic, and pulmonary diseases. Uses case studies to highlight selected geographic differences. Provides firm understanding of shifting disease burden, stakeholders, and interventions to address NCDs in low- and middle-income countries. Designed for graduate-level students, open to advanced undergraduates. Taught at Duke Kunshan University. Instructor: Yan. 3 units.

660K. Global Mental Health (A). Examination of global mental health from perspectives of culture, public health, epidemiology, human rights, policy, and intervention. Disciplines include cross-cultural psychiatry, medical anthropology, public mental health, and economics. Topics include ethics, stigma, cross-cultural classification of mental health, ethnopsychology, trauma, violence, disasters, and displacement. Populations include children, ethnic minorities, refugees, survivors of complex emergencies, and persons with chronic disease. Course highlights mixed-methods approaches to research and intervention evaluation. Designed for graduate students & advanced undergraduates. Prior research methods course recommended. Taught in Durham. Instructor: Staff. 3 units.

673SK. Global Surgical Care. Lack of access to surgical care threatens the health of people throughout the world's poorest regions, and impacts all areas of health care. This seminar will address issues surrounding the delivery of surgical and anesthesia care in low- and middle income countries for students and clinical trainees in global health. This course will focus on surgical care delivery and management; workforce, training, and education; and economics and finance. The content of this course will be based on the Lancet Commission on Global Surgery report and support materials. The format will be a weekly seminar, readings, and case studies. Taught in Durham. Instructor: Rice. 3 units.

700K. Global Health Field Research: Planning and Skill Development. Prepare students to successfully engage in field-based research in global health. Develop critical skills and reflective insights that can help students to manage the multiple aspects of fieldwork. Taught in China at Duke Kunshan University. Instructor: Long. 1 unit.

701K. Global Health Challenges. Course introduces major global health problems and social, behavioral, economic, biomedical and environmental determinants of health in resource limited settings. Topics include communicable diseases i.e. HIV, malaria, tuberculosis and common childhood diseases; chronic diseases such as cancer, diabetes, cardiovascular disease and mental health; and determinants of health associated with these diseases, such as poverty, gender imbalance, culture, poor environmental sanitation, malnutrition, tobacco use, and climate change. Other topics may include health promotion, reproductive health, maternal and child health, and disaster preparedness. Taught at Duke Kunshan University. Instructor: Staff. 3 units.

702K. Global Health Research: Design and Practice. Course provides a foundation in study design, research question development, field implementation, measurement, validity and reliability. Quantitative and qualitative research approaches are examined. Students build critical skills in reading, interpreting and synthesizing scientific literature. The selection of appropriate measurements and survey development is emphasized and issues in field implementation explored. Taught at Duke Kunshan University. Instructor: Abdullah. 3 units.

705K. Biostatistics and Epidemiology for Global Health Science I. Introduces principles of epidemiology, including disease frequency measures; measures of association; observational, experimental, and quasi-experimental study designs; validity—confounding, selection bias, measurement error; reliability. The course also will interweave introductory biostatistics for continuous and categorical variables. Lab section in which students walk through guided data analysis on provided data set using STATA. Taught at Duke Kunshan University. Instructor: Staff. 4 units.

707K. Biostatistics and Epidemiology for Global Health Science II. Modular course building on Quantitative Methods I.

Required module provides common understanding of regression including linear, logistic, and general linear regression, use and interpretation of dichotomous and continuous variables, indicator terms, and interaction terms, and regression diagnostics. Required lab section. Taught at Duke Kunshan University. Instructor: Abdullah. 4 units.

710K. Intermediate Epidemiology. This course covers in-depth topics in epidemiology with a focus on the global health context. The course textbook is "Epidemiology: Beyond the Basic" by Moyses Szklo and Javier Nieto. The textbook will be supplemented with publications selected from the epidemiologic, clinical, nutritional and other literature. Topics covered include epidemiologic study designs, measures of disease occurrence and associations with risk factors, confounding and interaction, time to event data, and methods for causal inference. Course content will focus on epidemiologic concepts. Related statistical concepts will be discussed, but data analysis will not be a focus. Prior epidemiology coursework required. Taught in Durham. Instructor consent required. Instructor: Egger. 3 units.

722K. Culture, Health and Illness in a Global Perspective. Seminar explores medical anthropology as: a perspective within global health; a resource for developing research & understanding of health issues; and, part of implementation science. Also draws from field of global public health. Divided into four areas: Local and global healing systems (China, the Americas, the Middle East, Africa, Europe); biocultural basis of health; methods & analytical perspectives for examining health disparities (country, region, global); community-based participatory action research and other implementation science approaches drawing on applied medical anthropology. Instructor: Burns. 3 units.

725K. Global Health and Migration. Issues/impact of migration on health of populations who move, those who are left behind, and on host communities. Focus on types of migration, including economic, political, violence-related, disaster-related migration, and human trafficking. Special attention to health disparities and inequities, and health determinants in host countries or regions. Case studies on migration and health from within Latin America and to the United States, within China, China and Africa, within African countries and mixed migration from Africa into Europe. Lessons learned, and ethically sound public health approaches will be discussed to promote health and protect human rights of migrants at global levels. Instructor: Amaya-Burns. 3 units.

731K. One Health: Introduction to the One Health Approach. Introduces principles of employing the One Health approach in preventing and controlling infectious diseases. Includes practical overview of host factors, environmental factors, and microbiological factors that influence this dynamic field of study. Through lectures and exercises, introduces infectious disease surveillance, diagnostic tools, outbreak investigations, vaccine trials, public health interventions, biodefense, emerging infectious diseases and analytical approaches as they pertain to infectious disease prevention and control. Introduces wide array of reference material for practical application of course material. Course offered in Durham for Duke Kunshan University students only. Instructor: Gray. 2 units.

732K. One Health: Introduction to Environmental Health. Course provides a comprehensive overview of major topic areas in Environmental Health. Includes major sources of environmental health risks, such as microbial, chemical, and physical agents in natural and anthropogenic environments. Also covers topics of toxicology and ecotoxicology, risk assessment and risk management, water and sanitation issues, infectious diseases, food safety, and other emerging topics. This course is offered in Durham for Duke Kunshan University students only. Instructor: Gray. 3 units.

735K. One Health: Introduction to Entomology, Zoonotic Diseases, and Food Safety. Course introduces public health students to entomology, zoonotic diseases, and principals of modern food safety. Includes methods for conducting studies of mosquitoes and ticks, controlling zoonotic diseases, and protecting the food supply. Special focus on modern food safety techniques in meat, dairy and produce production. Lectures complemented with considerable laboratory and/or field work. Course offered in Durham for Duke Kunshan University students only. Instructor: Gray. 3 units.

739K. One Health: Public Health Laboratory Techniques. Introduction to common laboratory techniques used in emerging infectious respiratory disease research and surveillance laboratories; emphasis on techniques for culturing, characterization, and serological surveillance of exposure to influenza viruses. This course is offered in Durham for Duke Kunshan University students only. Instructor: Gray. 1 unit.

740K. Ethics for Global Health Research. Course presents overview of practical and theoretical approaches to bioethics from a range of perspectives, including humanities, law, philosophy, medicine and science. Students apply various resources, terminology and frameworks to case studies, preparing them for their own research. Course includes IRB and responsible conduct of research. Taught at Duke Kunshan University. Instructor: Amaya-Burns. 2 units.

750K. Health Systems in Developing Countries. Course introduces key challenges faced in strengthening of health systems in low and middle income countries. Topics include: overview of organization of health systems, models of purchasing and providing health care, innovations in financing health care, issues in service delivery such as quality of care and human resource challenges, and frameworks and methods employed in the evaluation of health systems. Course will also draw attention to resource allocation problems and various frameworks used to address them. Readings primarily from health policy, economics and other social science journals. Taught at Duke Kunshan University. Instructor: Tang or Moe. 3 units.

751K. Developing Implementation/Operational Research for Improving Health Interventions. IR/OR: studies how to improve uptake, implementation, and translation of research findings into routine and common practices; moves results from effectiveness studies and efficacy trials to real-world settings, obtaining information to guide scale-up; helps implementers apply lessons from a program in one context to developing a similar program in a similar environment. Course covers: framework of IR/OR; methods of identifying program implementation problems; how to organize and develop an IR/OR proposal; main study design, research methods, data collection and analysis used in IR/OR; approaches to capacity building for IR/OR in developing countries. Offered at Duke Kunshan University. Instructor: Tang. 3 units.

755K. Health Economics. Develop economic understanding of how health care institutions and markets function. Includes discussion of theoretical and empirical findings pertaining to individuals' decisions about personal health and health care; decisions made by health services suppliers; and, government decision-making about resource allocation and policy in the health sector. Global

scope. Draws heavily on applied microeconomics, designed for students with limited economics background. Organized sequentially beginning from individual and firm-level, then shifting to market-level, and finally macroeconomic-level which views the economy as a whole and examines role of health and health care within the macroeconomy. Course will be taught at Duke Kunshan University. Instructor: Hsieh. 3 units.

758K. Case Studies in Data Science for Global Health. Application of statistical and data science skills to in-depth data analysis projects in global health. Principled use and interpretation of modern tools, including data wrangling and munging, visualization, exploratory analysis, predictive modeling, and inference using modern statistical software applied to global health data. Emphasis on communication of analysis results both technically and non-technically via presentations and written reports. Taught in Durham. Prerequisite: Global Health 705/705K and access to data for course project. Instructor: Herring. 3 units.

761K. Introductory Demographic Measures and Concepts. Introduction to demographic concepts, measures, and techniques. Focus on population change, mortality, morbidity, fertility, marriage, divorce, and migration. Illustration of broader application of demographic measurement and techniques to other aspects of society and population health, such as educational attainment, labor force participation, linkages between mortality, morbidity and disability, and health and mortality differentials. Students will also learn how to apply methods discussed. Taught in Durham. Instructor: Merli. 3 units.

770K. Qualitative Data Analysis for Global Health. Equips students with knowledge and skills to effectively analyze qualitative data in the field of global health. With a foundation in thematic analysis, teaches tools of memo writing, coding, diagramming and matrices to support the synthesis, interpretation and presentation of data in a systematic and rigorous way. NVivo software will be used to organize and manage the analytic process. Students should have previous qualitative coursework and/or qualitative experience. Best suited for students who have a qualitative data set that they are working to analyze toward a specific output (e.g., a publication, master's thesis or doctoral dissertation). Taught in Durham. Instructor: Watt. 3 units.

772K. Qualitative Methods in Health Research. This course will introduce the application of qualitative methods in health research, with particular emphasis on their application in implementation research in relation to policy or program design and evaluation issues. The course will begin with an overview of the theoretical basis and ethics of qualitative research. It will focus on training in choosing the qualitative field methods, skills of data collection, approaches of data analysis and reporting the qualitative research results. Taught at Duke Kunshan University. Instructor: Long. 3 units.

773K. Deconstructing Global Injury Control and Prevention through Systematic Review Methods. An introduction to the field of injury epidemiology and injury prevention. Prominent types of injury are very different in different settings and those to be discussed in the course are those related to motor vehicles, assaults, firearms, self-injurious behavior and global toxicology. Behavioral, biological, economic and social issues related to the implementation of injury reduction policies will be explored through case studies of specific injury scenarios and interventions. Course will delve into epidemiology, specific research methods and innovative research methods and articles. Taught at Duke Kunshan University. Instructor: Staff. 3 units.

774K. Program Evaluation for Health. Covers the principles and tools of evaluation, starting with the evaluation planning process and ending with the dissemination of evaluation results and their use to inform action. Examines different approaches to evaluation (e.g., participatory evaluation), common evaluation designs, and the use of quantitative and qualitative data. Discuss "real-life" evaluation challenges and explore current debates and developments in the field, utilizing examples of actual evaluations of health-related programs and policies (both domestic and international). For the course project, learners will work with local organizations to help the latter enhance their evaluation capacity. Instructor: Abdullah. 3 units.

777K. Infectious Disease Epidemiology in Global Settings — Surveillance, Prevention and Control. MSc-GH core graduate coursework to build towards integrated understanding of infectious disease epidemiology. Three modules: 1) Foundations in Infectious Disease Epidemiology, 2) Disease Surveillance & Prevention, 3) Disease Treatment & Control. Course taught exclusively on-line. Open to graduate students at Duke and DKU only. Instructor: Staff. 3 units.

781K. Ungraded Research in Global Health. Individual research in a field of special interest, the central goal of which is a substantive paper containing significant analysis and interpretation of a previously approved topic. Course will be offered at Duke Kunshan University. Instructor: Dear. Variable credit.

790K. Special Topics in Global Health. Topics vary depending on semester and section. Topics may include global health ethics, field methods, health technologies, rapid needs assessment, and global health policies. Course will be offered at Duke Kunshan University. Instructor: Staff. 3 units.

791K. Independent Study in Global Health. Individual non-research directed study in a field of special interest on a previously approved topic, under the supervision of a faculty member, resulting in a significant academic product. Course will be offered at Duke Kunshan University. Instructor: Staff. 3 units.

Medical Physics

Professor Yin, *Director*; Professor Huang, *Site Director*; Assistant Professor Bowsher, *Director of Graduate Studies*; Professors Das, Dewhirst, Dobbins, Frush, Howell, Huang, Izatt, Johnson, MacFall, Oldham, Provenzale, Samei, Smith, Allen Song, Spicer, Trahey, Vaidyanathan, Jackie Wu, Qiuwen Wu, Ying K. Wu, Yin, Zalutsky, and Yoshizumi; Associate Professors Badea, Bida, Cai, Chang, Charles, Chen, Chin, Craciunescu, Driehuys, Kirkpatrick, Lo, Reiman, Segars, Tornai, Turkington, Wang, Wax, and Yoo; Assistant Professors Adamson, Bowsher, Kapadia, Liu, Mazurowski, O'Daniel, Petry, Ren, Haijun Song, and Truong; Accelerator Health Physicist Gunasingha

Medical physics is a discipline that applies physics to the needs of medicine, and has been instrumental in the development of the medical fields of radiology, radiation oncology, and nuclear medicine. The medical physics graduate program offers an MS degree, and is organized into three academic tracks: diagnostic imaging physics, radiation oncology physics, and nuclear medicine physics. Graduates are trained for employment opportunities in academic settings, clinical service, industry, or government labs. The medical physics program is

a collaborative interdisciplinary program, and the faculty are drawn from Duke Kunshan University and from sponsoring departments of the medical physics program at Duke University, which are radiology, radiation oncology, occupational and environmental safety (health physics), biomedical engineering, and physics. MS thesis projects may be performed with co-advisors from Duke Kunshan University and the medical physics program at Duke University. Current research interests of the faculty include magnetic resonance imaging and microscopy, advanced digital imaging instrumentation and algorithms, detector and display characterization, computer-aided diagnosis, ultrasound, monoclonal antibody imaging and therapy, intensity modulated radiation therapy, on-board imaging in radiation therapy, SPECT and PET imaging, neutron-stimulated imaging, and dosimetry. All students take common core courses in the first year, followed by concentration in a major track of study. The first semester of the second year is on the Duke University campus in Durham, North Carolina, where students attend classes and work on MS thesis research. The summer between first and second years may also be on the Durham campus, working on MS thesis research.

Courses Offered at Duke Kunshan University

500K. Radiation Physics
505K. Anatomy and Physiology for Medical Physicists
507K. Radiation Biology
510K. Radiation Protection
520K. Radiation Therapy Physics
530K. Modern Medical Diagnostic Imaging Systems
541K. Nuclear Medicine Physics
751K. Seminars in Medical Physics
791K. Independent Study in Medical Physics

Courses Offered at Durham to Duke Kunshan University (and Duke) Students during First Semester of Second Year

722. Advanced Photon Beam Radiation Therapy
723. Advanced Brachtherapy/Special Topics and Procedures
731. Advanced Medical Imaging Physics
726. Practicum on Monte Carlo Methods in Medical Physics (*)
743. Basic Concepts of Internal Radiation Dosimetry (*)
728. Clinical Practicum and Shadowing (RT)
748. Clinical Practicum and Shadowing (NM)
792. Clinical Practicum and Shadowing (Diagnostic Imaging)

(*) These two courses are offered only when there is sufficient student interest.

Course Offered during the Summer in Durham

729. Medical Physics Clinical Internship

Courses in Medical Physics (MEDPHY) at Duke Kunshan University

500K. Radiation Physics. A course covering the basics of ionizing and non-ionizing radiation, atomic and nuclear structure, basic nuclear and atomic physics, radioactive decay, interaction of radiation with matter, and radiation detection and dosimetry. Instructor consent required. Taught at Duke Kunshan University. Instructor: Huang. 3 units.

505K. Anatomy and Physiology for Medical Physicists. A course focused on medical terminology, biochemistry pertaining to MP, basic Anatomy and physiology, elementary tumor and cancer biology, and overview of disease in general. Upon completion, the student should: (a) understand anatomic structures, their relationships, their cross-sectional and planar projections, and how they are modified by attenuation and artifacts in the final images; (b) understand the physiology underlying radionuclide images, (c) understand how (a) - (b) are modified by disease, (d) identify anatomical entities in medical images (different modalities), and (e) identify basic features in medical images. Instructor consent required. Taught at Duke Kunshan University. Instructor: McClearn. 3 units.

507K. Radiation Biology. An introduction to radiation biology. This course will cover the biological effects of radiation, including mechanisms of DNA damage, and normal tissue injury. The principle context is with relevance to radiation therapy treatment. Taught at Duke Kunshan University. Instructor: Li, Zheng. 1 unit.

510K. Radiation Protection. Course discusses the principles of radiation protection dealing with major forms of ionizing and non-ionizing radiation, the physics and chemistry of radiation biology, biological effects of ionizing and non-ionizing radiations (lasers, etc.) at cellular and tissue levels, radiation protection quantities and units, medical HP issues in clinical environments, radiation safety regulations, and basic problem solving in radiation safety. Consent of instructor required. Taught at Duke-Kunshan-University. Instructor: Huang. 3 units.

520K. Radiation Therapy Physics. This introductory course has a clinical orientation, and reviews the rationale, basic science, methods, instrumentation, techniques and applications of radiation therapy to the treatment of a wide range of human diseases. Major radiation modalities are covered including low and high energy photon therapy, electron and proton therapy, and low and high-dose rate brachytherapy. The clinical process of treatment, methods of calculating dose to patient, and the role of the medical physicist in radiation oncology clinic, are covered in detail. Consent of instructor required. Taught at Duke-Kunshan-University. Instructor: Huang. 3 units.

530K. Modern Diagnostic Imaging Systems. This course covers the mathematics, physics and instrumentation of several modern medical imaging modalities starting with a review of applicable linear systems theory and relevant principles of physics. Modalities studied include X-ray radiography (film-screen and electronic), computerized tomography, ultrasound and nuclear magnetic resonance imaging. Consent of instructor required. Taught at Duke-Kunshan-University. Instructor: Bowsher. 3 units.

541K. Nuclear Medicine Physics. This course addresses the role of physics in nuclear medicine, particularly with regard to single-photon-emission and positron-emission imaging. Course topics include (i) relevant basic physics, such as radioactive decay and the interaction of radiation with matter, (ii) instrumentation methods for single-photon-emission and positron-emission imaging, (iii) tomographic acquisition and image reconstruction, and (iv) quantitative analysis of images. The course will be taught at Duke Kunshan University and covers the same topics as the Nuclear Medicine Physics course (MPH 541) taught at Duke University. Instructor consent required. Instructor: Bowsher. 3 units.

722K. Advanced Photon Beam Radiation Therapy. This course will cover the physics and clinical application of advanced external beam photon therapies with special emphasis on IMRT. Taught at Duke Kunshan University. Prerequisite: Medical Physics 520K. Instructor: Wu. 3 units.

723K. Advanced Brachtherapy / Special Topics and Procedures. Covers advanced treatment procedures including image-guided radiation therapy as well as its application in stereotactic radiation therapy and stereotactic radiosurgery. Instructor consent required. Open to graduate students at Duke Kunshan University. Instructor: Yin. Variable credit.

726K. Practicum on Monte Carlo Methods in Medical Physics. This course focuses on the fundamentals of Monte-Carlo simulations and provides hands-on experience with clinical Monte-Carlo codes used in medical dosimetry. The course will introduce software such as MCNP, EGS, FLUKA, GEANT and Penelope and companion data analysis software ROOT, PAW and CERNLIB. Students will study at least one major code and will perform two or more projects based on a clinically relevant task. Prerequisites: Calculus, modern physics, and programming. Knowledge of C, C++, or Fortran would be a plus. Consent of instructor required. Taught at Duke Kunshan University. Instructors: Gunasingha, H. Song, A. Kapadia. Variable credit.

728K. Clinical Practicum and Shadowing (RT). The course gives hands-on experience in practical aspects of medical physics as applied to radiation therapy. Special emphasis is given to the operation of various therapy units and dose measuring devices, techniques of measuring the characteristics of radiation beams, commissioning and quality assurance checks for radiation producing devices in the clinic. The course includes shadowing a clinician, technologist, or physicist, while performing their routine clinical tasks. The course has 3 components, each of which may be taken for 1 credit. Some components are offered in Summer Session II at Duke University, while other components are offered in Spring Semester at Duke Kunshan University. Instructor: Fang-Fang Yin. Variable credit.

731K. Advanced Medical Imaging Physics. The course includes advanced topics in diagnostic imaging including linear system theory, image quality metrology, digital radiography and mammography, new advances on three-dimensional imaging modalities, MRI, CT, ultrasound, and evaluation of diagnostic imaging methods. Prerequisite: Medical Physics 530K. Taught at Duke Kunshan University. Instructor: Dobbins. 3 units.

733K. Clinical Practicum and Shadowing (Diagnostic Imaging). Review and real-life exercises on principles of modern medical imaging systems with emphasis on the engineering and medical physics aspects of image acquisition, reconstruction and visualization, observations of imaging procedures in near clinical settings, and hands-on experience with the instruments. Modalities covered include ultrasound, X-ray, CT, and MRI. Offered at Duke Kunshan University. Prerequisite: Medical Physics 530K or equivalent. Instructor: Samei. 3 units.

734K. Advanced Topics of Non-ionizing-based Imaging Modalities. This course covers advanced topics in non-ionizing Imaging modalities such as Ultrasound and MR imaging, including speckle statistics, Doppler imaging, advanced MR pulse sequences, MR angiography, flow and diffusion etc. Instruction will consist of didactic lectures accompanied by hands-on laboratory exercises (practicum). Offered at Duke Kunshan University. Instructor consent required. Instructor: Robertson. 3 units.

751-3K. Professional Development Skills for Medical Physicists. This seminar provides important skills for students' professional development through a series of presentations on relevant topics that include public speaking, effective scientific and professional communication, interviewing skills, entrepreneurship, etc. Designed for second year Medical Physics students. Taught at Duke Kunshan University. Instructor: Wilson. 1 unit.

751K. Seminars in Medical Physics. Medical physics is the application of the concepts and methods of physics and engineering to the diagnosis and treatment of human disease. This course consists of weekly lectures covering broad topics in medical physics including diagnostic imaging, radiation oncology, radiation safety, and nuclear medicine. Lectures will be given by invited speakers drawn from many university and medical center departments including Biomedical Engineering, radiology, physics, radiation safety, and radiation oncology. Prerequisites: background in engineering or physics. Instructor: Bowsher. 1 unit.

752K. Seminars in Medical Physics. Medical physics is the application of the concepts and methods of physics and engineering to the diagnosis and treatment of human disease. This course consists of weekly lectures covering broad topics in medical physics including diagnostic imaging, radiation oncology, radiation safety, and nuclear medicine. Lectures will be given by invited speakers drawn from many university and medical center departments including Biomedical Engineering, radiology, physics, radiation safety, and radiation oncology. Taught at Duke Kunshan University. Prerequisite: Background in engineering or physics. Instructor: Kapadia. 1 unit.

758K. Medical Physics Practicum and Shadowing. The course gives hands on experience in practical aspects of medical physics. Special emphasis is given to the operation of various therapy units and dose measuring devices, techniques of measuring the characteristics of radiation beams, commissioning and quality assurance checks for radiation producing devices in the clinic. Diagnostic Imaging, and Nuclear Medicine, and Health Physics equipment and procedures may be included. The course includes shadowing a clinician, technologist, or physicist, while performing their routine clinical tasks. Consent of instructor required. Taught at Duke Kunshan University. Instructor: Yin. Variable credit.

763K. Advanced Radiation Biology in Medical Physics. This course will teach students about cutting-edge topics in the field of radiobiology that have relevance to medical physicists. The teaching will be through the format of a Journal Club. Class and group participation is required. Students will select a topic from either the reviewed manuscripts or an approved subject of their own choosing. The student will write a detailed report on this subject. Grading will be based upon quality of manuscript review presentations and the

detailed final written report. Instructor consent required. Taught in Durham. Instructor: Dewhirst, Palmer. 1 unit.

764K. Fundamentals of Radiomics, Genomics and Big Data Analytics. Radiomics refers to the extraction and analysis of large amounts of advanced quantitative imaging features with high throughput from medical images obtained with computed tomography, positron emission tomography or magnetic resonance imaging. Genomics refers to a branch of biotechnology concerned with applying the techniques of genetics and molecular biology to the genetic mapping and DNA sequencing of sets of genes or the complete genomes of selected organisms, with organizing of the results in databases, and with applications of the data (as in medicine or biology). This course introduces fundamentals of these concepts and their applications in big data analytics. Offered at Duke Kunshan University. Instructor consent is required. Instructor: Yin. Variable credit.

770K. Frontiers of Biomedical Science. A course covering frontier topics of biomedical science that are currently not within the domain of medical physics, but that medical physicists, nonetheless, need to have knowledge of. Topics include genomics, bioinformatics, proteomics, and others. Offered at Duke Kunshan University. Instructor: Bowsher. Variable credit.

790K. Independent Study in Medical Physics. Enables students to study medical physics topics of interest via an independent study format. Specific topic, learning objectives and study materials are developed by the student and the instructor. Offered at Duke Kunshan University. Instructor: Huang. 1 unit.

791K. Independent Study in Medical Physics. An independent research project with faculty advisor. Consent of instructor required. Instructor: Staff. Variable credit.

Other Graduate Level Courses Taught at Duke Kunshan University

Courses in Electrical and Computer Engineering (ECE)

550DK. Fundamentals of Computer Systems and Engineering. Fundamentals of computer systems and engineering for Master's students whose undergraduate background did not cover this material. Topics covered include: Digital logic, assembly programming, computer architecture, memory hierarchies and technologies, IO, hardware implementation in VHDL, operating systems, and networking. Taught at Duke Kunshan University in Kunshan, China. Corequisite: ECE 551DK. Instructor: Xin Li. 3 units.

551DK. Programming, Data Structures, and Algorithms in C++. Students learn to program in C and C++ with coverage of data structures (linked lists, binary trees, hash tables, graphs), Abstract Data Types (Stacks, Queues, Maps, Sets), and algorithms (sorting, graph search, minimal spanning tree). Efficiency of these structures and algorithms is compared via Big-O analysis. Brief coverage of concurrent (multi-threaded) programming. Emphasis is placed on defensive coding, and use of standard UNIX development tools in preparation for students' entry into real world software development jobs. Taught at Duke Kunshan University in Kunshan, China. Instructor: Ivan Mura. 3 units.

580K. Introduction to Machine Learning. Introduction to core concepts in machine learning and statistical pattern recognition, with a focus on discriminative and generative classifiers (nearest-neighbors, Bayes, logistic regression, linear discriminant, support vector machine, and relevance vector machine). Dimensionality reduction and feature selection. Classifier performance evaluation, bias-variance tradeoff, and cross-validation. Taught at Duke Kunshan University in Kunshan, China. Instructor: Xin Li. 3 units.

581K. Random Signals and Noise. Introduction to mathematical methods of describing and analyzing random signals and noise. Review of basic probability theory; joint, conditional, and marginal distributions; random processes. Time and ensemble averages, correlation, and power spectra. Optimum linear smoothing and predicting filters. Introduction to optimum signal detection, parameter estimation, and statistical signal processing. Taught at Duke Kunshan University in Kunshan, China. Instructor: Ming Li. 3 units.

586K. Vector Space Methods with Applications. Covers key concepts from advanced linear algebra that are used regularly in ECE/CS journal papers on signal processing, communications, circuit design, and machine learning (e.g., logic, topology, vector spaces, optimization). For each topic, key mathematical ideas/proofs will be presented and applied. The goal is to use application topics such as Markov chains, alternating projections, and pattern classification to illustrate important mathematical topics. Background in linear algebra, a high-level programming language, and probability is assumed. Taught at Duke Kunshan University in Kunshan, China. Instructor: Ming Li. 3 units.

590K. Advanced Topics in Electrical and Computer Engineering. Opportunity for study of advanced subjects related to programs within the electrical and computer engineering department tailored to fit the requirements of a small group. Taught at Duke Kunshan University in Kunshan, China. Instructor: Kishor Trivedi. 3 units.

650K. Systems Programming and Engineering. Focuses on a range of topics that are central to both the design of operating systems and the programming system-level software. Students will apply knowledge of basic concepts in operating systems, networking, and programming towards these two areas. Topics covered will include concurrency, process management, hypervisors, networking, security, databases, and file systems. Students will be expected to demonstrate their understanding in these areas through a series of programming assignments covering these topics. Taught at Duke Kunshan University in Kunshan, China. Prerequisite: ECE 550DK and ECE 551DK. Instructor: Ivan Mura. 3 units.

651K. Software Engineering. Teaches students about all steps of the software development lifecycle: requirements definition, design, development, testing, and maintenance. The course assumes students are skilled object-oriented programmers from prior courses, but will include a rapid introduction to Java. Students complete team-based semester-long software project which will progress through all phases of the software lifecycle. Taught at Duke Kunshan University in Kunshan, China. Prerequisite: ECE 551DK. Instructor: Ivan Mura. 3 units.

Courses in Environment (ENVIRON)

510K. Environmental Change and Evolution of Ecosystems. The processes that control ecosystem production, the carbon cycle, and delivery of ecosystem services as well as the resilience of ecosystems exposed to environmental stress have been molded by

millions of years of evolution under Global Change. Our developing understanding of earth system processes and current Global Change depends strongly on looking to the past and considering evolution of the climate system, plant and ecosystem processes, biological feedbacks, soils development, and all of these with respect to ecosystem (biosphere) carbon, water, and nutrient cycles. Taught at Duke Kunshan University. Instructor: Tenhunen. 3 units.

511K. China and US Comparative Environmental Law and Governance. This course will study China's environmental challenges and governance and compare them with those in the US. We will consider how environmental law may shape business, government, and culture, and the ways in which China and the US may learn from one another. Taught at Duke Kunshan University. Instructor: Guttman. 3 units.

561K. Chinese Environmental Policy. This course provides a venue for students to investigate the most recent environmental and energy policies in China. We will study the causes and consequences of environmental and energy problems. We will examine Chinese environmental and energy governance: institutions, laws and regulations for environmental protection, energy production and consumption. We will also explore the practices of Chinese government to address the emerging environmental and energy problems, with a special focus on climate change. Taught at Duke Kunshan University. Instructor: Zhang. 3 units.

581K. Global Environmental Health Problems: Principles and Case Studies. Many environmental problems occur both locally & globally. Having insights and experience from different parts of the world is important for students to gain problem-oriented training. This course will cover fundamental principles on physical & chemical processes related to major environmental problems. These principles will then be integrated to discussions of case studies addressing a specific set of problems. The case studies will involve the participation of invited guest instructors who are experts on specific topics/cases. Depending on preference of guest instructors, they can introduce a case study via online lecturing/chatting or providing a pre-made video. Online course. Open to Duke Kunshan students only. Instructor consent required. Instructor: Zhang. 3 units. C-L: Global Health 581K

583SK. Energy and National Security. 3 units. C-L: see Public Policy 583SK; also C-L: Political Science 663SK

590K. Special Topics in Environmental Sciences and Policy. Content varies each semester. Offered only at Duke Kunshan University. Instructor: Staff. 3 units.

593K. Independent Studies and Projects. For iMEP students or Duke students studying abroad at Duke Kunshan University. Directed readings or research at the graduate level to meet the needs of individual students. Units to be arranged. Instructor consent required. Instructor: Zhang, Ji, Furst, Li, Ward. Variable credit.

600K. Key Areas in International Environmental Policy. An overview of the key areas in international environmental policy. This course's seven modules cover international environmental economics, international environmental policy and politics, international environmental negotiations, policy debates and simulations. The principal goal of the course is to preview the application of social sciences (economics, public policy, and political science) to the environment, and to facilitate the translation of core curricular concepts into a variety of real-word applications. Students will engage in self-directed research and learning on international environmental policy. Taught at Duke Kunshan University. Instructor: Fürst. 3 units.

601K. Building an NGO Toolkit: From Design to Monitoring. Non-governmental organizations (NGOs) that address conservation issues in China face large, complex, and urgent problems. To be successful, these NGOs must be equipped with the skills to be efficient, effective, and transparent when planning, implementing, and monitoring their conservation initiatives. In this hands-on course, students will become familiar with decision-support tools that allow organizations to systematically address strategic planning, project design, project budgeting, implementation, monitoring, evaluation, communication, and donor transparency. Students will apply these tools to real-world conservation problems. Taught at Duke Kunshan University. Instructor: Losos. 3 units.

602K. Natural Resources and Protected Area Management. Toolkit for practical natural resources management and understanding the challenges involved in protected area management. Wildlife monitoring, environmental change tracking, socio-economic surveys and stakeholders engagement. Combines lectures for essential survey methods and experiential education through a seven-day field course. Students will design their own group project to carry out in the local context. Taught in Kunshan, China, at Duke Kunshan University. Instructor: Li. 3 units.

637K. Population and Environmental Dynamics Influencing Health. 3 units. C-L: see Global Health 637K

640K. Climate Change Economics and Policy. Explores the economic characteristics of the climate change problem, assesses national and international policy design and current implementation issues, and surveys the economic tools necessary to evaluate climate change policies. Prerequisite: Public Policy 810 and 812, or equivalent, or consent of the instructor. Instructor: Pizer. 3 units. C-L: Public Policy 585K

716K. Modeling for Energy Systems. Introduction to the use of computer models and the methods of optimization and simulation for students interested in the analysis of energy systems; emphasis in the formulation of optimization problems and simulation models, and in the identification of the available methods to solve them. Students should also be familiar with capital-sigma (¿) notation for compactly representing summation of similar terms, and know the basics of Excel. Taught in China at Duke Kunshan University. Recommended prerequisite: college-level calculus (including partial derivatives of functions of several variables), probability theory, and basic linear algebra (how to write—and solve—systems of linear equations in matrix form). Instructor: Patiño-Echeverri. 3 units.

718K. Environmental Sciences. This course introduces students to the core concepts and topics of environmental sciences. It will give an in-depth overview of main themes in the field of environmental studies: global environmental challenges, human population trends, global atmospheric changes, air, land and water resources and pollution, the ocean and fisheries, key ecosystems (forests, grasslands, wetlands, freshwater and marine environment), biodiversity and conservation, non-renewable and renewable energy, agriculture and sustainable production. Quantitative and qualitative research methods will be introduced with case studies. Taught at Duke Kunshan University. Instructor: Li. 3 units.

736K. Planetary Health and Environmental Epidemiology. Study the human health impacts of accelerating environmental

change through interdisciplinary approaches including environmental science, political science, public health and social science; engage in diverse materials from many types of examples of planetary health research, from nutrition and mental health, to infectious and non-communicable diseases. A special emphasis will be placed on environmental epidemiology. Taught in China at Duke Kunshan University. Recommended prerequisite: one quantitative methodology class (statistics, biostatistics, epidemiology, or econometrics). Instructor: Ji. 3 units.

759K. Environmental GIS. Core concepts and latest application of geographic information system in environment area; an in-depth overview of the key data types (raster and vector files) in this area, data collection and entry, data management, data analysis and output using ArcGIS; introduction of application of GIS in real world problem solving, such as species habitat mapping and conservation planning. Students will be exposed to Google Earth, QGIS and other open source GIS tools. Taught in China at Duke Kunshan University. Instructor: Li. 3 units.

781K. Narrating Nature: Documentaries For Environmental Studies. Evaluate and illustrate how film documentary media can help communicate, critique, and educate the public about the complex environmental and social issues of our times. Taught in China at Duke Kunshan University. Instructor: Rojas-Sotelo. 3 units.

803K. Environmental Policy Process. This course provides an introduction to and overview of the environmental policy process. The first part of the course introduces the environmental policy process with case studies from different countries exemplifying regional differences. The second part of the course introduces various aspects and challenges in the design and formation of environmental policies. The third part of the course focuses on implementation and tools to evaluate the impact of environmental policies. The fourth part of the course discusses the formation of international environmental policies and their impact on national priorities. Taught at Duke Kunshan University. Instructor: Furst. 3 units.

805K. Environmental Economics. An overview of environmental economics by introducing analytical methods and tools to analyze environmental problems and identify policy solutions; including 1) a microeconomic foundation of environmental economics, with a focus on market efficiency and market failures; 2) environmental policy decision tools, such as benefit-cost analysis and cost-effectiveness criterion; 3) environmental regulation, with topics covering command-and-control regulation, market-based approaches, and behavioral interventions. Instructor: Zhang. 3 units.

806K. Environmental Economics II. This course provides for continued development and practice of skills learned in Statistics and Program Evaluation and Environmental Economics. Students develop conceptual and professional skills related to environmental policy evaluation. The goal is to stimulate critical thinking about today's environmental problems and the public policies designed to improve them by implementing the theories and principles acquired in class. Prerequisites: Public Policy 870K and Environment 805K or instructor consent. Taught at Duke Kunshan University. Instructor: Kim. 3 units.

835K. Environmental Law. Emphasizing the practical use and application of legal concepts within the context of pollution control and resource management; exploring the role of law, regulation and governance in protecting, managing and restoring the environment and natural resources. Taught in China at Duke Kunshan University. Instructor: Furst. 3 units.

898K. Master's Project International Master in Environmental Policy II. Designed to help students develop a master's project (MP). Guide students in conceptualizing an idea, identifying key environmental policy question, writing a prospectus, finding an advisor, finding a client, designing an analytical approach, data collection, and a producing a draft of their project. Taught at Duke Kunshan University. Instructor: Ji. 3 units.

899K. Master's Project II. Follows after Environment 898K, in which students conceived of, designed, and completed the initial steps of their master's project (MP). Students will complete their MP and present project findings. Students will review and revise project content in peer-to-peer and instructor-to-student settings, critically evaluate their methods and data, search for new ways to leverage their findings, and tighten their resulting analysis. Required course for iMEP students. Taught at Duke Kunshan University. Instructor: Ewing. 3 units.

Courses in Graduate Studies (GS)

705K. Responsible Conduct of Research: DKU Master's Workshop. Graduate level training in research ethics is a formal degree requirement for every Master's degree student at Duke Graduate School/DKU beginning with Fall 2014 matriculants. Topics include the Duke Community Standard, academic integrity, research ethics, plagiarism and proper citation methods, authorship and intellectual property, and Duke resources to assist graduate students. Entering Master's degree students must attend a four-hour Orientation on various RCR topics to include training within departmental groups led by faculty. Instructor: Moreton. 0 units.

720K. Academic Writing for EFL Students. In Academic Writing, students improve their writing skills by writing multiple drafts of some of the standard graduate-level text forms. On all drafts, peer review and instructor feedback are offered to help students advance to their proficiency levels. In the process of writing their papers, students also develop an awareness of text purpose and audience expectation while improving grammar, vocabulary and reading skills. Specific skills such as recognizing and avoiding plagiarism are taught through appropriate paraphrasing and source citation. Instructor: Bryson. 3 units.

721K. Academic Communication Skills. For non-native English speakers. Instruction in oral communication, with significant focus on assessing and improving English pronunciation and listening skills. Develops oral communication skills in specific academic settings, e.g. seminars, professional networking, interviews; includes field-specific presentations and Q&A. Participation in and facilitation of group discussions for mastery of language functions, grammatical accuracy, and fluency. Extensive vocabulary work. Filmed presentations with instructor feedback, peer review and self-evaluation. Individual instructor/student conferences. Taught at Duke Kunshan University. Instructor: Allen. 3 units.

Course in Political Science (POLSCI)

663SK. Energy and National Security. 3 units. C-L: see Public Policy 583SK; also C-L: Environment 583SK

Courses in Public Policy (PUBPOL)

583SK. Energy and National Security. Energy and National Security examines links between available, reliable, affordable, and sustainable energy supplies and economic and national security of an advanced economy in early the 21st Century. Countries of particular interest are China and the United States. Both are net energy importers, depend on smoothly functioning global energy markets and open sea-lanes, and face ethical and environmental issues as they choose among their energy sources and suppliers. Both also are highly dependent on energy to power their economies, fuel their militaries, and preventing enemies or competitors from inflicting damage on their economies or populations. Taught at Duke Kunshan University. Instructor consent required. Instructor: Staff. 3 units. C-L: Environment 583SK, Political Science 663SK

585K. Climate Change Economics and Policy. 3 units. C-L: see Environment 640K

631K. Environmental Science Research Methods. Research methodology for environmental sciences, including health sciences and social sciences. Topics covered include quantitative and qualitative methods, experimental and quasi-experimental research designs, sampling and sample size determination, survey design and implementation, and the process of publishing academic research. Students will review published research of other scholars and critically evaluate the strengths and weaknesses of the methods they employ in addressing their specific research questions. Taught at Duke Kunshan University in Kunshan, China. Instructor: Ji and Ward. 3 units.

872K. Environmental Economics Policy Practicum. This course will use environmental policy issues as a platform for students to develop their analytic, writing, and oral presentation skills. Students will work on three environmental policy problems over the course of the semester. Each will include a diverse set of readings and a prompt. Based on these readings, students will conduct policy analysis and produce a set of deliverables such as briefing memos, policy decision memos, visual presentations, and oral presentations. Throughout the semester, students will receive feedback from instructors and peers and learn to work both individually and collaboratively. Class sessions will be devoted to discussions about the policy problems, evaluating strengths of arguments, in-class presentations, peer feedback and collaborative work-sessions. Taught at Duke Kunshan University. Instructor: Schanzer. 3 units.

Les Todd

Special Study Centers

Megan Morr

Bass Connections

Bass Connections is a university-wide initiative that brings together faculty, postdocs, graduate and professional students, and undergraduates to explore societal challenges in interdisciplinary research teams. Past teams have tackled societal challenges around the world, ranging from the health needs of refugees in Durham, to strategies for using American forests and wetlands as carbon sinks, to higher education in Brazil.

Bass Connections includes:

- **Year-Long Research Teams** in which graduate students have the opportunity to receive academic credit while also gaining experience in applied research, project management and leading teams
- **Summer Research Programs** in which graduate students serve as project mentors for teams of undergraduate students conducting research
- **Interdisciplinary, Collaborative Courses**

For graduate students, benefits of participating in a Bass Connections project team include:

- Enhancing dissertation or master's thesis research
- Coauthoring publications
- Deepening relationships with faculty
- Gaining experience in project management and leading teams
- Building career-enhancing skills to stand out on the job market
- Networking with colleagues in diverse fields
- Getting experience mentoring others, particularly undergraduates
- Gaining opportunities for possible funding

Each year, Bass Connections hosts more than sixty year-long research teams, thirty-five summer research teams, and approximately thirty-five courses. For more information on Bass Connections and how to get involved, visit https://bassconnections.duke.edu/. For examples of graduate students who have participated, visit https://bassconnections.duke.edu/student-resources/student-stories.

University Institutes and Centers

Duke Global Health Institute

The Duke Global Health Institute (DGHI) is one of the leading academic centers for the study of global health. Recognizing that global health problems stem from economic, social, environmental, political and health care inequalities, DGHI brings together interdisciplinary teams to solve complex health problems and to train the next generation of global health scholars. It offers an innovative Master of Science in Global Health Program, a doctoral certificate in global health, and mentorship and support to Duke doctoral candidates pursuing global health research. Most programs require a field research experience in locations around the world. In addition to formal programs, DGHI engages students through seminars, conferences, and a journal club. For more information, visit the DGHI website at https://globalhealth.duke.edu/.

Duke Institute for Brain Sciences

The Duke Institute for Brain Sciences (DIBS) is a cross-school, campus-wide, interdisciplinary institute dedicated to building an interactive community of brain science research and scholarship, to advancing interdisciplinary research and education that transforms the understanding of brain function, and to providing innovative solutions for the challenges facing health and society. As one of Duke's Signature Institutes, DIBS encourages innovation and collaborations that transcend the boundaries of traditional disciplines, bringing together a diverse community of academics from the biomedical sciences, social sciences, physical sciences, humanities, law, business, public policy, mathematics, computer sciences, and engineering. DIBS administers the Cognitive Neuroscience Admitting Program, whose students later matriculate into the many PhD programs within the brain sciences. DIBS also partners with individual departments to support their PhD programs through student-focused events, sponsorship of collaborative research, and ongoing training programs.

For more information, visit the DIBS website at https://dibs.duke.edu/.

Center for Cognitive Neuroscience

The Center for Cognitive Neuroscience (CCN)—a unit of the Duke Institute for Brain Sciences—serves as the central focus for research, education, and training in the biological, psychological, and computational mechanisms mediating higher brain functions, including perception, attention, memory, emotion, social cognition, motor behavior, decision-making, and consciousness. Cognitive neuroscience is by its nature interdisciplinary. It addresses long-standing questions about brain and mind from new perspectives that cut across traditional intellectual and departmental boundaries. To advance this agenda, the DIBS-CCN and its activities bring together faculty from multiple schools in the university, including the Trinity College of Arts & Sciences, the School of Medicine, the Pratt School of Engineering, and The Fuqua School of Business, representing departments of psychology and neuroscience, neurobiology, psychiatry, biomedical engineering, philosophy, evolutionary anthropology, computer science, linguistics, neurology, radiology, finance, and marketing.

Students can obtain post-graduate training in cognitive neuroscience on either of two tracks. The Cognitive Neuroscience Admitting Program (administered by DIBS) provides a point of entry for incoming PhD students, who complete coursework and laboratory rotations within the program before matching, during their second year, with an advisor and a department in which to earn their PhD. Alternatively, students admitted directly to a departmental program can complete coursework and research that lead to a certificate in cognitive neuroscience. For additional information, see the entry "Cognitive Neuroscience" on page 118 in this bulletin or email colleen.bauer@duke.edu.

For more information, visit the DIBS-CCN website at https://dibs.duke.edu/centers/ccn.

John Hope Franklin Humanities Institute

Founded in 1999, the Franklin Humanities Institute (FHI) is built on a collaborative model fitting Duke's emphasis on facilitating interdisciplinarity. Through an array of innovative programs, the insitute seeks to encourage the conversations, partnerships, and collaborations that are continually stimulating creative and fresh research, writing, and teaching in the humanities at Duke. The FHI is one of six university-wide institutes reporting to the Office of the Vice Provost of Interdisciplinary Studies.

The FHI is located in a 12,000 square-foot space in Smith Warehouse on Duke's East Campus (Bays 4 and 5). Since 2010, the FHI has been home to the Humanities Labs, which contribute to Duke's research and pedagogical missions by convening groups of faculty, graduate students, and undergraduates around discipline-crossing projects. Lab projects are organized thematically (e.g. Health Humanities, Social Movements, From Slavery to Freedom) and run for two-three years. One of these labs is the PhD Lab in Digital Knowledge, which provides an arena in which PhD students in the humanities and interpretive social sciences can learn about digital approaches in research, teaching, scholarly communication, and public engagement. The PhD Lab is a part of the broader Digital Humanities Initiative (DHI@FHI), which offers additional opportunities for scholarly and pedagogical engagement.

The FHI is the Duke anchor point of the Academy for Global Humanities and Critical Theory, a trilateral partnership involving Duke, University of Bologna, and University of Virginia. The academy sponsors an annual two-week Summer School in Bologna, which has a strong track record of bringing young scholars from the Global South into dialogue with their counterparts from the United States and Europe. Each year up to five Duke humanities doctoral students receive travel grants to participate.

The FHI hosts a wide range of public lectures, conferences, seminars/workshops, and other events throughout the academic year, notably the Annual John Hope Franklin Distinguished Lecture and weekly tgiFHI series, which features Duke faculty talks on their works-in-progress. In conjunction with Faculty Book Manuscript Workshops, the FHI also offers workshops and other programs on scholarly publishing that may be of interest to graduate students.

The Center for Philosophy, Art, and Literature (PAL@FHI), an affiliated center of the FHI, sponsors a graduate certificate, an annual graduate conference in collaboration with Stanford University, and other programs designed to support doctoral students. The Duke Human Rights Center at the Franklin Humanities Institute (DHRC@FHI) provides summer research grants for graduate students and research opportunities through its environmental justice and human rights initiative.

For more information, visit the FHI website at https://fhi.duke.edu/.

Kenan Institute for Ethics

The Kenan Institute for Ethics at Duke University is an interdisciplinary "think and do" tank committed to promoting moral reflection and commitment, conducting interdisciplinary research, and shaping policy and practice. At Duke, the institute serves as a central hub for analysis, debate, and engagement on ethical issues at the university and beyond.

The Kenan Institute for Ethics currently features work in six program areas: global migration, human rights, ethical tech policy, moral attitudes and decision-making, religions and public life, and virtues and values.

For more information, contact the Kenan Institute for Ethics, Box 90432, 102 West Duke Bldg., Durham, NC 27708; (919) 660-3033; https://kenan.ethics.duke.edu/.

Nicholas Institute for Environmental Policy Solutions

The Nicholas Institute for Environmental Policy Solutions improves environmental and energy policy making worldwide through objective, fact-based research to confront the climate crisis, clarify the economics of limiting carbon pollution, harness emerging environmental markets, put the value of nature's benefits on the balance sheet, develop adaptive water management approaches, and identify other strategies to attain community resilience.

Established in 2005, the Nicholas Institute has a track record of leadership in addressing these and other urgent environmental and energy challenges and for helping decision makers to apply the best and most current knowledge to them. The institute's ability to provide unbiased evaluations of policy risks and rewards has led to a host of interdisciplinary environmental and energy solutions. These successes are owed to the intellectual horsepower of the institute's staff and the unparalleled expertise they draw from at Duke University, the openness of those who work with the Nicholas Institute outside of Duke, the institute's capacity to target research problems and opportunities as they arise, and its ability to bring decision makers and stakeholders together in a policy-neutral setting to share analyses.

Tim Profeta serves as director of the Nicholas Institute, which is composed of the following five interdisciplinary programs: climate and energy, ocean and coastal policy, state policy, water policy, and ecosystem services.

For more information about the Nicholas Institute and its opportunities for students, please visit, please visit https://nicholasinstitute.duke.edu/ or email nicholasinstitute@duke.edu.

Social Science Research Institute

The Social Science Research Institute (SSRI) brings together researchers with interests in problems that cross the various social and behavioral sciences, including problems that connect with the humanities and natural sciences. The institute promote multidisciplinary collaboration among such scholars as they work on important social issues that are challenging to address fully from within any given

discipline.

SSRI's core mission is to catalyze pioneering social science research and methods and their broad application by:

- Developing and populating a 21st century social science data infrastructure that facilitates collaboration, empowers researchers to ask new questions, and addresses confidentiality and privacy concerns surrounding sensitive and protected data;
- Providing support across the full range of social science methods to researchers and teams at all levels;
- Facilitating cross-disciplinary connections between researchers interested in significant social problems and, where appropriate, supporting student and external engagement in these connections; and
- Incubating new cross-disciplinary collaborations that confront important social problems, and assisting in scaling such collaborations while connecting them, when appropriate, to external support.

SSRI, in collaboration with iiD, has created the new Duke University Master in Interdisciplinary Data Science (MIDS)—a home for creative problem-solvers who want to use data strategically to advance society. MIDS combines rigorous computational and technical training with field knowledge and repeated practice in critical thinking, teamwork, communication, and collaborative leadership to generate data scientists who can add value to any field.

Since opening its doors in the summer of 2003 and becoming one of Duke's signature University Institutes in 2006, SSRI has continued to grow and now has two locations: SSRI (Gross Hall) and SSRI (Erwin Mill).

SSRI (Gross Hall) provides research space and support for social science faculty and students in Gross Hall near the heart of West Campus. Enter the new space and be surrounded by team rooms devoted to research and projects. A welcoming large space, known as The Connection, features informal areas to cross paths on the way to coffee and refreshments as well as extensive whiteboards and writable glass to facilitate the instant exchange of ideas. Seminars, classes and teams operating in the space are able to draw on an extensive social science data infrastructure backed up by a 21st century help desk (Connection Bar), providing assistance with data access, data management and social science methods. This combination of space and research infrastructure serves as an incubator for social science research by faculty and students at Duke.

SSRI (Erwin Mill) is located at Erwin Mill near East Campus and supports a broad range of research centers including:

- Center on Biobehavioral Health Disparities Research (BHDR)
- Behavioral Science & Policy Center (BSPC)
- Global Value Chains Center (GVCC)
- Interdisciplinary Behavioral Research Center (IBRC)
- Center on Genomics, Race, Identity, Difference (GRID)

For more information, visit the SSRI website at https://ssri.duke.edu.

The Center for Child and Family Policy

The Center for Child and Family Policy brings scholars from many disciplines together with students, policymakers, and practitioners to address problems facing children in contemporary society. As a national leader in addressing issues of early childhood adversity, education policy reform, youth violence and problem behaviors, and adolescent substance abuse prevention, the center bridges the gap between research and policy by assisting policymakers in making informed decisions based on sound evidence and research. In addition, the center periodically offers graduate student fellowships which support the development of promising students who are interested in a career that blends basic social science with public policy. The Center for Child and Family Policy is housed at the Sanford School of Public Policy and is located in Rubenstein Hall, Duke Box 90545, Durham, NC 27708-0545; (919) 613-9303; https://childandfamilypolicy.duke.edu/.

The Duke Population Research Institute (DUPRI)

The Duke Population Research Institute, an SSRI-affiliated center, promotes a variety of activities related to the advanced study of demographic issues and supports the pursuit of advanced degrees in sociology, economics, public policy, and other disciplines related to population studies. DUPRI's faculty members and research scientists have been awarded a large number of research grants spanning a full range of population topics and welcome the expansion of intellectual activity at Duke devoted to population research in the classroom as well as in the laboratory and in the field. Inquiries for training and research opportunities, especially as related to sociology, biology, and health science, may be directed to DUPRI faculty member Dr. Angela O'Rand, Director of the Center for Population Health and Aging, Sociology Department, Box 90088, Durham, NC 27708-0088. Inquiries for all other training and research opportunities related to population research, such as those related to economics, public policy, and psychology, may be directed to DUPRI faculty member Dr. M. Giovanna Merli, Director of the Duke Population Research Center, Duke University, Sanford School of Public Policy, Box 90097, Durham, NC 27708-0097.

School-Based Interdisciplinary Centers

There are more than sixty interdisciplinary centers based within Duke's ten schools, many of which offer programs, certificates, research opportunities, and other programming for graduate students. More information about all of the interdisciplinary institutes and centers can be found on the interdisciplinary studies website at https://interdisciplinary.duke.edu/.

International Centers

John Hope Franklin Center for Interdisciplinary and International Studies

The John Hope Franklin Center for Interdisciplinary and International Studies is a unique consortium of programs committed to revitalizing notions of how knowledge is gained and exchanged.

Participants from a broad range of disciplines converge to explore intellectual issues, including some of the most pressing social and political themes of modern time: race and race relations, the legacy of the African American experience, equality and opportunity among diverse populations, and the implications of accelerated globalization. At its core, the Center claims an intrepid mission: to bring together humanists and those involved in the social sciences in a setting that inspires vigorous scholarship and imaginative alliances. In this way, historians, artists, literary scholars, and philosophers contribute to a rich understanding of moral and ethical issues.

Inspired by the example of John Hope Franklin—Duke professor emeritus, historian, intellectual leader, and life-long civil rights activist—the Franklin Center fosters fresh approaches to scholarship and learning while offering stimulating opportunities to the larger community.

On the bus line and within walking distance to other parts of Duke's campuses, the Center is easily accessible to residents from the Durham and Triangle area, who are invited to participate in and experience workshops, lectures, exhibits, and other public events.

In sum, the Franklin Center seeks to meld past knowledge and present questions, international perspectives and local concerns, timeless scholarship and timely issues. For more information, visit the center's website at https://jhfc.duke.edu/.

Duke University Center for International and Global Studies (DUCIGS)

Located in the John Hope Franklin Center for Interdisciplinary and International Studies, the Duke University Center for International and Global Studies (DUCIGS) supports the globalization efforts of the university. DUCIGS is home to various international area studies centers, councils and initiatives including the Africa Initiative (AI), the Asian Pacific Studies Institute (APSI), the Duke Brazil Initiative (DBI), the Center for Latin American and Caribbean Studies (CLACS), the Concilium on Southern Africa (COSA), the Center for Slavic, Eurasian, and East European Studies (CSEEES), the Slavic and Eurasian Languages Resource Center (SEELRC), the Duke India Initiative (DII), the Duke Islamic Studies Center (DISC), the Duke University Middle East Studies Center (DUMESC), the Global Asia Initiative (GAI), and the Observatory on Europe.

The mission of DUCIGS is to:

- Support, engage, and connect researchers, students, departments, and schools to work on international issues
- Promote interdisciplinary research and education to understand and engage with challenging global issues
- Support and coordinate the activities of the area studies centers, councils and initiatives

Historically, DUCIGS was instrumental in developing new international area studies centers at Duke. In recent years, it has concentrated on creating long-term initiatives with strong interdisciplinary and interregional emphases. DUCIGS sponsors a wide range of global thematic activities, including seminars, workshops, research programs, conferences, film series, art exhibitions, readings and performances, many of which are open to undergraduate and graduate students. It is an established goal of DUCIGS to ensure that faculty and students have access to leading scholars and government officials from around the world; it does this through a range of activities from single lectures to semester-long visiting appointments. DUCIGS organizes the biennial Anthony Joseph Drexel Biddle, Jr. Lecture on International Studies. It also regularly hosts a Diplomat in Residence from the U.S. Department of State who advises students seeking careers in the foreign service.

Four region-specific initiatives, the Africa Initiative (AI), the Duke India Initiative (DII), the Global Asia Initiative (GAI), and the Observatory on Europe are also housed within DUCIGS. The AI is a faculty-led initiative that brings scholars together—from across Duke University and the Duke University Health System—who have a shared interest, whether through their research or programmatic activities, in the countries and cultures of the African continent. The goals of the initiative are to:

- Build connections between schools, programs, institutes and departments;
- Continue to foster new collaborations across disciplines;
- Transport existing knowledge gained whether in Durham or the African continent to other Duke locations around the globe; and
- Explore and pursue new funding opportunities and sponsored research.

The AI encourages discussion about African politics, economics, society, and culture and fosters interdisciplinary academic and research collaborations related to Africa on campus. Duke faculty and students are also actively engaged in service-learning opportunities, courses, and research projects on the African continent.

The DII builds and fosters collaborations at Duke and with partners across India. The initiative supports research and educational activities related to India, from distance learning classes to India-related seminars and working groups. In doing so, the DII aims to:

- Develop deep and sustaining ties with Indian partners
- Foster multidisciplinary research collaborations on India at Duke
- Encourage dialogue about India among research communities on campus and abroad

The DII is also a partner of Duke University India, an initiative based in Bangalore to coordinate Duke research, learning and engagement activities in India and Southeast Asia.

The GAI at Duke has its origins in the efforts by groups across the world to articulate a new paradigm that looks at Asian nations, cultures, and civilizations in terms of their connections, interactions, and interdependencies in both historical and geographical space. The motive for such an exploration derives from contemporary research that exposes the entangled relations between countries in East, Southeast, South and West Asia not only in contemporary affairs, but also in the distant past. The GAI supports research on inter-Asian topics that are collaborative and interdisciplinary, involving research in more than one country. The GAI joined the Social Science Research Council's (SSRC) Inter-Asian Connections program as a coordinating partner and a hub for nodal research activities in March 2016. The SSRC project has been active together with its coordinating partners at the National University of Singapore, Hong Kong

University, Yale University, the University of Göttingen and several other sponsoring partners across the world since 2008.

The Observatory on Europe is a DUCIGS initiative dedicated to supporting interdisciplinary research, study, and discussion about Europe at Duke. The Observatory acts as a catalyst for scholarship on Europe for faculty and students by organizing and supporting workshops, conferences, panels, publications and exhibitions on contemporary as well as historically grounded research on issues related to single European nations, the European Union, and connections with other regions of the world. Themes of interest include the aftermath of Brexit, the rise of populism and the polarization of the political spectrum, the refugee crisis, challenges at the border of Europe, and the economic and geopolitical interactions with the United States, China, Africa, and the Middle East. Additionally, DUCIGS offers a graduate certificate in Interdisciplinary European Studies. The graduate certificate is open to all advanced degree students who meet the necessary requirements.

In recognition of its commitment to international studies, DUCIGS is a recipient of numerous grants from federal agencies and private foundations. The center has an annual competition for graduate summer research grants. It also provides yearlong grants to graduate student working groups on global issues. DUCIGS supports student research activity by providing both pre-award and post-award services. The center supports instruction in less commonly taught languages, in addition to offering support to students studying these languages. Since the early 2000s, DUCIGS has administered the Fulbright Visiting Scholars Program, which brings to campus scholars from over 100 countries around the world to conduct post-doctoral research at US institutions. This program is sponsored by the US Department of State and administered nationally through the Council for International Exchange of Scholars (CIES), a branch of the Institute for International Education (IIE). DUCIGS also manages the Fulbright-Hays Doctoral Dissertation Research Abroad (DDRA) Fellowship. This fellowship, through an annual national competition, provides grants from the US Department of Education to fund individual doctoral students to conduct research in other countries in modern foreign languages and area studies for periods of six to twelve months. These projects are intended to deepen research knowledge on, and help the United States develop capability in, areas of the world not generally included in US curricula. Duke students have regularly received grants for research in various disciplines among diverse locations around the world. For more information, please contact (919) 668-1663 or visit https://igs.duke.edu/. Address: John Hope Franklin Center, 2204 Erwin Road, Office 125.

Asian/Pacific Studies Institute (APSI)

The Asian/Pacific Studies Institute (APSI) is the focal point of research and teaching on the Asia/Pacific region at Duke University. Since 1981, APSI has been supporting a dynamic group of faculty with a broad range of interdisciplinary expertise in humanities and social sciences. APSI fosters an active community of scholars of East and Southeast Asia, promotes the highest standards of undergraduate and graduate education in Asian Studies, and enhances understanding of Asian cultures at Duke and across the Triangle. APSI also offers an interdisciplinary MA program in East Asian studies, a joint JD/MA program, and an East Asian Studies certificate for students pursuing undergraduate and graduate degrees in a variety of disciplines who wish to document their specialization in East Asia. It also administers the Duke in China Program in conduction with the Global Education Office for Undergraduates. John Hope Franklin Center, 2204 Erwin Road, Box 90411, Duke University, Durham, NC 27708-0411. Email apsi@duke.edu or visit https://asianpacific.duke.edu/.

Center for Latin American and Caribbean Studies (CLACS)

The center coordinates undergraduate and graduate education in Latin American and Caribbean Studies and promotes research and dissemination of knowledge about the region. CLACS offers an interdisciplinary undergraduate certificate in Latin American studies, which students can earn in conjunction with their bachelor's degree. Additional information about this certificate program can be found in the chapter "Departments, Programs, & Course Offerings" on page 66. Faculty associated with the center offer a wide range of courses in the humanities, social sciences, environmental sciences, Portuguese, Spanish, French, and Haitian Kreyol, and K'iche' Maya. The center also sponsors visiting professors from Latin America, speaker series, conferences, summer research grants, and DukeEngage programs throughout the region. In addition, CLACS and the Institute for the Study of the Americas at The University of North Carolina at Chapel Hill sponsor the Consortium in Latin American Studies that includes occasional exchanges of faculty members from each institution and joint undergraduate and graduate student working groups as well as the annual Latin American Film Festival and consortium conference. The Duke Brazil Initiative (DBI) fosters research and language training opportunities for students interested in multidisciplinary studies focused on Brazil and the Amazon basin. The DBI sponsors research grants, an annual Global Brazil Conference, exchanges with Brazilian students, faculty and artists, and team-based projects through the Global Brazil Humanities Lab. For more information, please contact (919) 681 3981, email las@duke.edu, or visit https://latinamericancaribbean.duke.edu/. CLACS is located in the John Hope Franklin Center, 2204 Erwin Road, Office 134.

Center for Slavic, Eurasian, and East European Studies (CSEEES)

The Center for Slavic, Eurasian, and East European Studies (CSEEES) supports courses, comparative research, teacher training, and graduate student and undergraduate student training in the social sciences and humanities associated with Russia, Eastern and Central Europe, and Eurasia. Faculty associated with CSEEES offer courses in a broad range of disciplines, including history, economics, cultural anthropology, political science, literature, linguistics, and languages. CSEEES offers two graduate certificates, sponsors internationally renowned speakers, and is the primary organization working with Ambassador Jack Matlock on research and writing about Russian-American relations, sponsored by the Carnegie Corporation. For more information, please contact (919) 660-2421 or visit https://slaviccenters.duke.edu/. CSEEES is located in the Languages Building.

Slavic and Eurasian Languages Resource Center (SEELRC)

The Slavic and Eurasian Languages Resource Center (formerly Slavic and East European) combines the resources of Duke University with outstanding research teams drawn from universities and government agencies across the United States. SEELRC focuses on the languages of thirty-four countries with a combined population approaching two billion people and most of these languages fall into the category of less commonly taught languages (LCTLs). The cardinal purpose of SEELRC is to improve the national capacity to meet strategic US needs in teaching and learning the LCTLs of Eurasian (including but not restricted to Eastern and Central Europe, and the former Soviet Union). SEELRC provides teacher training in proficiency testing and certification and technologies, conducts research with direct outcomes with a focus on the advanced level in the languages of the region, and develops authentic language instructional materials in multi-platform technological formats and diagnostics. For more information, please contact (919) 660-2421 or visit https://

slaviccenters.duke.edu/. SEELRC is located in the Languages Building.

Concilium on Southern Africa (COSA)

The Concilium on Southern Africa is an interdisciplinary network of faculty committed to widening and deepening relationships between Duke University and the countries and peoples of Southern Africa, and offering ongoing opportunities on the Duke campus for faculty and students to engage with Southern African concerns. To this end, COSA encourages a wide range of scholarly engagement with Southern Africa, initiating or coordinating discussion groups, faculty and student exchanges, and visits to Duke by Southern African scholars, artists, and social commentators; provides a forum to share research, reports on student visits, and educational experiences; explores issues relating to Southern Africa through reading groups and lectures; organizes conferences and seminars to expand knowledge of, and deepen relationships with, Southern Africa; and welcomes faculty members and other professionals in the Triangle interested in engagement with Southern Africa. For more information, please contact (919) 668-1663 or visit https://igs.duke.edu/units/concilium-southern-africa. COSA is located in the John Hope Franklin Center, 2204 Erwin Road, Office 125.

Duke Islamic Studies Center (DISC)

The Duke Islamic Studies Center is a vibrant, diverse community of scholars and students engaged in interdisciplinary teaching, interactive learning, and cutting-edge research about Islam and Muslims. The center educates today's students to become tomorrow's leaders by equipping them with knowledge about the breadth and diversity of Islamic cultures, cross-cultural experiences, and language skills. DISC is one of the leading institutions in North America for the study of Islam and Muslims. Its comparative, cross-cultural approach to Islamic studies will foster fresh interpretations of Islam and encourage creative solutions to the economic, political and social challenges involving Muslims. The center is committed to working with partners at home and abroad to provide undergraduate and graduate students, professionals and policy makers with the knowledge about Muslims and Islamic cultures, beliefs and practices that will enable them to operate effectively in a multicultural world. DISC offers an undergraduate certificate in Islamic Studies and convenes ISTHMUS, a graduate level work group that brings students from UNC and Duke together to workshop academic papers and conference presentations. The center sponsors and co-sponsors events during the school year open to Duke and the greater community with the hopes of educating and dialoguing with people interested in the study of Islam. For further information, please contact (919) 668-1955 or visit https://islamicstudies.duke.edu/. DISC is located in the John Hope Franklin Center, 2204 Erwin Road, Offices 108 and 112.

Duke Middle East Studies Center (DUMESC)

The Duke University Middle East Studies Center is a hub for research, education, and outreach that serves as a forum at the local, national and international levels. The center prepares tomorrow's leaders by equipping them with knowledge about Middle Eastern languages, cultures, and societies. The center is distinguished by its trans-regional approach to the Middle East. The center approaches the Middle East as a unit extending from the Mediterranean to the Indian Ocean. The center's approach emphasizes interdisciplinarity, comparativity, and connectivity. DUMESC is part of the Duke-UNC Consortium for Middle East Studies. The Consortium combines the strengths of the center with those of the Carolina Center for the Study of the Middle East and Muslim Civilizations. The Consortium for Middle East Studies has recently been awarded a Title VI Middle East Studies grant, establishing the Consortium as a National Resource Center for Middle East Studies. The grant enables us to offer Summer Foreign Languages and Area Studies Fellowships for undergraduate students. For more information, please contact (919) 668-1653 or visit https://middleeaststudies.duke.edu. DUMESC is located in the John Hope Franklin Center, 2204 Erwin Road, Office 110 and 112.

Other Centers, Programs, and Opportunities

Center for the Study of Aging and Human Development

The Center for the Study of Aging and Human Development is a multidisciplinary program devoted to research and training in gerontology and geriatrics. Established in 1955, the center was one of the first university-based, interdisciplinary programs in the United States focused on social and biological science of aging. Although the center does not offer degrees, the varied programs, research laboratories, and clinical settings provide a context and resource for undergraduate and graduate students and for health professionals with special interests in adult development and aging. The center conducts multidisciplinary, two-year programs for postdoctoral fellows interested in focused training for independent research on many varied aspects of aging and adult development via the NIA funded T32 Post-Doctoral Training Program. Resources of this all-university program include data from longitudinal studies, a wide range of archival data of special interest to social, translational and clinical scientists, a human subjects registry, core resources of the NIA-funded Claude Pepper Center (e.g., biostatistical support, molecular and physiological measurement), and the center's basic and applied research laboratories with a particular focus on understanding and enhancing resilience in older adults. A nationally renowned division of geriatrics coordinates research, training, and clinical services related to the care of older adults. Undergraduate and graduate students of the university are welcome to inquire about participation in all programs at the center. Inquiries should be addressed to Heather E. Whitson, MD, director, Duke University Center for the Study of Aging and Human Development, Box 3003, Duke University Medical Center, Durham, NC 27710, or heather.whitson@duke.edu. Visit https://sites.duke.edu/centerforaging/ for more information.

Center for Documentary Studies

The Center for Documentary Studies (CDS) at Duke University offers an interdisciplinary program in the documentary arts—photography, audio, film/video, narrative writing, new media, and other means of creative expression—that emphasizes active engagement in the world beyond the university campus. Much more than a traditional educational center, CDS encourages experiential learning in diverse environments outside the classroom, with an emphasis on the role of individual artistic expression in advancing broader societal goals. Programs range widely to include university undergraduate courses, popular summer institutes that attract students from across the country, international awards competitions, award-winning book publishing and radio programming, exhibitions of new and established artists in the center's own galleries, an international documentary film festival, nationally recognized training for community

youth and adults, and fieldwork projects in the United States and abroad.

At the graduate level, CDS offers courses and other opportunities as part of the master of fine arts in experimental and documentary arts program at Duke. Graduate students also may participate in a variety of documentary studies courses cross-listed with several Duke departments and programs, including art, art history and visual studies; public policy studies; arts of the moving image; history; English; sociology; and cultural anthropology. The CDS website lists documentary studies courses offered at the 700 level, which are open to graduate students for registration and credit. Center-sponsored projects offer a limited number of assistantships to graduate students in the arts and humanities.

For more information, check the CDS website at https://documentarystudies.duke.edu or contact Christopher Sims, Undergraduate Education Director, csims@duke.edu, Center for Documentary Studies, 1317 West Pettigrew Street, Durham, NC 27705; (919) 660-3663; Fax: (919) 681-7600.

Oak Ridge Associated Universities

Since 1946, students and faculty of Duke University have benefited from membership in Oak Ridge Associated Universities (ORAU). ORAU is a consortium of more than one hundred doctoral-granting academic institutions and a contractor for the US Department of Energy (DOE) located in Oak Ridge, Tennessee. ORAU member universities share the common objective of advancing scientific research and education by creating mutually beneficial collaborative partnerships involving academe, government, and industry. ORAU's emphasis is on developing and promoting partnerships with national laboratories—in particular, Oak Ridge National Laboratory (ORNL).

For decades, ORAU has recruited students and recent graduates to pursue degrees and conduct research in disciplines of interest to federal agencies with science research missions. ORAU has helped direct the educational paths and research careers of more than 35,000 individuals through

- graduate fellowships;
- undergraduate scholarships;
- postgraduate internships;
- postdoctoral research appointments;
- faculty research programs; and
- other science education programs.

In addition, through its management of the Oak Ridge Institute for Science and Education (ORISE), ORAU strives to advance science education and research programs. ORISE creates opportunities for collaboration through partnerships with other DOE facilities, other federal agencies, the academic community, and industry.

Fundamental to ORISE's mission objectives are

- strengthening the nation's research and development enterprise through education and research participation programs;
- ensuring the readiness of the nation to respond to terrorist incidents and other emergencies; and
- protecting workers, the public, and the environment through research, outreach, and verification activities.

For more information about ORAU and its programs, contact Duke's ORAU counselor: Keith Hurka-Owen, director, Office of Research Support, (919) 684-3030; or refer to ORAU's website at https://www.orau.org/.

Office of Research Support

The Office of Research Support (ORS) assists Duke faculty, students, and staff in the following areas:

- For Duke campus faculty, students, and staff, ORS reviews and approves all proposals (including graduate fellowships) requiring an institutional signature. For additional information on this process please see https://ors.duke.edu/grants-contracts-and-compliance.
- For nonmedical human subjects research conducted on campus, the Office for Human Subjects Protections coordinates the Institutional Review Board (IRB), which must approve all protocols before research can proceed. For further information, please see https://ors.duke.edu/grants-contracts-and-compliance-responsible-conduct-research-rcr-university-policies/use-human.
- For faculty, students, and staff throughout Duke University (campus and medical center), ORS provides information on funding opportunities including specific funding information for graduate and professional students. For a current list of opportunities, please see https://ors.duke.edu/funding-opportunities/graduate-and-professional-student-funding.
- For faculty, students, and staff throughout Duke University (campus and medical center), the Office of Export Controls provides assistance on travel to embargoed countries, transport of computers and other equipment overseas, and exports in general. For further information please see https://ors.duke.edu/grants-contracts-and-compliance-responsible-conduct-research-rcr-university-policies/export-controls.
- ORS offers extensive information on external funding for thesis and dissertation research, postdoctoral fellowships, travel awards, and other research and training support. Online resources include funding-opportunities databases and Duke's *Funding Alert* newsletter to which students may subscribe at https://researchfunding.duke.edu/.
- As well, ORS offers regular workshops for graduate students on how to use its online funding information resources. For a schedule of upcoming workshops, please refer to https://ors.duke.edu/about-us/events. Students may also use online resources, such as PIVOT and the Foundation Directory Online, which are available via the ORS website at https://ors.duke.edu/funding-opportunities/funding-search-tools. Once students are ready to begin writing a grant or fellowship application, they can access proposal writing guide resources at https://ors.duke.edu/funding-opportunities/proposal-preparation. Before submitting a proposal, students will need to work with his/her home department and ORS for institutional review of his/her proposal, and also will need to begin the process of obtaining IRB approval for any human-subjects protocol that may be part of his/her research.

For all of these services, please call ORS at (919) 684-3030.

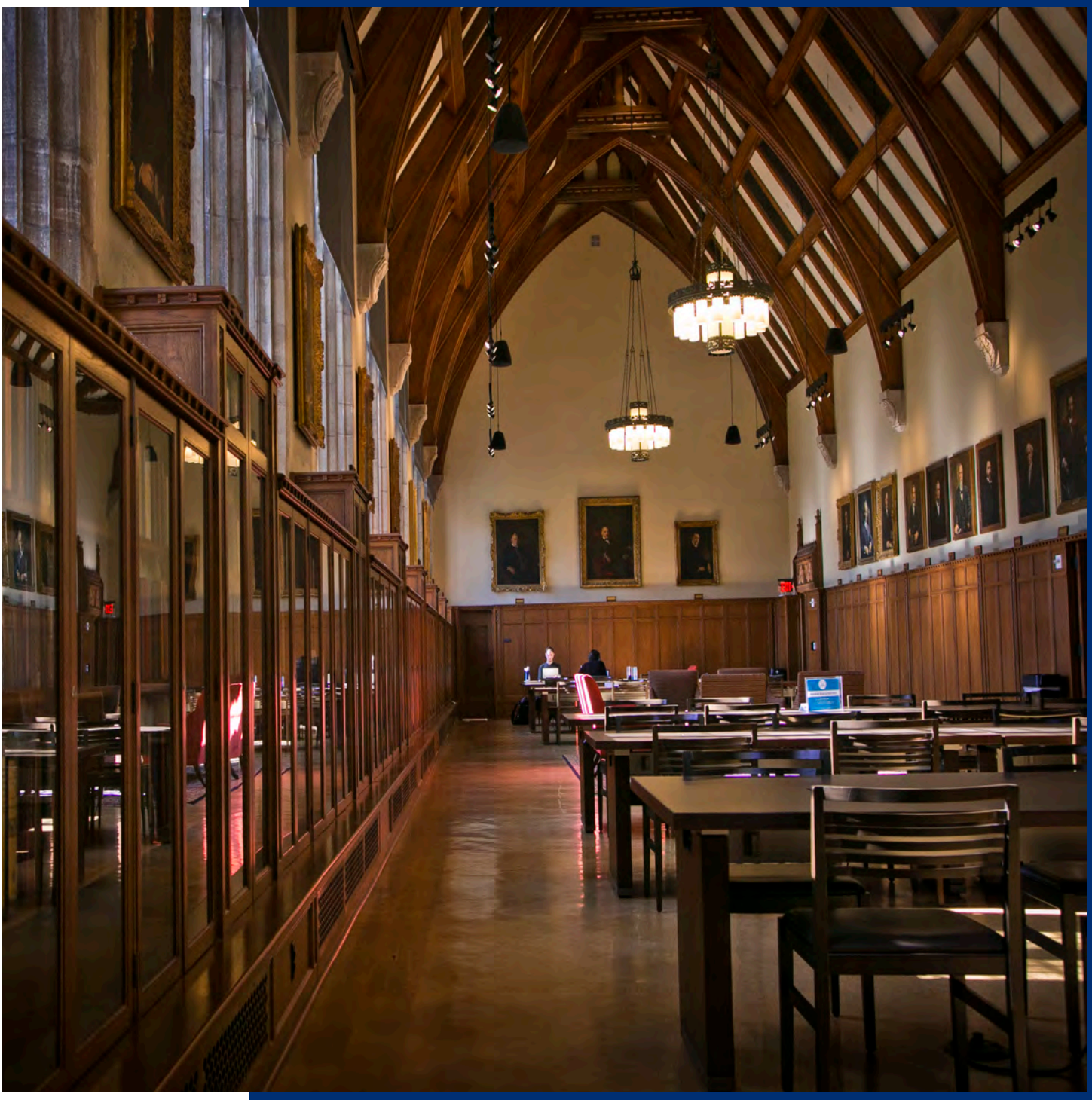
Center for Tropical Conservation

The Center for Tropical Conservation was established to focus the activities of Duke faculty and students who share a common concern for tropical biodiversity. The primary goal of the center is to unite biological scientific inquiry with conservation advocacy. The center serves to gather and disseminate pertinent information; to promote and coordinate research relevant to biodiversity and the sustainable development of natural resources; and to sponsor interdisciplinary workshops and courses.

Inquiries should be addressed to Professor John W. Terborgh, Director, Center for Tropical Conservation, 3705-C Erwin Road, Simons Building, P.O. Box 90381, Durham, NC 27708-0381.

Julie Schoonmaker

Resources for Study



Meghan Mendenhall

The Libraries

The William R. Perkins Library, Bostock Library, and David M. Rubenstein Rare Book & Manuscript Library comprise Duke's main library complex, which is joined on East Campus by the Lilly and Music Libraries, and by the Pearse Memorial Library at the Duke Marine Lab. Together with the separately administered libraries serving the schools of business, divinity, law, and medicine, they comprise one of the nation's top ten private research library systems. Graduate students can borrow books and journals from any campus library and can use most electronic resources, including electronic journals and databases, from anywhere on or off campus. The main library website at https://library.duke.edu is a gateway to the individual websites of all the campus libraries, and provides access to records of print and electronic materials as well as online forms and information about a variety of services.

The libraries at Duke have collaborated with other campus partners to create an open-access digital archive of scholarly articles written by Duke faculty. Duke is granted a limited license to the final draft manuscript of all scholarly articles that faculty authors elect to place in the open-access repository. This library-managed repository DukeSpace (https://dukespace.lib.duke.edu/dspace/) also provides electronic access to recent Duke dissertations and master's projects as well as university records and other related digital content.

All Duke students and faculty have borrowing privileges at the libraries of North Carolina Central University, North Carolina State University, and The University of North Carolina at Chapel Hill. These reciprocal privileges are a benefit of the libraries' membership in the Triangle Research Libraries Network, one of the oldest academic library consortia in the United States. The four TRLN library systems also cooperate in collection-building and preservation and the purchase of online databases and services. Library users may search the holdings of all four member libraries through the Duke University Libraries website.

Services Available to Graduate Students at Every Duke Library

The descriptions below are intended only as a general overview. Contact a library for more complete information about these and other services.

Checking Out Books and Journals

Graduate students may borrow materials from any Duke library and return them to any campus library. Alternatively, they may also request that materials be delivered to any campus library they specify for convenient pick-up or return. The length of the circulation period for books and journals varies from library to library as do renewal policies.

Reserving Materials for Course Use

Guidelines for reserving materials for class use as well as submission forms for books, e-reserves, and videos are available at https://library.duke.edu/course-support/course-reserves. These guidelines apply at Perkins Library, Lilly Library, and the Music Library. Contact the Divinity Library, the Goodson Law Library, the Medical Center Library, and the Ford Library at Fuqua to reserve materials at those libraries for your classes

Document Delivery

The document delivery and interlibrary loan service, offered at each campus library, obtains books, microforms, dissertations, journal articles, reports, and other materials not available on campus.

Reference/Research Assistance

Librarians at public service desks offer general and specialized assistance in the use of electronic and print sources and document retrieval. In addition to working with students and faculty at these desks, reference librarians also assist users via telephone, email, chat reference, and IM. Chat reference assistance and IM are accessible from the libraries' website at https://library.duke.edu/research/ask.

Instructional Services and Resources for Classes and Labs

Librarians offer a range of services to instructors, including workshops, course-related websites, and subject guides. Details are available at https://library.duke.edu/research/citing/refworks/.

Assistance with Innovative Use of Technology in Teaching and Other Work With Students

Duke Learning Innovation, a division of the library system, supports the university's academic mission by helping instructors find innovative ways to use technology to achieve their teaching goals. For more information about Duke Learning Innovation and its activities, including support for using the Sakai course management system, go to https://learninginnovation.duke.edu/.

Assistance with Copyright and Other Scholarly Communication Issues

The library's copyright and information policy consultant is available to assist faculty and students regarding copyright use and ownership of digital and print material. For more information, contact Arnetta Girardeau at arnetta.girardeau@duke.edu.

Library Profiles

The Divinity School Library

The Divinity School Library serves the university with collections ranging across the entire spectrum of world religions. Areas of particular strength include Biblical studies, Christian theology, American Christianity, Methodism,

religious art and architecture, mysticism, and archaeology of the Near East. The library has significant and growing collections in Judaism, Islam, Hinduism, and Buddhism as well.

The selection of materials reflects the curricular offerings of Duke Divinity School and the Department of Religion at both the undergraduate and graduate levels, as well as the research programs of faculty in both divisions and doctoral candidates in the fields of religion and theology. The library collects in both print and eBook formats and offers patrons a wide selection of online databases. In addition, the Divinity Library has a budding digitization department that strives to make and ever expanding offering of original source materials available in online formats. Its digital collections are cross-searchable and are available at https://divinityarchive.com. Library users are welcome to submit reference requests and suggestions concerning potential projects for digitization via div.lib@duke.edu.

Information about the Divinity School Library, including circulation policies, study carrels, and reference and instructional services, may be found on the library's website at https://library.divinity.duke.edu/.

The Ford Library at The Fuqua School of Business

Ford Library provides the principal business collections and services for the Duke community. The library's collection is extensive, composed of close to 50,000 print books and journals, a comprehensive collection of e-books and e-journals, a robust career collection, an ESL and language learning collection in print and online, and a strong media collection of circulating Kindles, popular films, and audio books. In 2020, the library added a board game collection. Significant areas of focus in the collection are accounting, decision sciences, entrepreneurship, financial economics, global business management, health sector management, marketing, operations management, organizational behavior, and strategy. Recent acquisitions focus on key business issues in the curriculum, such as leadership, ethics, sustainability, and social responsibility. Ford Library also offers data services with subscriptions to over 90 business information databases, most of which are available to entire Duke community. Duke University graduate students have free and ready access to the subscription databases provided by Ford Library from major business information producers, such as Bloomberg, Bureau van Dijk, Factiva, FactSet, Forrester, IBISWorld, MarketLine, Mergent, Mintel, Passport, Refinitiv, and S & P. These databases contain information on companies, industries, financial markets, and other topics of interest to students and researchers. While Ford Library's collection is tailored to the curriculum strengths and research interests of The Fuqua School of Business, all graduate students, faculty members and researchers throughout the university are welcome to use library materials and databases and to consult with subject expert librarians. Librarians assist students, faculty members, and other researchers by telephone, email, chat, WebEx, and in person. Ford Library's website highlights library resources, events, services, and programs. In 2020, the library launched a newsletter, which includes announcements of new acquisitons, book reviews, database changes, and other library news. Additional information about the Ford Library is available at the library's website, https://library.fuqua.duke.edu/.

The Medical Center Library and Archives

The Medical Center Library and Archives provides access to thousands of biomedical resources in electronic and print formats including medical, nursing, and health sciences journals and databases. The Medical Center Archives collects and preserves the institutional records and history of Duke Health through faculty papers as well as administrative and departmental documents. The library collection supports Duke Health's mission and programs, including those of the schools of medicine and nursing, Duke Hospital, Clinics and Health System, and the research enterprise. However, faculty, students, and staff across the university have access to these educational and research resources.

The library and archives provide a variety of services to assist faculty and students in using biomedical resources. In addition to traditional reference services, librarians are available for in-depth consultations to assist with identifying the most relevant information resources, searching the literature including systematic review searches, evaluating results, and learning how to use specific databases and information tools. Education services include tours and orientations, drop-in classes on the use of the library and customized training sessions for departments and schools. Evidence-based medicine training is also available for faculty, students, and clinical staff.

The library website is the virtual gateway for those seeking biomedical resources and services, and offers specialized subject guides including clinical tools and nursing tools pages, online tutorials, and evidence-based medicine resources. The website at https://mclibrary.duke.edu/ also provides more details about and links to library services.

The J. Michael Goodson Law Library

The Goodson Law Library is a rich resource for legal materials and research services for the Duke Law School, and the entire Duke community. The Library staff is highly knowledgeable in law, legal research, and in the uses of information technology and will assist in all facets of legal research and use of the Law Library collections. All Duke students who require access to legal literature are welcome to use the Library, consult with law-trained reference librarians, and check out circulating materials.

The Law Library relies increasingly on electronic sources of legal information while continuing to develop and maintain in-house collections of print resources to support research and scholarship. It is one of the strongest research collections of legal literature in the region, including current and retrospective primary materials from courts, legislatures, and administrative agencies. In addition to books and treatises, the Law Library has available journals, encyclopedias, reference materials, and finding tools on all legal subjects for the United States and foreign jurisdictions, as well as on topics of comparative and international law.

Reflecting Duke's emphasis on interdisciplinary approaches to scholarship and learning, the Library's collections provide access to a broad range of resources on law's intersections with other disciplines. Comparative and international perspectives enhance nearly every area of law, and so the Law Library maintains strong foreign and international law collections to support research in these areas and Duke's focus on internationalization. The foreign law collection is extensive in coverage, with long-standing concentrations in European law and growing collections in Asian and Latin American law. The international law collection is strong in primary source materials and monographs on both private and public international law topics.

For more information, including Duke University Community hours, visit the Law Library website at https://law.duke.edu/lib/. Keep up with current news and announcements by following the Goodson Blogson at https://dukelawref.blogspot.com/.

The Duke University Libraries System

The William R. Perkins Library, Bostock Library, and David M. Rubenstein Rare Book & Manuscript Library form the university's main library complex.

PhD candidates who have passed their preliminary examinations may apply for a library carrel. Because of high demand, the library system maintains a carrel waiting list. Carrels are assigned on a first-requested, first-accommodated basis. For carrel use policies and reservation instructions, visit https://library.duke.edu/using/policies/carrels.

The libraries also offer a Graduate Research Commons on the second floor of Perkins Library. The Graduate Research Commons is a shared office space for writing and research that can accommodate a limited number of Duke doctoral students. Desk space in the Graduate Research Commons is not assigned. Students may simply choose an unoccupied desk and work as long as they wish. For use policies and to sign up for access to the Graduate Research Commons, visit https://library.duke.edu/using/policies/graduate-research-commons.

The library collections support the social sciences, humanities, biological and environmental sciences, chemistry, engineering, mathematics, physics, computer science, and astronomy/astrophysics and reflect Duke's interdisciplinarity and international focus. There are extensive collections from and about East and South Asia, Latin America, Africa, Europe, and the United States as well one of this country's largest collections of Canadiana. Complementing the print collections are electronic resources, including tens of thousands of e-journals, databases, and statistical tools. The library is a depository for United States, North Carolina, and European government documents.

Research librarians assist individuals (with book and journal requests, specialized research assistance, etc.) and serve as liaisons to academic departments and programs and the university's interdisciplinary institutes and centers. For a listing of librarians, visit https://library.duke.edu/research/specialists.

The Libraries' Digital Collections Program builds distinctive digital collections that provide access to Duke's unique library and archival materials for teaching, learning, and research at Duke and worldwide. Particular digital collection strengths include advertising and consumer culture, documentary photography and film, Duke University and Durham history, African American history, women's history, transcultural experiences, and art, literature, and music. To browse the collections and related resources, visit https://library.duke.edu/digitalcollections/.

The holdings of the **David M. Rubenstein Rare Book & Manuscript Library** located adjacent to Perkins Library, range from ancient papyri to the records of twentieth-century advertising agencies. The collections support research in a wide variety of disciplines and programs, including African American studies, anthropology, classics, economics, history, literature, political science, religion, sociology, and women's studies. Among the areas of particular strength are the history and culture of the US South, English and American literature, history of economic theory, history of medicine, African American history and culture, British and American Methodism, human rights and social justice, women's history and culture, and the history of modern advertising.

The **Duke University Archives,** part of the Rubenstein Library, is the official repository for records of the university, collecting, preserving, and administering materials that have continuing administrative or historical value. Working together with The Graduate School and other campus units, the University Archives launched DukeSpace, a digital repository providing access to electronically submitted Duke dissertations, master's papers, university records, and other related digital content. For more information, please see https://dukespace.lib.duke.edu/dspace/.

The **Lilly Library** on East Campus houses the university's research collections for the visual arts, art history, philosophy, and theater studies plus Duke's collection of more than 30,000 international and interdisciplinary feature films and documentaries and experimental and animated productions. Request videos for a classroom showing or place videos on reserve for the semester by submitting forms at https://library.duke.edu/lilly/reserves. Please allow three working days for the processing of your request.

The **Music Library,** also on East Campus, has a rapidly expanding collection of music scores, books, journals, and music-related media, encompassing more than 120,000 print items and 25,000 sound recordings in various formats. The music collection supports teaching and research in musicology, historical performance practice, and composition. Additional strengths include keyboard music (monographs as well as scores), music and art, and musical instruments.

The **Library Service Center (LSC)** is an off-site, high-density library repository designed to support the ever expanding growth of the libraries' various collections. The center is located a short drive from the main campus off Highway 147 and Interstate 40. The LSC has a robust document delivery service available for all circulating material. Materials requested through the library catalog are retrieved and delivered within twenty-four hours Monday through Saturday morning.

One additional Duke library, the **Pearse Memorial Library,** is located in Beaufort, North Carolina, at the Duke Marine Laboratory. Its holdings are in marine sciences and policy-related aspects of the marine environment.

The Office of Information Technology

The Office of Information Technology strives to enhance teaching, learning, and research at the university by providing information technology resources that are easy to use and well-matched to the needs of faculty, staff, and students. OIT is responsible for

- electronic identity management (your Duke "NetID" and password), which allows access to Duke systems;
- personal computing services (software, email, calendaring, and instant messaging);
- research and large-scale computing services, as well as virtual computing environments;
- Duke's wired and wireless networks;
- mobile computing applications;
- support for the use of multimedia in teaching, in cooperation with Duke Learning Innovation;
- web design services; and
- technology innovation via the Innovation Co-Lab. Emerging technologies include virtual and augmented reality, 3D printing, and the Internet of Things (IoT) devices. Services can be accessed in three locations—at the Technology Engagement Center (TEC) located in the Telecommunications Building on West Campus, the Co-Lab Studio at the Rubenstein Arts Center (Ruby), and 3D printing stations in Lilly Library.

Students will find most everything they need to know about technology by searching the Duke OIT website at https://oit.duke.edu and on the special pages designed to support new members of the Duke community, https://oit.duke.edu/about/new-duke. To get tech support, contact the OIT Service Desk at https://oit.duke.edu/help or walk up to the Service Desk at The Link in the lower level of Perkins Library. Service hours can be found on the OIT website at https://oit.duke.edu/help.

There are many other departmental IT organizations and support groups across campus. OIT encourages students to familiarize themselves with some of these sites:

Enterprise-wide IT Organizations

- Health System: Duke Health Technology Services (DHTS): https://dhts.duke.edu
- Duke Information Technology Security Office: https://security.duke.edu
- Duke Web Services: https://webservices.duke.edu
- Duke Enterprise Web Applications: https://oit.duke.edu/what-we-do/services/enterprise-web-and-mobile-applications
- DukeCard: https://dukecard.duke.edu
- Information Technology Advisory Council: https://services.duke.edu/itac/

Academic Technology Support

- Duke Learning Innovation: https://learninginnovation.duke.edu
- Duke Research Computing: https://rc.duke.edu
- Innovation Co-Lab: https://colab.duke.edu
- Academic Media Services: https://oit.duke.edu/what-we-do/services/academic-media-services
- IT Training: https://oit.duke.edu/what-we-do/services/it-training-and-outreach

School-based IT Support

- Duke Divinity School: https://library.divinity.duke.edu/computing
- Duke University School of Law: law.duke.edu/actech/helpdesk
- Duke University School of Nursing: https://nursing.duke.edu/about-us/information-technology
- The Fuqua School of Business: https://it.fuqua.duke.edu
- Nicholas School of the Environment: https://nicholas.duke.edu/staff-faculty-resources
- Trinity College of Arts & Sciences' Office of Technology Services: https://trinity.duke.edu/technology
- Sanford School of Public Policy: https://inside.sanford.duke.edu (requires NetID to access)
- Pratt School of Engineering: https://it.pratt.duke.edu

Science Laboratories

Biological Laboratories

Facilities for graduate study in the Department of Biology are located on West Campus, together with those of supporting departments (physics, chemistry, earth and ocean sciences, and the basic medical sciences). Scientists in plant and animal biology with common interests are clustered in two buildings: the Biological Sciences Building, and the French Family Science Center. The two buildings are physically connected and maximal interaction occurs between the different groups in biology through seminars, shared instrumentation and collaborative research projects. Special facilities include animal rooms, greenhouses, refrigerated and controlled environment rooms, access to the Shared Material Instrumentation Facility and the Light Microscopy Core Facility (LMCF). The LMCF offers a wide range of confocal and conventional fluorescence microscopes and image analysis resources. As a centrally funded shared resource, the core's aim is to offer affordable and efficient access to standard and advanced imaging instrumentation for users of all levels of experience and from any discipline across the Duke University and the Duke Medical Center campuses. Extensive facilities for experimentation in environmental control of plant growth are available in the Phytotron adjacent to the greenhouses.

The herbarium contains approximately 800,000 specimens and includes notable collections of mosses, lichens and vascular plants. Other assets for teaching and research are the Sarah P. Duke Gardens on West Campus; the eleven-acre experimental plot and field laboratory; the Duke Forest, composed of 7,050 acres of woodland adjacent to West Campus; the field station for the study of ecology; and the Nicholas School of the Environment's Marine Laboratory, an interdepartmental facility located on a small island on the coast at Beaufort, North Carolina, where twenty-two buildings and a small flotilla of ships and boats provide teaching and research facilities for resident graduate students and faculty as well as visiting individuals or groups..

Duke University, through the Department of Biology, is a member institution of the Organization for Tropical Studies, Inc., a consortium of universities with field station facilities in Costa Rica that provide opportunities for coursework and research in tropical science.

Highlands Biological Station

Duke University holds a contributing membership in the Highlands Biological Station at Highlands, North Carolina, on the southern edge of the Blue Ridge Mountains at an elevation of 4,118 feet. The station and the region offer an excellent opportunity for field studies and some laboratory work. A limited number of qualified students in biology may make arrangements to carry out research here. Scholarships for advanced study during the summer months are available through the station.

The Plant Teaching and Research Complex

Managed by Duke Biology, The Plant Teaching and Research Complex is the core support facility for researchers using plants in the instruction of students and in biological research programs for Duke University. It plays an important role in supporting the university's objective through research, teaching, and extension.

The Plant Teaching and Research Complex is composed of five separate facilities: the Phytotron, the Research Greenhouse, the Teaching Collection, the Field Station and the Botany plot. These facilities are dedicated to Duke University researchers and instructors.

The Phytotron

The Phytotron houses sixty-seven growth chambers of varying sizes and six greenhouse units. Environmental factors controlled in these units include light, temperature, nutrients, carbon dioxide concentration, and humidity. Founded in 1968, the facility has a long and distinguished history of plant-controlled environment research, and is an important tool for global change research. It supports studies ranging from individual plant to whole ecosystem responses to changes in atmospheric carbon dioxide levels and/or temperatures. The facility boasts a dedicated staff with many years of experience in controlled environment research.

Research Greenhouse

The Research Greenhouse, built in 2004, is equipped with some of the latest technology in greenhouse-controlled space. The total facility spans 12,676 square feet. This space encompasses eight growing zones separated by airlocks, and a propagation room.

Teaching Collection

The Teaching Collections greenhouses were constructed in 2009, directly adjacent to the Research Greenhouses, and are considered one of Duke's hidden gems. This diverse reference display of plants is used for both research and teaching. The collection features more than 1,800 labeled species hosting a variety of interesting and important genera, including aquatic, desert, tropical, temperate, rare, and endangered species. The primary function of the plant teaching collection is to serve undergraduate teaching at Duke University. Because of its uniqueness, this collection also serves as a resource for world-renowned botanists as well as local school groups. In addition, the collections protect species on the list of rare or threatened plants. Tours are available by appointment only.

Field Station

The biological Field Station, located adjacent to the Duke Lemur Center, is the primary location for in-ground plant research trials. Open to all faculty and students, this protected two acres is used by plant geneticists and ecologists throughout the growing season, April to October. Field space is protected by an 8-foot-high fence to ensure the safety of the research from foraging deer.

Botany Plot

The Botany Plot on Cameron Boulevard is additional in-ground protected plant research space open to all labs for plant experiments.

Duke Forest

Since 1931, the Duke Forest has served as Duke University's living laboratory and outdoor classroom. It occupies over 7,000 acres of land in Durham, Orange, and Alamance counties. The mission of the forest is to facilitate teaching and research across a broad range of topics, and the primary management objectives demonstrate excellence in natural resource stewardship and sustainable timber production. The forest also provides opportunity for nature-based, passive recreation.

The forest lies near the eastern edge of the piedmont plateau and supports a cross-section of the woodlands found in the upper coastal plain and the lower piedmont of the Southeast. A variety of ecosystems, forest cover types, plant species, soils, topography, and past land-use conditions are represented within its boundaries. In terms of size, diversity, accessibility, and accumulated long-term data, the Duke Forest is a resource for studies related to forest ecosystems and the environment that is unmatched by any other university.

Academic use of the Duke Forest ranges from class instruction to long-term research projects, including studies on vegetation composition, landscape ecology, remote sensing, invertebrate zoology, atmospheric science, and global climate change. Background information available for teaching and research includes features such as soils, topography, forest cover, and management records; much of this data is electronically available in a geographic information system (GIS) format. A bibliography of past and current studies in the Duke Forest is also available.

In addition to leading educational tours and field laboratory exercises, Duke Forest staff are available to assist researchers in site establishment and management. Researchers can request forest stand manipulations, such as thinning and prescribed burning, or assistance in preparing fields by mowing, disking, or planting. Staff can also assist in siting and mapping study areas using Global Positioning System (GPS) units and a GIS system.

All graduate students who wish to initiate research or lead class activities in the Duke Forest should contact Sara Childs, director (Office of the Duke Forest, Duke University, Levine Science Research Center—Room A142; (919) 613-8013; sara.childs@duke.edu) to discuss the project. Through a simple registration and approval process, students have the opportunity to use this invaluable resource to maximize their educational experience at Duke. Maps and gate keys ($10 deposit required) are available from the office. For more information, visit dukeforest.duke.edu.

Earth and Ocean Sciences Laboratories

Morphodynamics and Coastal Processes Simulation Lab. Dr. Brad Murray's lab includes Silicon Graphics and LINUX computers, as well as PCs, and access to a large number of processors in a computing cluster in Colorado. Along with students, postdocs, undergraduate assistants, and visiting scholars, Murray uses these machines chiefly for developing and running numerical models of Earth surface processes. Experiments with relatively simple models address the evolution and response to climate change of an array of environments, including sandy and rocky coastlines, nearshore seabeds, coastal marshes, surf zones, rivers, deltas, desert sand dunes, arid landscapes, and patterned arctic permafrost. Interactions between physical landscape forming processes and biological processes, including humans, take center stage in several of these efforts. Field observations play a key role in motivating and testing these theoretical investigations, and the lab includes equipment to facilitate observations, including a basic GPS unit, video collection and analysis hardware and software, and a high-powered PC for processing large remote sensing (e.g. LIDAR) data sets.

Electron Microprobe Laboratory. The electron microprobe lab, directed by Dr. Alan Boudreau, is used by the petrology and geochemistry groups at Duke and The University of North Carolina at Chapel Hill. As such, it is an indispensable basic tool in mineral analyses. The machine consists of a Cameca CAMEBAX (French manufacture) electron microprobe with four wavelength-dispersive spectrometers, an energy dispersive spectrometer and digital electron microbeam imaging system. It is automated with control through PC operating system. The lab is part of a Duke-UNC shared laboratory facilities agreement.

Geochemistry Laboratory. Dr. Paul Baker's lab has all facilities necessary for major and minor wet chemical analysis. Dr. Baker's

lab also has field sampling equipment including seismic reflection profilers and a variety of coring equipment for undertaking marine and fresh water sediment and water column sampling.

Geochemistry Laboratories. Instruments and laboratory facilities overseen by Dr. Emily Klein include the following instruments and laboratory equipment for sample preparation. (1) ARL-Fisons Spectraspan seven direct current plasma (DCP) spectrometer, equipped with a twenty-four channel multi-element cassette for major- and high-abundance trace-element analysis for elements and high abundance trace elements (to ppm levels). (2) VG PlasmaQuad-3 inductively-coupled-plasma mass-spectrometer (ICP-MS) for bulk analysis of low abundance trace elements including the rare earth elements, high field strength elements and a wide range of other elements.

The Thermal Ionization Mass Spectrometer (TIMS) Lab (https://nicholas.duke.edu/tims/). Dr. Avner Vengosh oversees this laboratory, housed in the Division of Earth and Ocean Sciences at the Nicholas School of Environment. The heart of the lab is a fully automated Thermo Scientific *TRITON* thermal ionization mass spectrometer (TIMS). The TRITON is a new thermal ionization mass spectrometer with the most precise and accurate isotope ratios for positive and negative ions (see at https://www.thermofisher.com/us/en/home.html). The instrument was installed in February 2008. Currently the lab has developed the analytical procedures for boron and strontium isotopes.

The Laboratory for Environmental Analysis of RadioNuclides (https://nicholas.duke.edu/learn/). Dr. Avner Vengosh oversees this laboratory, which includes:

Two scintillation alpha counters (made by *Scientific Computer Instruments*, West Columbia, South Carolina) for measuring low abundances of ^{224}Ra and ^{223}Ra activities (Moore and Arnold, 1996; Vinson et al., in press)

Canberra high resolution Broad Energy germanium (BEGe) detector (BE5030) gamma spectrometry with 50 percent relative efficiency equipped with ultra low background hardware, an *In Situ* Object Counting System (ISOCS), mathematical calibration software, and Genie 2000 Multi-Input software. The instrument is currently calibrated for measurements of ^{226}Ra, ^{228}Ra, ^{210}Pb, and ^{137}Cs radionuclides.

RAD7 Electronic Radon Monitor/Sniffer for accurate measurements of radon in air and water, made by *Durridge* Company Inc., MA, USA. The instrument is calibrated for measurement of ^{226}Ra in Mn-fibers after three-weeks incubation.

Marine Biogeochemistry and Ecophysiology Laboratory. The main objective of Dr. Nicolas Cassar's lab is to constrain the mechanisms governing carbon cycling, ocean fertility, the biological pump, ocean/atmosphere gas fluxes and carbon acquisition mechanisms in marine phytoplankton. The laboratory hosts several analyzers used in the lab and on ships: two quadrupole mass spectrometers, a cavity ring-down laser absorption spectrometer, optodes and a transmissometer. Several other peripherals include: high vacuum lines, pumps (peristaltic, gear and piston) and valco valves. Chemostats (or continuous-growth cultures) are also being built. See https://sites.nicholas.duke.edu/cassar/ for further details.

Eco-hydrology and Bio-geomorphology Lab. Dr. Marani's laboratory will be equipped to address issues related to interacting geomorphological, hydrological, and biological processes, in tidal systems as well as in fluvial environments. The lab will include computing facilities to develop and run numerical models and to analyze remote sensing information. The lab will also include a water isotope analyzer, DGPS equipment and software, a VIS/NIR radiometer, an ADV system, a sonic anemometer, and sensors to characterize hydrologic states and fluxes (soil moisture probes as well as traditional rain gauges and weirs).

Forestry Sciences Laboratory

The Forestry Sciences Laboratory of the USDA Forest Service, Southern Research Station, is located in the Research Triangle Park near Durham. This research organization provides excellent opportunities to complement research conducted by students in the Nicholas School of the Environment. Specialized research projects in forest economics, carbon cycling, and productivity are currently under way at the laboratory. The staff of the laboratory is available for consultation and participation in seminars. Arrangements may be made for students to conduct certain aspects of their research at the laboratory.

Marine Laboratory

The Duke University Marine Laboratory (DUML) of the Nicholas School of the Environment is an educational and research facility. DUML is located on Pivers Island within the Outer Banks, adjacent to the historic seacoast town of Beaufort, North Carolina, with direct access to the Atlantic Ocean, Cape Lookout National Seashore Park, estuaries, sand beaches, wetlands, and coastal forests. The area provides an excellent opportunity for teaching and research at the undergraduate, master's, and doctoral levels. There are approximately thirty master's and thirty resident doctoral students. (For additional information concerning the PhD graduate programs refer to the chapter "Departments, Programs, & Course Offerings" on page 66 in this bulletin, and for the master of environmental management graduate program, refer to the bulletin of the Nicholas School of the Environment.) The Marine Laboratory accommodates nearly 3,700 visitors per year. The physical plant consists of twenty-three buildings including five research buildings, six dormitories, a dining hall, classroom laboratories, student center, and a maintenance complex. Research from the molecular to the population level is supported at the Marine Laboratory.

For information concerning teaching and research space, contact Auxiliaries Services, Duke University Marine Laboratory, 135 Duke Marine Lab Road, Beaufort, NC 28516-9721; (252) 504-7652; dominick.brugnolotti@duke.edu.

Lemur Center

The Duke Lemur Center is located in Duke Forest about two miles from the main campus. It is the world's only facility devoted entirely to the care, conservation, and study of lemurs. The colony is composed of approximately 250 animals from more than fifteen named taxa. The lemurs, and their closest relatives, the lorises, are housed in spacious indoor and outdoor facilities. In the summer months in particular, numerous lemurs "free range" in large tracts of open area within Duke Forest, providing a unique opportunity for investigators and students to study lemur behavior in a semi-natural setting. The center also houses frozen cadavers, biological samples, and fossil primate collections for study. All collections are utilized by students and faculty from a wide variety of Duke departments, as well as by scholars from other national and international institutions. Graduate students wishing to conduct research at the center should identify this interest to the director of graduate studies for the department to which they are applying. For information pertaining to the use of the Duke Lemur Center, graduate studies, or availability of research space, contact Dr. Erin Ehmke, erin.ehmke@duke.edu, Director of Research, Duke Lemur Center, 3705 Erwin Road, Durham, NC 27705.

Chemistry Laboratories

In 2007, the Department of Chemistry moved to the French Family Science Center, a state-of-the-art research facility donated by the Bill and Melinda Gates Foundation. This building houses not only the entire chemistry department, but also biological sciences, and a portion of the physics department and research labs. The building contains 275,000 square feet of total area, with additional research space in the Levine Science Research Center to accommodate chemistry at the biology interface. This well-equipped chemical laboratory provides conditions conducive to research in many areas of current interest. Major shared instruments, including those for nuclear magnetic resonance and mass spectrometry, are housed in the departmental instrumentation facility, along with optical and other instrumentation, including FTIR, UV/VIS, and fluorescence spectrometers. A wide array of more specialized instrumentation is available in the various research laboratories, from ultrafast laser systems to atomic force microscopes to automated solid-phase synthesizers. Other major facilities on campus include the Free Electron Laser Laboratory and the University NMR Center, which maintains several ultra high field NMR instruments. A broad range of instrumentation for biological and materials science applications is accessible in the medical center and Pratt School of Engineering, with additional facilities available at the neighboring universities and in Research Triangle Park, including those for x-ray diffraction and structure determination.

Computing facilities in chemistry include SGI and Redhat Linux workstations, Beowulf clusters, and clusters of PC's associated with the teaching laboratories. The department is linked to the university's high-speed fiber optic network and to the university's high-performance shared computing cluster. This building is primarily a research facility, and the majority of space is dedicated to research and teaching labs. In addition, the department has state-of-the-art computer/video projection systems in its lecture hall and conference rooms and wireless networking for incorporation of the latest computational research tools into the undergraduate chemistry curriculum.

Physics Laboratories

The physics building houses research and instruction in the departments of physics and mathematics. Additional space is provided in the adjacent buildings such as Triangle Nuclear Building (TUNL), French Family Science Center (FFSC), and the Duke Free Electron Laser Laboratory (FEL). Graduate students conducting research in these buildings often have their offices there.

About half of the physics space is devoted to research laboratories for the department's programs. Among the special equipment housed in the department are: 1 GeV linear accelerator; a high current electron storage ring driving an ultraviolet to soft X-ray Free Electron Laser (FEL) (this facility is used, among other things, to produce a high-intensity gamma-ray source known as the HIGS; a 20 MeV tandem Van de Graaff accelerator with polarized source and cryogenically cooled polarized targets. In addition, the department houses a number of table top laboratories with state-of-the-art equipment used in performing experiments in hard and soft condensed matter, biophysics, nonlinear and complex systems, and optics. Examples include ultrafast, high power, short wavelength, far-infrared and frequency-stabilized lasers, traps for ultra-cold atoms, high-speed oscilloscopes, classical and quantum optical telecommunication systems, entangled-photon sources, specially designed apparatus or soft matter experiments, conventional and ultra-high speed imaging equipment, cryostats for achieving milliKelvin temperatures, and associated equipment for fabricating experimental samples. In addition, a scanning electron microscope with electron beam lithographic capability and other materials processing equipment is housed in the Shared Materials Instrumentation Facility (SMIF). An appropriately staffed instrument shop is also located in the physics building.

The department contains several computers for data collection and processing in all of the research groups and a massively parallel computer system for use in particle, nuclear, and condensed matter experimental and theoretical research. Desktop computers are typically provided for all grad students. The computing infrastructure is maintained and supported by computing staff located in the physics building

The physics building is located near the Bostock Library, which contains a world-class collection of books and scholarly periodicals.

Engineering Research Laboratories

The laboratories of the four departments of the Pratt School of Engineering contain extensive state-of-the-art equipment that is used in several specialized fields. The Shared Materials Instrumentation Facility (SMIF) provides researchers with high quality and cost-effective access to advanced materials characterization and clean room fabrication capabilities. SMIF operates as a multidisciplinary shared use facility, and is available to Duke University researchers from the various schools and departments as well as to external users from other universities, government laboratories, and industry. SMIF is housed in the Fitzpatrick Center for Interdisciplinary Engineering, Medicine and Applied Sciences (CIEMAS). The 11,000-square-foot facility consists of 4,000 square feet of class 100 and class 1000 clean room space, and more than 2,600 square feet of specialized laboratory space for characterization equipment. The remainder of the space is composed of facility support areas, staff offices, and a conference/classroom.

Duke Research Computing offers a range of computing options, ranging from high-throughput/high-performance cluster computing to virtual machines. The Duke Compute Cluster consists of machines that the University has provided for community use and that researchers have purchased to conduct their research. At present, the cluster consists of about 7,000 CPU-cores, with underlying hardware from Cisco UCS and Dell M600-series blades in Dell M1000-series chassis. Interconnects are 10 GBs.

The following is an overview of research and capabilities found in each department:

Biomedical Engineering. This biomechanics and mechanobiology research focuses upon mechanics at and across the molecular, cellular, tissue, and organ levels with applications in orthopaedics, injury mechanics, and biomaterial and tissue engineering design. Biomaterials research includes the molecular design of soft materials, nanomaterials, immune-active materials, scaffolds for tissue engineering, and basic investigations into the complex mechanisms by which materials engage biology. The Duke BME program is a world leader in development of novel biomedical imaging technologies, with translational and basic science applications. The program has pushed the boundaries of discovery and innovation in optics and photonics, ultrasound, MRI, X-ray, and nuclear medicine-based imaging technologies, developing new diagnostic and treatment tools for ailments ranging from cancer to cardiovascular, neurological, and ophthalmic diseases. Neural engineering research focuses upon developing novel neural technologies that can interact with the brain on a much finer scale and with greater coverage than previously possible, using both electrical and optical measurements. Research in biosensors and bioinstrumentation utilizes recent advances in biochemistry, electronics, omics (genomics, epigenetics, proteomics), and physiology to develop novel diagnostic, therapeutic, and prosthetic devices. The program engineers macro- and nano-scale devices that utilize biological components, such as antibodies or enzymes, to detect and quantify minute amounts of chemicals or investigate biological process in diverse systems and environments. The program is developing methods to read and manipulate genetic code,

including new strategies for regenerative medicine, treatment of genetic disease, and techniques to establish robust gene circuit function. Researchers within the Duke BME community focus on the study and advancement of computational methods and data analysis techniques to understand biological phenomena. This research spans many application areas including electrophysiology, patient-specific hemodynamics, cellular mechanisms, gene circuits, and synthetic biology.

Civil and Environmental Engineering. Faculty in civil and environmental engineering routinely design, construct, and adapt laboratory equipment for specialized teaching and research tasks in engineering mechanics, environmental engineering, geomechanics, structural engineering, and water resources engineering. In addition, arrays of standard laboratory facilities are available to support each research area.

Research and teaching facilities in engineering mechanics, structural engineering, and geomechanics include four independent closed-loop electrohydraulic dynamic loading systems (MTS), with a frequency range up to 100 Hz, and ranges of load to capacity 6,000, 35,000, 50,000 and 220,000 lbs. For teaching and research, the department has a 10,000 lb. universal testing machine and a 10,000 lb. torsion machine both fully instrumented with computer data storage, as well as a Kistler force plate with ten decades of sensitivity. Equipment is available for fabricating specimens and testing fiber-reinforced polymer composites. An environmental chamber tests in the temperature range of -100° to +350° F; equipment for spectral and modal dynamic analysis, and an ultra-high pressure triaxial shear apparatus is available for confining pressures up to 100,000 psi. Rock-testing facilities, model-testing equipment for anchored walls and penetrometer studies, a large-aperture research polariscope, a reflective photoelastic polariscope, and a sustained-loading facility for long duration in studies of prestressed concrete are routinely used in teaching and research procedures.

Research and teaching facilities in environmental engineering include wet and dry laboratories equipped to study a range of physical, chemical, and biological processes. A fully integrated resource recovery pilot plant, calorimetry for the measurement of heat values of secondary fuels, air classifiers interfaced with computer monitors, as well as indoor and outdoor water resources monitoring devices including flumes, Venturi meters, and digital computation hardware are available. The biotechnology and physical-chemical laboratories are equipped with autoclaves, a media preparation room, walk-in environmental rooms, numerous fume hoods, a biohazard containment facility for cultivation of genetically engineered microorganisms, fully instrumented bioreactors with online control, and various analytical instrumentation including liquid scintillation counting, autoradiography, atomic adsorption spectroscopy, total carbon analysis to ppb levels, gas chromatographs equipped with ECO, FID, and TCD detectors, HPLCs, computer-assisted image analysis microscopes, and a recently acquired Fourier transfer infrared spectrometer facility.

CEINT has 30 controlled release facilities—tightly controlled and highly instrumented ecosystems (aka mesocosms) located in the Duke Forest. Conditions in the mesocosm (air and water temperature, redox potential, water level, air pressure and humidity) are continuously monitored and recorded through a sophisticated network of sensors that allow for real-time on-line data collection and analysis, available to CEINT researchers worldwide through a secure internet portal. The data logging (via a network of CR1000 and multiplexers Campbell) has been micro-coded and programmed for the acquisition of the large amount of probes and sensors implemented at the mesocosm site.

The Aquatic Research Facility, located in the Duke Forest, is comprised of approximately 1,500 square feet of AAALAC-approved space for holding and performing experiments with aquatic organisms. The facility contains static and flow-through systems for both holding and exposing fish and is approved for research with hazardous chemicals and for research with radiolabeled (H-3 and C-14) compounds.

Instrumentation available in the labs of CEINT researchers ranging from advanced multi-angle dynamic light scattering, ellipsometers, and electrokinetic and surface area analyzers for nanomaterial characterization to PCR, Real-Time PCR, DGGE, Gel-Doc, confocal scanning laser microscopes and IMARIS and COMSTAT software to analyze and quantify confocal microscope images, and related equipment for molecular microbiology work. Students and faculty also have substantial access to X-ray and synchrotron facilities at DOE labs including SSRL/SLAC, PAS/ANL, ALS/LBNL, and EMSL/PNNL and associated sample preparation instrumentation.

Electrical and Computer Engineering. The Computer Engineering (CE) group engages in design, implementation, evaluation, and testing of computer systems at all levels of a computer system, from computing substrates and materials to hardware architectures to the software that runs on the hardware. The computer engineering group collaborates closely with the computer systems group in the computer science department, particularly with researchers in architecture, distributed systems, networking, and databases. Microelectronics, photonics, and nanotechnology (MPN) research focuses on materials and devices that include micro- and nano-fluidic systems, integration of these fluidic systems with optical systems, photovoltaics, nano-optics, photodetectors, lasers and LEDs, optical biochemical sensors (fluidic and aerosol), silicon photonics, integrated circuit design through the MOSIS foundry, CMOS circuits, nanostructured materials and devices, and chip scale integrated optical/electrical systems. Strong software design and optimization capabilities in MPN are complemented by the fabrication and characterization capabilities in the SMIF, and through ultra-mixed signal test facilities in MPN labs. Duke ECE has a strong experimental and theoretical research presence in novel and structured metamaterials, surface science, electromagnetic and acoustic waves, quantum sciences, imaging systems and communication systems. Research in this area includes design and realization of functional advanced information processing systems; electromagnetic, wave and quantum physics used for representation, transmission and manipulation of information; mathematical and computational principles for encoding and processing of information. Signal and Information Processing and Robotics plays a key role at the intersection of fundamental science, domain knowledge, and theory and algorithms. Research involves robot motion planning and control, semiautonomous robots, and integrating perception and planning; design and analysis of cyber-physical systems, physics-based statistical signal processing algorithms, image and video processing, computer vision, computer graphics, and computational vision.

Mechanical Engineering and Materials Science. The department has a number of well-equipped laboratories for studies in aerodynamics, acoustics, nonlinear dynamics and chaos, microscale and convective heat transfer, computational fluid mechanics and heat transfer, control theory, cell and membrane biomechanics, biorheology, polymer engineering, corrosion, electronic materials, physical metallurgy, positron annihilation spectroscopy, and expert systems. Equipment in these laboratories includes a wind tunnel, several scanning electron microscopes and scanning tunneling microscopes, Doppler broadening and lifetime positron systems, a liquid helium cryostat, DSC/DMA facilities and diffusion furnace, inverted microscopes, atomic force microscopes, low-light-level video cameras and a photon counter, cell-culture systems, an anechoic chamber, dynamic signal analyzers and laser velocimeters for dynamic analysis, an x-ray generator and diffractometer, FTIR spectrometer, high-power lasers with lock-in amplifier, a 3D Systems ProX 350 metal 3D printer, and fluorescence microscopes. Duke's MRSEC Soft Matter Lab contains instrumentation for synthesis of colloids and biopolymers and

for characterization of their assemblies. These include capacity for synthesis and purification of recombinant biopolymers, microfluidic production of colloids, high throughput production of nanoparticles.

The Duke Hypo-Hyperbaric Center

The Duke Hypo-Hyperbaric Center is a major center for research, treatment, and training involving hyperbaric and hypobaric exposure and simulation. The facility includes the F. G. Hall Laboratory, a large multi-chamber complex, and supporting clinical and laboratory services. Hyperbaric oxygen is used in the treatment of many disorders, including decompression illness, gas gangrene, carbon monoxide poisoning, and wound healing. The hyperbaric facility is fully equipped with state-of-the-art hemodynamic and blood gas monitoring equipment, allowing uninterrupted delivery of critical care for patients requiring intermittent hyperbaric oxygen therapy.

As the major facility in the southeastern United States for the referral and treatment of serious diving accidents and air embolism cases and for patients with hypoxic and nonhealing conditions for which hyperbaric oxygen is used, the laboratory provides wide opportunities for scientific, clinical, and research training for graduate students, postdoctoral fellows, and physicians in high and low pressure-related medicine and physiology. The center faculty also consult on recreational diving illness for the National Diver's Alert Network (DAN) and Dive Assure. The program is interdisciplinary with major participation by the departments of anesthesiology, medicine, surgery, cell biology, neurobiology, and the Pratt School of Engineering.

The Medical Center

Currently the medical center at Duke University occupies approximately 140 acres on West Campus. The southern quadrant is contiguous with the main quadrangle of the university and consists of the following: Duke Clinic, Davison Building, Baker House, Barnes Woodhall Building, Diagnostic and Treatment Building, Ewald W. Busse Building, Eugene A. Stead Building, Clinical Research II, Edwin A. Morris Clinical Cancer Research Building, and the new Duke Cancer Institute, which opened in February 2012.

The northern portion of the medical center campus includes the Joseph and Kathleen Bryan Research Building for Neurobiology; Nanaline H. Duke Medical Sciences Building; Alex H. Sands Medical Sciences Building; Edwin L. Jones Basic Cancer Research Building; Clinical and Research Laboratory Building; Joseph Levine Research Center; CIEMAS Building; Seeley G. Mudd Communications Center and Library; Mary Duke Biddle Trent Semans Center for Health Education, which opened in February 2013; Joseph A. C. Wadsworth Building (Eye Center); Albert Eye Research Institute (Eye Center); Hudson Building, which opened in June 2015 (Eye Center); Duke University Hospital and Anlyan Tower; and Lenox Baker Hospital. The new Duke Medicine Pavilion opened in July 2013.

In the eastern section of the medical center campus are the Pickens Rehabilitation Center, Civitan Mental Retardation and Child Development Center, Trent Drive Hall, Christine Siegler Pearson School of Nursing, and Duke Health Center for Interprofessional Education, which opens in August 2019. In the western section of the medical center campus are Surgical Oncology Research Building; Environmental Safety Building; Research Park Buildings I, II, III, and IV; the Vivarium; the Medical Science Research Buildings I, II, and III, which opened in October 2018; Genome Science Research Building; the Synderman Research Building; the Global Health Research Building; and the Cancer Center Isolation Facility.

Meghan Mendenhall

Student Life

Jared Lazarus

Off-Campus Housing

Housing and Residence Life (HRL) will offer on-campus housing for Graduate and Professional Students during the 2020-2021 academic year at 301 Swift. Assignment priority will be given to graduate or professional students on student visa status who are attending school outside of their home country for the first time. IInformation about the apartments, location to schools, and application can be found at https://studentaffairs.duke.edu/hdrl/graduate-professional-students/graduate-living-campus. Questions can be answered via housing@duke.edu or (919) 684-4304.

The Housing Assignments Office is a resource to assist in locating off-campus rental housing options in the Durham area. The Housing Assignments Office, in partnership with the *Chronicle,* maintains a database of available rental housing which is accessible through the NearDuke website, https://www.nearduke.com/housing. The Housing Assignments office is located at 301 Swift Avenue, #25; (919) 684-4304; housing@duke.edu. Office hours are 8:30 AM to 5 PM Monday through Friday. Appointments are recommended to meet with staff.

Dining Services

Duke is home to one of the most innovative, dynamic, and cutting edge collegiate dining programs in the country. The goal of Duke Dining is to provide a delicious, nutritious, and affordable community dining experience, no matter where students choose to eat on campus.

Whether students are craving a stacked deli sandwich, hand-cut steak, or salad with locally grown greens, Duke Dining Services offers a variety of ways to tempt and please any palate. From ethnic specialties and vegan entrees to down-home Southern cooking and delicious desserts, Duke Dining offers a wide array of exciting and nutritious food options.

Au Bon Pain offers a variety of soups, salads, sandwiches, entrees, authentic artisan breads, and pastries. (Brodhead Center)

Bella Union brews fresh coffee and offers fresh baked goods, frozen drinks, and novelty snack foods. (684-2326; McClendon Tower)

Beyu Blue offers coffee, tea, espresso drinks, and snacks and pastries. (Bryan Center)

Café: This bakery and coffee spot features made-to-order crepes, house-made gelato, pastry-chef delicacies, and specialty coffee and teas. (Brodhead Center)

Café 300: Urban market-style spot featuring grab-and-go gourmet deli foods as well as a full-service coffee and tea bar. (Swift Avenue)

Café at Smith Warehouse: Fresh deli sandwiches, salads, fruit and parfaits, ice cream treats, and hot and cold beverages. (423-6779; Smith Warehouse)

Café De Novo: Made-to-order sandwiches, salads, and daily specials. (613-8552; Duke Law School)

The Chef's Kitchen: A unique dining, teaching, and learning venue, check out how The Chef's Kitchen adds exciting, new flavor to the Brodhead Center, providing a pop-up restaurant one day and a culinary lab the next! (Brodhead Center)

The Commons: A community lunch spot where faculty and staff can enjoy a daily lunch buffet of chef-prepared specialties. Come evening, The Commons transforms into a fine dining restaurant for students, faculty, staff, and visitors, featuring the finest broiled USDA Choice steaks in the Carolinas. (Brodhead Center)

The Devil's Krafthouse: Craft beers on tap paired with an ideal menu of appetizers and entrees—all served at this on-campus pub. Students will not want to miss out on the fabulous fish tacos and of course, the Krazy Krafthouse Burger! (Brodhead Center)

Divinity Café offers organic and locally grown foods including vegetarian and vegan options. (668-3498; Duke Divinity School)

Dolce Vita Café is a full-service coffee bar serving mostly Organic Fair products, Mightly Leaf Tea, sandwiches, salads, wraps, and pastries. (French Science)

The Farmstead: Farm-to-fork sustainability meets wholesome and healthy using only the best local ingredients from local farms. (Brodhead Center)

Freeman Center for Jewish Life: This mecca of Duke's Jewish life features a gourmet kosher kitchen. Dinner is served Monday through Thursday, with special spreads for Friday Shabbat and Jewish holidays, including Passover. Vegetarians and those with dairy allergies are sure to find this location a treat. (684-0136; Faber Street)

Ginger & Soy: The confluence of different cuisines from East and Southeast Asia, including poke bowls, dumplings, buns and made-to-order stir-fry, choose from the finest ingredients and watch as your meal is expertly prepared and served sizzling. (Brodhead Center)

Gyotaku: Exquisite sushi and sashimi prepared to order with a unique flair by sushi chefs who are known for their imaginative creations. (Brodhead Center)

Il Forno: Enjoy a selection of Artisan, wood-fired pizzas and the option to create your own delicious pasta dishes made with fresh house-made pasta. (Brodhead Center)

JB's Roasts & Chops: Wood-fired cooking done right, enjoy the paella dishes prepared Valencia style as well as classic American cuisine, including broiled London wood-fired flank steak with sherry mushroom sauce. (Brodhead Center)

The Loop Pizza Grill features pizzas, gourmet salads, fresh grilled fish, burgers, soups, desserts, and a lighter menu. (Bryan Center)

Marketplace features an all-you-care-to-eat breakfast, dinner, and weekend brunch, a-la-carte weekday lunch, and late-night dining. Options include hot and cold breakfast items, made-to-order pasta, rotisserie meats, gourmet pizzas, ethnic cuisine, a full grill menu, and a gourmet salad bar. (660-3935; East Union)

McDonald's is open twenty-four hours a day, seven days a week. (668-2404; Bryan Center)

Nasher Museum Café: This sit-down restaurant serves a variety of locally grown and organic dishes, as well as upscale desserts and cappuccino-style beverages. (684-6032; Nasher Museum of Art)

Panda Express: Traditional Chinese favorites served fresh and quick (660-5080; Bryan Center)

Pitchfork Provisions: This cafe, which is open twenty-four hours a day, offers a variety of fresh, eclectic fare. (684-3287; McClendon Tower)

Red Mango Café offers smoothies, fresh-cut fruit, grab-and-go options, and salads and sandwiches that compliment a student's healthy lifestyle. (660-3987; Wilson Recreation Center)

Saladelia @ The Perk: Where students can relax and enjoy fair trade, organic tea and locally roasted coffee with homemade desserts and pastries. Also serving healthy signature sandwiches, wraps, salads, and soups. (684-2049; Bostock Library)

Saladelia Cafe @ Sanford serves made-to-order sandwiches, fresh salads, gourmet soups, and specialty pastries. (613-7304; Sanford Institute of Public Policy)

Sazón: This Latin American table brings true, authentic Latin American cuisine to the Brodhead Center, offering made-to-order arepas, tortillas, and bowls created with only the freshest ingredients. (Brodhead Center)

The Skillet: Upscale Southern cuisine celebrating a rich tradition of home-style cooking with the best fried chicken and biscuits, ever! (Brodhead Center)

Sprout: The Raw Food Movement is now at Duke! Sprout will be sure to please any palate with vegetables ruling the tastes at this 100% vegan-inspired venue, including produce from the Duke Campus Farm. (Brodhead Center)

Tandoor: Enticing Indian foods, authentic flavors and preparation, including house-made naan, without having to travel the globe, prepared in real Tandoor ovens. (Brodhead Center)

Terrace Café: Enjoy freshly made sandwiches and salads, ice cream bars, gourmet baked treats, and hot and cold beverages. (660-3957; Duke Gardens)

Trinity Café: This East Campus coffee bar serves gourmet coffees, smoothies, and fresh pastries. Light entrees, including salads, sandwiches, and sushi are also available. (660-3942; East Union)

Twinnie's: This Irish pub offers hot out-of-the-oven breakfast pastries, made-to-order sandwiches, and fresh entrée salads in addition to its beer on tap and classic blends of coffee. (660-3944; CIEMAS)

Merchants-on-Points

Merchants-on-Points allow students to use food points or their FLEX account to order from a variety of vendors, delivered right to campus from local off-campus restaurants. Merchants-on-Points restaurants deliver to Duke seven days a week.

Current Merchants-on-Points vendors (subject to change) include:

- Devil's Pizzeria
- Enzo's Pizza Co.
- Jimmy John's
- MediTerra Grill
- Naan Stop
- Sake Bomb
- Sushi Love
- Vine Sushi
- Zweli's

Food Trucks

Food points can also be used for food trucks. Food trucks are located throughout campus Monday through Thursday to provide even more dining options. The calendar can be viewed at https://studentaffairs.duke.edu/dining.

List subject to change. Visit the Duke Dining website for updated Merchants-on-Points and food truck vendors.

Special Diets

Duke wants students to feel comfortable with their dining options and will help identify foods available on campus that fit into their diet.

Toni Apadula, a registered dietician on staff, has specific training on all aspects of nutrition and is available to meet with students

upon request. If students have any questions or want advice about nutrition, they should contact Toni at (919) 613-1218 or toni.apadula@duke.edu.

For more information on nutritional, dietary, and food allergen resources please visit the Duke Dining website at https://studentaffairs.duke.edu/dining/nutrition-dietary-information.

More Information

Food purchases may be made in one of three ways: cash, a dining plan (food points), or a flexible spending account (FLEX). Information about DukeCard accounts is available from the DukeCard Office and online at https://dukecard.duke.edu.

Further information about campus dining locations and dining plan options is available from Duke Dining, (919) 660-3900. Stay up to date with the latest in dining news by visiting https://studentaffairs.duke.edu/dining.

Services Available

Student Disability Access Office

Duke University charges the Student Disability Access Office (SDAO) with the responsibility of exploring possible coverage and reasonable accommodations for qualified students who are disabled in compliance with Section 504 of the Federal Rehabilitation Act of 1973, the Americans with Disabilities Act (ADA) of 1990 and the ADA Amendments Act of 2008 (ADAAA). SDAO's goal is to provide and coordinate accommodations, support services, and programs that enable students with disabilities to have equal access to all Duke University programs and activities. Services and accommodations are provided to students with a variety of disabilities including Attention Deficit Hyperactivity Disorders, blindness/low vision, deafness/hard of hearing, learning disabilities, mobility and chronic health impairments, psychological disorders (including Autism Spectrum disorders), and other medical conditions.

In order to receive consideration for reasonable accommodations under Section 504 of the Rehabilitation Act of 1973, the Americans with Disabilities Act of 1990 (ADA), and the ADA Amendments Act of 2008, a student must have a physical or mental impairment that substantially limits one or more major life activities. An individual with a disability is a person who has a physical or mental impairment that substantially limits one or more major life activities, has a record of such impairment(s), or is regarded as having such impairment(s). Major life activities may include but are not limited to functions such as caring for one's self, performing manual tasks, walking, seeing, hearing, speaking, breathing, and learning. Under the ADAAA, a qualified individual with a disability is an individual with a disability who meets the essential eligibility requirements for receipt of services or participation in programs or activities. Whether a particular condition constitutes a disability within the meaning of the ADAAA requires a case-by-case determination. Students who wish to be considered for reasonable accommodations must self-identify to the SDAO by submitting the formal request form and complete and current documentation to the SDAO online via their website: https://access.duke.edu/students. Additional information regarding requests for accommodations and documentation guidelines may also be found on the SDAO website: https://access.duke.edu/.

In the interest of providing reasonable accommodations under the ADAAA, The Graduate School will accommodate students who have a documented disability and who are registered and approved to receive accommodations through the SDAO. Any questions may be addressed by visiting their website, https://access.duke.edu/; by contacting the SDAO via email, sdao@duke.edu; or by calling (919) 668-1267 or (919) 668-1329 (TTY).

The Vice President for Institutional Equity is the designated compliance officer for the Americans with Disabilities Act of 1990 (ADA), the ADA Amendments Act of 2008, and the Rehabilitation Act of 1973. The compliance officer can be reached at (919) 684-8222. Section 504 of the Rehabilitation Act states: "No qualified [disabled] person shall, on the basis of [disability], be excluded from participation in, be denied the benefits of, or otherwise be subjected to discrimination under any program or activity that receives benefits from federal financial assistance." (Appendix II, section 51.51(a))

Student Health Services

Student Health Services (SHS) at Duke University is a joint program supported by the Division of Student Affairs and the Department of Family Medicine. A wide variety of services are available through SHS.

Student Health Center

The Student Health Center (SHC) is the primary location for health care services including general medical care, nutrition counseling, laboratory, pharmacy, travel and immunization clinics, and allergy/immunotherapy clinic. Most services are covered by the Student Health Fee (see below). Radiology studies, prescription drugs, most laboratory tests, and all specialty services received at the SHC are not covered by the fee. The SHC is located in the Student Wellness Center at 305 Towerview Rd. Medical services are provided by board-certified faculty physicians and by physician assistants, nurse practitioners, and resident physicians under faculty supervision. Students are seen by appointment 8:00 AM to 4:30 PM Monday, Tuesday, Wednesday, and Friday and 9:00 AM to 4:30 PM Thursday. Appointments can be made online through Duke MyChart (dukemychart.org) or by calling (919) 681-9355 and selecting option 1. Nurse advice is available at all hours when the SHC is closed by calling (919) 966-3820. See https://studentaffairs.duke.edu/studenthealth for more information.

Students are encouraged to use the Student Health Center as their portal of entry to other health resources, including the specialty clinics within the general community and Duke University Health System. This helps with coordination of care. In the event of a life-threatening emergency, students should go directly to the Emergency Department. If necessary, Duke Police (911) or (919) 684-2444) provides on-campus transportation to the Emergency Department.

Nutrition Services

- Free individual counseling for current Duke students
- Nutrition consultation for special dietary needs (food allergies, intolerances, etc.)

- Personalized nutrition programs for groups, teams, dorms
- Consult services for planning events

Duke Student Wellness Center (DUWELL)

DUWELL fosters a living/learning environment that promotes and encourages the full development of the individual as an engaged member of the community. The staff helps students focus on an individual wellness perspective that integrates many areas of their life, including financial, social, spiritual, intellectual, mind-body, and environmental. Each of these dimensions of wellness is essential in maintaining harmony and balance in students' lives. See https://studentaffairs.duke.edu/duwell for more information on topics including fitness assessment, alcohol and other drug usage, sexual activity and sexually transmitted diseases, stress management, and others.

Confidentiality

Information regarding the physical or mental health of students is confidential and is released only with the student's permission except in life-threatening circumstances. As a member of the Duke University Health System, the Student Health Center is fully compliant with HIPAA federal regulations.

Student Health Fee

All currently enrolled full-time students and part-time degree candidates are assessed a mandatory Student Health Fee each semester. This covers most services delivered within Student Health. Students not enrolled in the university for medical, judicial, or personal reasons are not eligible to pay the health fee or receive services normally covered by the fee. The health fee may be waived under certain conditions. A waiver can be granted if the student resides more than fifty miles away from campus and does not come to campus for research or other academic activity for the entire semester. Students studying at the Duke Marine Lab are not eligible for waiver. Duke employees and spouses of employees who are also students may request wavier. An optional summer health fee for students not enrolled in summer sessions is also available.

Services Covered by the Health Fee

The health fee covers most of the services at the Student Health Center if medically indicated and ordered by a student health provider. These include:

- medical care for acute and chronic illness and minor injuries;
- physical exam;
- gynecological exam; men's health exam;
- limited laboratory services performed at Student Health: urine screening, pregnancy testing, rapid influenza test, mono and strep throat testing;
- administration of allergy/immunotherapy shots;
- nutrition consultation;
- health promotion services (DUWell); and
- Consultation and Psychological Services (CAPS).

Services Not Covered by the Health Fee

If a student is unsure whether a service is covered, they should contact the Student Health Insurance Manager (shs-insurance@duke.edu) prior to receiving the service. Students are financially responsible for

- prescription drugs;
- laboratory services not listed above;
- x-rays and other radiology studies;
- vaccines;
- medical care provided in the Emergency Department, hospital, or other nonstudent health facility;
- care provided by specialist consultants, including those working within the Student Health facilities;
- dental care;
- physical therapy;
- tests, procedures, and prescriptions not medically indicated, not on the approved list, or not ordered by Student Health providers; and
- immunizations/titers required for matriculation and travel.

Immunization Requirements

North Carolina state law and the Infection Control Committee at the medical center require all new students to provide, within thirty days of matriculation, evidence of immunity to certain vaccine-preventable illnesses. Upon acceptance, students receive the Student Health Immunization Form and Report of Medical History which should be completed and returned to the Student Health Center, Box 2899, DUMC, Durham, NC 27710.

Duke University Medical Center and the School of Medicine hold the health and welfare of their students, patients, and faculty in the highest regard. Students' failure to comply with North Carolina state immunization requirements and those of the School of Medicine will result in the student not being allowed to continue coursework or to take exams until all immunization requirements are met. For questions or concerns about immunization requirements, please contact the Student Health Department at immunizations@dm.duke.edu or by phone at (919) 681-WELL, option 2.

Student Medical Insurance Plan (SMIP)

Health insurance is essential to protect against the high cost of unexpected illnesses or injuries that require hospitalization, surgery, or the services of specialists outside of Student Health. Therefore, all full-time and part-time degree-seeking candidates who are in programs that require payment of the health fee are required to have insurance. For those who do not have insurance, Duke University sponsors a plan (SMIP) designed with students needs in mind. The SMIP provides protection twenty-four hours per day during the twelve-month term of the policy of each student insured and is specifically designed to complement the coverage provided by the fee. Students

are covered on and off campus, at home, while traveling between home and school, and during interim vacation periods. Coverage for the student's spouse and dependent children also may be purchased directly from the insurance company. The charge (student only) for the SMIP will appear on the tuition bill and may be waived only by providing proof of adequate insurance coverage. Certain restrictions apply. See https://studentaffairs.duke.edu/studenthealth for important enrollment and waiver information. Enrollment in the Duke SMIP is mandatory for J1/F1 visa holders.

Counseling and Psychological Services (CAPS)

Counseling and Psychological Services (CAPS) provides a range of mental health services for Duke University students. The services include individual and couples counseling; group services; psychiatric evaluation and medication management; workshops; and referral services. CAPS also engage with the campus community by offering consultation to those who may be concerned about another student's well-being and with faculty and staff who are in a support role with students. CAPS staff represents a broad range of student identities so that the lived experiences of students are understood, and they are committed to addressing the ways that marginalization, discrimination, and oppression negatively impact mental health. The professional staff is comprised of psychologists, clinical social workers, a psychiatric nurse practitioner, and psychiatrists experienced in working with graduate and professional school students, in addition to the undergraduate community.

To get started with services, students should come to CAPS on the third floor of the Student Wellness Building between 9 AM and 4 PM Monday through Friday and ask to speak with a counselor. No appointment is necessary. These consultations are offered on a first-come, first-served basis, so the earlier in the day the better. During a student's consultation they will visit with a counselor for 15-20 minutes to determine which services are most appropriate for their care. The student will leave with referrals that may be to CAPS services, campus resources, or community providers. If the student's care will be at CAPS, the student will be scheduled for an appointment with a CAPS treatment provider before they leave. If referred to community providers, students will meet with the referral services coordinator, who can assist with navigating insurance and other barriers to care, such as financial.

CAPS offers a range of workshops and group services that cater to specific issues and student identities. For example, CAPS participates in the campus effort to provide Koru, a mindfulness meditation practice that has been shown to decrease anxiety and depression, as well as improve concentration, focus and sleep. Specific workshops are offered on building resilience skills, managing anxiety, and healing perfectionism. A primary mode of treatment is group counseling, which is equally effective as individual services and serves to improve self- and other-understanding, as well as decrease a sense of social isolation. CAPS offer group services for specific populations, including but not limited to Black Women and LGBTQIA+ identified students.

According to professional ethics and the North Carolina law, CAPS maintains a policy of strict confidentiality concerning information about each student's contact with CAPS. If a student desires information to be released, written authorization must be provided. CAPS' services are covered by the student health fee. There are no additional costs for these services. For more information, see the website at https://studentaffairs.duke.edu/caps or call (919) 660-1000.

The Career Center

The Career Center encourages graduate students to begin their career development process as soon as they arrive on campus and supports them throughout their time at Duke. Services for graduate students include confidential one-on-one advising, group advising, and workshops for professional skill development such as interviewing, networking, and cover letter writing. In addition to developing strategies for career planning, transitions, and searches, the Career Center assists students in connecting with alumni, recruiters, and employers interested in hiring master's and doctoral candidates for internships and full-time opportunities.

The Duke Career Center supports graduate students interested in a variety of careers, including academia, industry, nonprofits, and government. All Career Center services are available to Duke students enrolled in The Graduate School and to alumni of its programs up to one year after graduation. For information about services, programs, and resources, see the Career Center's website at https://studentaffairs.duke.edu/career

For information about services, programs, and resources, see the Career Center's website, https://studentaffairs.duke.edu/career.

Student Affairs

The Center for Multicultural Affairs

The Center for Multicultural Affairs (CMA) supports the campus in addressing the academic and socio-cultural needs of students of color (African, Asian, Latino, Native American, and multiracial/biracial) and conducts diversity education programs for the general student body. Additionally, the Center offers the campus community a number of resources for programming and research purposes that cover a wide array of multicultural topics. Reservable space is available for clubs and organizations to meet, as well as space where individual students can study and relax. The staff also provides technical support to individuals and organizations planning multicultural, racial, and ethnic specific events. The interests and cultural programming activities of student organizations are of major importance to the staff. Dedicated to making diversity and community essential aspects of the Duke experience, the Center collaborates with other campus agencies to offer unique educational programs designed to explore the complex dynamics of creating an inclusive campus. Fall 2017 ushers in the second year of expansion of the Center for Multicultural Affairs. Please look forward to an exciting calendar of programs throughout the year. For more information, visit https://studentaffairs.duke.edu/cma.

Duke Office of Civic Engagement

The Duke Office of Civic Engagement (DOCE) strengthens and connects the ways in which Duke partners with communities. The DOCE supports Duke's collaborations on pressing social challenges by increasing the capacity of the campus to sustain partnerships and sharing best practices in community engagement. The DOCE provides volunteer and partnership opportunities, trainings, workshops, consultations and a listing of community-based federal work study opportunities. In these ways, the DOCE aims to advance civic engagement and promote equitable approaches to strengthen partnerships between Duke and the community. Find out more at civic.duke.edu.

International House

International House's mission is to provide educational programs, services, and advocacy to Duke global community on campus as well as outreach to the greater Durham area. The International House offers extensive cross-cultural programming and information to enhance the global mission of the university. I-House is part of the Division of Student Affairs. Currently there are over three thousand international students from more than one hundred countries enrolled at Duke.

International House staff conduct an intensive orientation at the beginning of the fall semester and a less intensive session at the beginning of the spring semester for incoming international graduate students. This year's fall orientation will be held on August 10 and 11 in Penn Pavilion and the Bryan Center on West Campus. The Resource Fair, which will be offered on the first day, is a convenient way to access local vendors, including banks and cell phone providers, as well as other campus resources. The International Graduate and Professional Student Orientation will be offered the following day, and it is a very important event to attend. Students will meet fellow incoming international graduate students and learn about ways to thrive at Duke University. For more information and registration, please visit the I-House website at https://studentaffairs.duke.edu/ihouse/intl-graduate-and-professional-students. The spring orientation will be held in early January 2021.

Ongoing programs during the academic year include Friday morning's Global Café and Thursday evening's Extended Orientation Series called Connect. Learn. Grow. The workshop series Connect. Learn. Grow (CLG) covers various practical topics on social, mental, and academic well-being. I-House offers monthly trips to the Department of Motor Vehicles and weekly trips to the Social Security Office. Programs for language and culture exchange include International Friends Program (matching internationals with local students and families); Conversation Clubs in English and Spanish (for casual conversation in a small group setting); Global Engagement Program (a leadership and intercultural program for U.S. American Students); and Duke Language Partners (pairing native speakers of different languages based on their language interests). International House also hosts extensive social and educational programs for spouses and partners throughout the year.

International House is open Monday through Friday from 9:00 AM to 5 PM throughout the year. Students may stop by during office hours with questions or concerns. The advisor on call will be available. For more information about International House, visit https://studentaffairs.duke.edu/ihouse, email ihouse@duke.edu, or call (919) 684-3585.

Jewish Life at Duke

Jewish Life at Duke is proud to serve as the home for all Jewish students, staff, and faculty at Duke University. Jewish Life at Duke is based out of the Freeman Center for Jewish Life (1415 Faber Street) and is proud to offer a variety of religious, community, and social programming for students within all of Duke's graduate and professional schools. Highlights include:

- **Shabbat:** Weekly Friday evening Shabbat services and dinner that are open to the entire community. Shabbat festivities begin with Shabbat singing and snacks at 5:30 PM, a community Shabbat service at 6:00 PM, and a free Shabbat dinner at approximately 7:00 PM. Please RSVP each week to ensure enough food is prepared.
- **Holiday Services and Meals:** Jewish Life at Duke offers a full schedule of holiday services and meals for Rosh Hashanah and Yom Kippur, as well as options for celebrating Sukkot, Hanukkah, and Passover. Information about services and meals can be found on the Jewish Life at Duke website.
- **Kosher Dining:** Enjoy a kosher all-you-can-eat buffet meal at the Freeman Center, every Monday-Thursday from 5:00-8:00 PM, as well as grab-and-go options on both Duke's East (in Trinity Café) and West (kosher case next to Au Bon Pain) campuses.

Jewish Life at Duke is proud to support the following graduate and professional student organizations:

- **JBA (Jewish Business Association):** The JBA strives to provide Jewish Fuqua students with a platform for social, cultural, academic, and community activities. The JBA coordinates social and cultural events with other graduate, young professional, and Jewish groups around the Triangle.
- **JLSA (Jewish Law Students Association):** The JLSA is a student-run group that exists as a resource to the Jewish community here at Duke Law School. The JLSA seeks to create and maintain a vibrant, fun, and supportive Jewish community through Shabbat dinners, holiday celebrations, mixers, academic lectures, and other events.
- **JGPA (Jewish Graduate and Professional Association):** The JGPA is the Jewish student group for post-undergraduate students on campus. JGPA works to bring all Duke graduate students, across all academic programs, together for religious and social experiences, including holidays and Shabbat.

Jewish Life at Duke is happy to serve as a resource for all of Duke's graduate and professional schools and works to connect students with the larger Triangle Jewish community. Contact the group for more information about local synagogues, Jewish community organizations, and other local resources. Subscribe to their graduate and professional student email listserv for up-to-date information about Jewish Life at Duke by emailing jewishlife@duke.edu and visit their website at https://studentaffairs.duke.edu/jewishlife.

The Center for Sexual and Gender Diversity

The Center for Sexual and Gender Diversity (CSGD) strives to achieve an inclusive campus climate for students, staff, faculty, and alumnx with marginalized sexual orientations, gender identities, and gender expressions through education, advocacy, support, mentoring, academic engagement, and providing space. Please visit the center's website for more information: https://studentaffairs.

duke.edu/csgd.

Mary Lou Williams Center for Black Culture

The Black graduate student presence at Duke University began in 1961 when the university desegregated the campus with the admission of three Black students. Over the next twenty years, the growing Black student population at Duke continued to advocate for the addition of faculty, staff, programs, and services to both represent and address the many and complex issues that emerged as a result of rising visibility on the university campus. Artist in Residence Mary Lou Williams was a strong mentor and educator of students at Duke from 1977 until her death in 1981, and as a result, Duke University's Center for Black Culture has borne her name since its dedication in September 1983.

The Mary Lou Williams Center for Black Culture is critically concerned with issues of race and the impact of social difference at the individual, interpersonal, and institutional levels. Through lectures, performances, exhibits, and informal gatherings, the Mary Lou Williams Center strives to foster an appreciation for and increase knowledge of the peoples, histories, and cultures of the African Diaspora and its many contributions to the world. Located in the Flowers Building, the Mary Lou Williams Center for Black Culture is a beautiful facility reflecting a vintage luxe aesthetic created by the hardwood floors, grand windows, custom carpets, an exquisite new digital grand piano, and an ever-expanding collection of photography and art that serves to visually represent Black culture at Duke University and beyond.

Among the center's services and resources is the lending library, which is a collection of more than 1,000 books, DVDs, audio resources, and other culturally relevant materials that may be borrowed by members of the Duke community. The center also offers individual student counsel and advising to Black graduate, professional, and undergraduate organizations to assist with their leadership development and programming.

The center welcomes all who want to engage with and be empowered by a greater understanding of the Black experience, to view the Mary Lou Williams Center as their home away from home. To learn more, visit https://studentaffairs.duke.edu/mlw.

Duke University Women's Center

The Duke University Women's Center is dedicated to helping every female-identified student at Duke become self-assured with a streetwise savvy that comes from actively engaging with the world. It is an inclusive space that welcomes every gender and person who is committed to gender equity and social change. The Women's Center facilitates discussions on feminism, womanism, gender equity, and social justice concerns.

The center cultivates an environment for civic engagement and activism. Staff provides advocacy, support, referrals, leadership, and mentorship for the undergraduate and graduate and professional student communities. Clinical services are also available for students (of any gender) who are a victim-survivor of experiencing gender-related concerns, such as sexual harassment, gender discrimination, gender and sexual violence, stalking, and intimate partner violence.

Duke University Women's Center is located on East Campus in the Garden Level of Crowell Building (underneath the Coffeehouse). Support is available anytime by emailing wchelp@duke.edu or calling (919) 970-2108. For more information, call (919) 684-3897 or visit https://studentaffairs.duke.edu/wc/.

Graduate and Professional Student Council

The Graduate and Professional Student Council (GPSC) is the representative body for students of Duke's over 8,000 graduate and professional students across nine schools. The council selects students for membership on university committees, oversees election of the graduate and professional Young Trustee, and coordinates social and community service events throughout the year. Representatives of each department and officers of the council are selected annually, but council meetings and most events are open to all graduate and professional students. GPSC also distributes GPSCNews, an electronic news digest, circulated weekly via email. Please visit the GPSC website at dukegpsc.org to find out more about graduate and professional student organizations at Duke and for information on upcoming events. Please contact GPSC (gpsc@duke.edu) for additional details on how students can become involved.

Religious Life

In partnership with the Division of Student Affairs, the Chapel convenes, supports, and advocates for all of the officially recognized Religious Life groups on campus that serve students, including Buddhist, Catholic, Hindu, Jewish, Latter-Day Saints, Muslim, Orthodox, and Protestant organizations and groups. There are about two dozen Religious Life groups at Duke; find a listing of them at chapel.duke.edu/ReligiousLife.

With a mission of "bridging faith and learning," the Chapel holds ceremonies, concerts, Christian worship services, and more. It is a sanctuary open to all people for important personal moments of prayer, reflection, grief, and gratitude. The Chapel's Student Ministries provides opportunities for undergraduate students to hear and respond to God's call for their lives on campus, in Durham, and beyond through study, artistic expression, counsel, service, and communityLearn more at chapel.duke.edu.

Index

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

W