Washington University in St. Louis

Biology

Biology is an exciting, diverse field that ranges from the molecular biology of individual cells to interactions among entire populations of organisms. Members of the biology faculty are recognized internationally for their research, and they bring a variety of strengths and teaching styles into the classroom. The major program in biology provides a thorough education in the history of scientific discovery in biology, the logical and statistical procedures used to formulate and test biological hypotheses, and the technical skills needed to conduct contemporary biological research.

The biology major program emphasizes the hierarchical nature of biological complexity and the major structures and functions that emerge at the molecular, cellular, organismal, populational and ecosystem levels. Each student masters at least one dimension of contemporary research in sufficient detail to describe the major hypotheses currently being tested and to demonstrate techniques used to test those hypotheses. Mastery of this material is evident in a student's ability to critique published data, to identify ambiguities and uncertainties in the conclusions drawn from those data, and to evaluate the societal importance of the research. Biology majors are prepared to make creative contributions to biology.

The biology major program provides a wide range of research opportunities. Because more than 400 faculty members conduct research in biology and biomedical sciences at Washington University, it is easy to find a project that suits a student's main interests. Many students complete their research projects at the Washington University School of Medicine, one of the top-ranked medical schools in the country. Summer research fellowship programs are available, funded by sources including the Howard Hughes Medical Institute, the Children's Discovery Institute, the National Science Foundation, and the Washington University Office of Undergraduate Research. Detailed information about finding a research mentor (https://biology.wustl.edu/undergraduate-research/) is available online.

Phone:	314-935-6860
Email:	webmaster@biology.wustl.edu
Website:	http://wubio.wustl.edu

Faculty

Chair

Ram Dixit (https://biology.wustl.edu/people/ram-dixit/)
PhD, Cornell University

Endowed Professors

Erik D. Herzog (https://biology.wustl.edu/people/erik-herzog/)
Viktor Hamburger Distinguished Professor in Arts & Sciences
PhD, Syracuse University

Joseph Jez (https://biology.wustl.edu/people/joseph-jez/)
Spencer T. Olin Professor in Biology
PhD, University of Pennsylvania

Jonathan B. Losos (https://biology.wustl.edu/people/jonathan-losos/)
William H. Danforth Distinguished Professor
PhD, University of California, Berkeley

Himadri B. Pakrasi (https://biology.wustl.edu/people/himadri-pakrasi/)
Myron and Sonya Glassberg/Albert and Blanche Greensfelder Distinguished University Professor
PhD, University of Missouri-Columbia

David C. Queller (https://biology.wustl.edu/people/david-queller/)
Spencer T. Olin Professor of Biology
PhD, University of Michigan

Barbara A. Schaal (https://biology.wustl.edu/people/barbara-schaal/)
Mary-Dell Chilton Distinguished Professor in Arts & Sciences
PhD, Yale University

Joan E. Strassmann (https://biology.wustl.edu/people/joan-strassmann/)
Charles Rebstock Professor of Biology
PhD, University of Texas at Austin

Richard D. Vierstra (https://biology.wustl.edu/people/richard-d-vierstra/)
George and Charmaine Mallinckrodt Professor
PhD, Michigan State University

Peter Wyse Jackson (https://biology.wustl.edu/people/peter-wyse-jackson/)
George Engelmann Professor of Botany
PhD, Trinity College Dublin

Professors

Roger Beachy (https://biology.wustl.edu/people/roger-beachy/)
PhD, Michigan State University

Yehuda Ben-Shahar (https://biology.wustl.edu/people/yehuda-ben-shahar/)
PhD, University of Illinois

Bruce A. Carlson (https://biology.wustl.edu/people/bruce-carlson/)
PhD, Cornell University

Douglas L. Chalker (https://biology.wustl.edu/people/douglas-chalker/)
PhD, University of California, Irvine

Ian Duncan (https://biology.wustl.edu/people/ian-duncan/)
PhD, University of Washington

Robert G. Kranz (https://biology.wustl.edu/people/robert-kranz/)

PhD, University of Illinois

Barbara Kunkel (https://biology.wustl.edu/people/barbara-kunkel/)
PhD, Harvard University

Allan Larson (https://biology.wustl.edu/people/allan-larson/)
PhD, University of California, Berkeley

Petra A. Levin (https://biology.wustl.edu/people/petra-levin/)
PhD, Harvard University

Kenneth M. Olsen (https://biology.wustl.edu/people/kenneth-olsen/)
PhD, Washington University

Philip A. Osdoby (https://biology.wustl.edu/people/philip-osdoby/)
PhD, Case Western Reserve University

Paul S.G. Stein (https://biology.wustl.edu/people/paul-stein/)
PhD, Stanford University

Hani Zaher (https://biology.wustl.edu/people/hani-zaher/)
PhD, Simon Fraser University

Xuehua Zhong (https://biology.wustl.edu/people/xuehua-zhong/)

PhD, The Ohio State University

Associate Professors

Joshua Blodgett (https://biology.wustl.edu/people/joshua-blodgett/)
PhD, University of Illinois

Arpita Bose (https://biology.wustl.edu/people/arpita-bose/)
PhD, University of Illinois

Jonathan A. Myers (https://biology.wustl.edu/people/jonathan-myers/)
PhD, Louisiana State University

Assistant Professors

Keith B. Hengen (https://biology.wustl.edu/people/keith-hengen/)
PhD, University of Wisconsin-Madison

Michael Landis (https://biology.wustl.edu/people/michael-landis/)
PhD, University of California, Berkeley

Elizabeth K. Mallott (https://biology.wustl.edu/people/liz-mallott/)
PhD, University of Illinois

Ben N. Mansfeld (https://biology.wustl.edu/people/ben-mansfeld/)
PhD, Michigan State University

Duygu Özpolat (https://biology.wustl.edu/people/b-duygu-%C3%B6zpolat/)
PhD, Tulane University

Rachel M. Penczykowski (https://biology.wustl.edu/people/rachel-penczykowski/)
PhD, Georgia Institute of Technology

Jennifer Wang (https://sites.wustl.edu/centrosome/)
PhD, Johns Hopkins University

Professors Emeriti

Robert E. Blankenship (https://biology.wustl.edu/people/robert-blankenship/)
PhD, University of California, Berkeley

Sarah C.R. Elgin (https://biology.wustl.edu/people/sarah-elgin/)
PhD, California Institute of Technology

Ursula W. Goodenough (https://biology.wustl.edu/people/ursula-goodenough/)
PhD, Harvard University

Tuan-hua David Ho (https://biology.wustl.edu/people/tuan-hua-david-ho/)
PhD, Michigan State University

George B. Johnson (https://biology.wustl.edu/people/george-johnson/)
PhD, Stanford University

Kathryn G. Miller (https://biology.wustl.edu/people/kathryn-miller/)
PhD, Johns Hopkins University

Ralph S. Quatrano (https://biology.wustl.edu/people/ralph-quatrano/)
Spencer T. Olin Professor Emeritus
PhD, Yale University

Peter H. Raven (https://biology.wustl.edu/people/peter-raven/)
PhD, University of California, Los Angeles

Nobuo Suga (https://biology.wustl.edu/people/nobuo-suga/)
PhD, Tokyo Metropolitan University

Alan R. Templeton (https://biology.wustl.edu/people/alan-templeton/)
PhD, University of Michigan

Robert E. Thach (https://biology.wustl.edu/people/robert-thach/)

PhD, Harvard University

Majors

The Major in Biology

Total units required: 58

Required courses:

Code	Title	Units
Biol 2960	Principles of Biology I	4
Biol 2970	Principles of Biology II	4
Chem 111A	General Chemistry I	3
or Chem 105	Introductory General Chemistry I	
Chem 112A	General Chemistry II	3
or Chem 106	Introductory General Chemistry II	

Chem 151	General Chemistry Laboratory I	2
Chem 152	General Chemistry Laboratory II	2
Chem 261	Organic Chemistry I with Lab	4
Chem 262	Organic Chemistry II with Lab	4
Math 132	Calculus II	3
Math 2200	Elementary Probability and Statistics	3
or Math 233	Calculus III	
or Math 3200	Elementary to Intermediate Statistics and Data Analysis	
Physics 191	Physics I	3
or Physics 193	Focused Physics I	
Physics 191L	Physics I Laboratory	1
or Physics 193L	Focused Physics I Laboratory	
Physics 192	Physics II	3
or Physics 194	Focused Physics II	
Physics 192L	Physics II Laboratory	1
or Physics 194L	Focused Physics II Laboratory	
Total Units		**40**

Students may substitute Chem 401 Physical Chemistry I for Chem 262 Organic Chemistry II with Lab. Students who plan to take physical chemistry must take Math 233 Calculus III. Math 2200 Elementary Probability and Statistics (required for the tracks in ecology and evolution and in genomics and computational biology) and Math 322 Biostatistics are valuable, particularly for students interested in research. Students who have taken Math 233 may take Math 3200 Elementary to Intermediate Statistics and Data Analysis rather than Math 2200 Elementary Probability and Statistics for a more advanced treatment of statistics.

At least 18 units in advanced biology courses (numbered 300 or above) are required. These 18 units may not include Biol 303A, Biol 307A, Biol 3160, Biol 3180, Biol 343, Biol 363, Biol 387, Biol 388, Biol 3900, Biol 4202, Biol 429, Biol 4582, Biol 487 or Biol 488; cross-listed courses originating in other departments (except Biol 354, Biol 360, Biol 4540, Biol 4580, Biol 4810, Biol 4820 and Biol 4833, which count as biology major credit despite external origins); courses in the School of Continuing & Professional Studies; or more than 3 units of history-of-science courses.

Majors are required to take at least one course from each of the following three areas:

Area A: Cellular and Molecular Biology

Code	Title	Units
Biol 324	Human Genetics	3
Biol 334	Cell Biology	3
Biol 3481	Parasitology	3
Biol 349	Microbiology	4
Biol 424	Immunology	4
Biol 4344	Epigenetics	3
Biol 4492	Infectious Diseases: History, Pathology, and Prevention	3
Biol 451	General Biochemistry	4
Biol 4810	General Biochemistry I	3
Biol 4820	General Biochemistry II	3

Area B: Organismal Biology

Code	Title	Units
Biol 3151	Endocrinology	3
Biol 328	Principles in Human Physiology	4
Biol 3411	Principles of the Nervous System	3
Biol 3421	Introduction to Neuroethology	3
Biol 3422	Genes, Brains and Behavior	3
Biol 4023	How Plants Work: Physiology, Growth and Metabolism	3
Biol 4030	Biological Clocks	3
Biol 4071	Developmental Biology	3
Biol 4072	Regenerative and Stem Cell Biology	3
Biol 4381	Cell-Based Tissue Engineering and Regenerative Medicine	3
Biol 4580	Principles of Human Anatomy and Development	3

Area C: Evolution, Ecology and Population Biology

Code	Title	Units
Biol 3220	Woody Plants of Missouri	3
Biol 347	Darwin and Evolutionary Controversies	3
Biol 3501	Evolution	4
Biol 370	Animal Behavior	3
Biol 381	Introduction to Ecology	3
Biol 4181	Population Genetics (and Microevolution)	3
Biol 4182	Macroevolution	3
Biol 4183	Molecular Evolution	3
Biol 419	Community Ecology	3
Biol 4195	Disease Ecology	4
Biol 472	Behavioral Ecology	4

Majors also must take an advanced laboratory course from the following list:

Code	Title	Units
Biol 3110	Vertebrate Structure Laboratory	4
Biol 3423	Behavioral Genetics Laboratory	3
Biol 3491	Microbiology Laboratory	3
Biol 3492	Laboratory Experiments with Eukaryotic Microbes	3
Biol 3493	Bacterial Bioprospecting and Biotechnology	3
Biol 360	Biophysics Laboratory	3
Biol 404	Laboratory of Neurophysiology	4
Biol 4193	Experimental Ecology Laboratory	4

Biol 4220	Practical Bioinformatics	4
Biol 4342	Research Explorations in Genomics	4
Biol 434W	Research Explorations in Genomics (Writing Intensive)	4
Biol 4522	Laboratory in Protein Analysis, Proteomics and Protein Structure	3
Biol 4523	Molecular Methods in Enzyme Analysis	4
Biol 4525	Structural Bioinformatics of Proteins (Writing Intensive)	4

All courses to be counted toward a major in biology must be taken for a letter grade if a letter grade is offered. A grade of C- or better must be earned in all of these courses.

In special cases, students may earn credit for graduate courses offered by the Division of Biology and Biomedical Sciences.

Optional Biology Major Tracks

A student majoring in biology may choose one of five optional tracks within the major if the student's interests lie primarily within one of these subfields of biology. A track provides strong training for graduate study in its subfield. *All tracks require completion of the biology major requirements as stated above* but provide concentrated study in one of the five subfields.

The Major in Biology: *Ecology and Evolution Track*

Total units required (including the biology major requirements): 65

Additional requirements include Math 2200 or Math 3200. Students whose main interest is ecology must take at least two ecology electives and one evolution elective; students whose main interest is evolution must take at least two evolution electives and one ecology elective (evolution electives: Biol 3501, Biol 4181, Biol 4182 and Biol 4183; ecology electives: Biol 370, Biol 381, Biol 419, Biol 4195 and Biol 472). Also required are one elective in analytical methodology (CSE 131 or Math 322) and one elective in Earth, environmental, and planetary sciences (EEPS 201 or EEPS 323). The course used to fulfill the advanced laboratory requirement for the major must be Biol 4193, Biol 4342 or Biol 434W.

The Major in Biology: *Genomics and Computational Biology Track*

Total units required (including the biology major requirements): 64

Additional requirements include an advanced genomics/computational biology elective (Biol 324, Biol 4183, Biol 4344, Biol 548 or Biol 5488); statistics (Math 2200 or Math 3200); and two outside electives (CSE 131 and CSE 247). CSE 240 is strongly recommended as well. The course used to fulfill the advanced laboratory requirement for the major must be Biol 3492, Biol 3493, Biol 4220, Biol 4342, Biol 434W or Biol 4525. Biology courses recommended for students in this track include Biol 334, Biol 3422, Biol 349, Biol 3491, Biol 4030, Biol 4181, Biol 4183 and Biol 4810. Recommended mathematics electives include Math 217 and Math 309.

The Major in Biology: *Microbiology Track*

Total units required (including the biology major requirements): 68

Additional requirements include Biol 349, which should be taken during the spring of the sophomore year, and either Biol 451 or the pair of courses Biol 4810 and Biol 4820. The advanced laboratory course used to fulfill major requirements must be one of the following: Biol 3491, Biol 3492 or Biol 3493. At least one of the following must be taken as an advanced microbiology elective: Biol 3481, Biol 4242, Biol 4492 or Biol 5426. At least one of the following must be taken as an allied elective: the pair of courses Biol 191 and Biol 192, Biol 424, Chem 453 or EEPS 323. Students should select one course each from biology major areas B and C. Biol 3501 is highly recommended as the course used to fulfill biology major area C. The total number of upper-level credits earned in major-track biology courses and allied electives must be at least 24 (6 additional units to the 18 units required for the biology major).

The Major in Biology: *Molecular Biology and Biochemistry Track*

Total units required (including the biology major requirements): 58

Additional requirements include both Biol 4810 and Biol 4820 as well as either Biol 334 or Biol 349. The advanced laboratory course used to fulfill major requirements must be one of the following: Biol 3423, Biol 3491, Biol 3492, Biol 3493, Biol 4342/Biol 434W, Biol 4522, Biol 4523 or Biol 4525. Additional biology courses recommended for students in this track include Biol 4023, Biol 4071, Biol 4183, Biol 4344, Biol 4833 and Biol 5312.

The Major in Biology: *Neuroscience Track*

Total units required (including the biology major requirements): 60

Biology major requirements must be met with the following courses: Biol 3057 or Biol 3058, area A (Biol 334, Biol 451, Biol 4810 or Biol 4820), area B (Biol 3411), and any course in area C. Students must then choose one of the following laboratory pathways: (1) Laboratory Pathway 1: one of the following courses: Biol 3423, Biol 360 or Biol 404; or (2) Laboratory Pathway 2: any other upper-level biology laboratory course on the list of approved laboratory courses for the biology major plus 6 credits of Biol 500N and/or Biol 500U (Independent Research in Neuroscience). Students must select at least one biology elective (Biol 3110, Biol 3151, Biol 328, Biol 3421, Biol 3422, Biol 3424, Biol 4030 or Biol 4580) and one outside elective either in physics (Physics 350, Physics 355, Physics 360 or Physics 453) or psychology (Psych 330, Psych 360 or Psych 3604). Math 2200 or Math 3200 is

recommended. Optional seminar courses in neuroscience include Biol 171 and Biol 4934. Physics 360may count either as the advanced laboratory requirement or the outside elective course but not for both requirements.

Related majors can be found in the biomedical engineering (http://bulletin.wustl.edu/undergrad/engineering/biomedical/#majors), philosophy-neuroscience-psychology (PNP) (http://bulletin.wustl.edu/undergrad/artsci/philosophyneurosciencepsychology/#majors) and philosophy of science (http://bulletin.wustl.edu/undergrad/artsci/philosophy/#majors) pages of this *Bulletin*.

The Major in Environmental Biology

Students interested in environmental biology typically take Biol 2950 Introduction to Environmental Biology during fall of the first year of study; although, it may be taken later.

Total units required: 58-65

Required courses:

Code	Title	Units
Biol 2950	Introduction to Environmental Biology	3
Biol 2960	Principles of Biology I (lecture and lab)	4
Biol 2970	Principles of Biology II (lecture and lab)	4
Biol 381	Introduction to Ecology	3
Chem 111A	General Chemistry I (lecture and lab)	3
or Chem 105	Introductory General Chemistry I	
Chem 112A	General Chemistry II	3
or Chem 106	Introductory General Chemistry II	
Chem 151	General Chemistry Laboratory I	2
Chem 152	General Chemistry Laboratory II	2
EEPS 201	Earth and the Environment (lecture and lab)	3-4
or EEPS 202	Introduction to Earth, Environmental, and Planetary Science	
or EEPS 219	Energy and the Environment	
Math 131	Calculus I	3
Math 132	Calculus II	3
Physics 191	Physics I	3
or Physics 193	Focused Physics I	
Physics 191L	Physics I Laboratory	1
or Physics 193L	Focused Physics I Laboratory	
Total Units		**37-38**

One of the following chemistry courses:

Code	Title	Units
Chem 261	Organic Chemistry I with Lab	4
EEPS 323	Biogeochemistry	3
EECE 210	Introduction to Environmental Engineering	3
EECE 505	Aquatic Chemistry	3
EECE 531	Environmental Organic Chemistry	3

One of the following courses in statistics or GIS:

Code	Title	Units
Math 2200	Elementary Probability and Statistics	3
Math 3200	Elementary to Intermediate Statistics and Data Analysis	3
EnSt 380	Applications in GIS	3

One upper-level biology lab course:

Any course that fulfills the advanced laboratory requirement of the biology major is acceptable; we recommend Biol 4193 Experimental Ecology Laboratory (4 credits, writing intensive).

One of the following Biol 300+ courses (Areas A and B in Biology):

Code	Title	Units
Biol 3151	Endocrinology	3
Biol 328	Principles in Human Physiology	4
Biol 334	Cell Biology	3
Biol 3411	Principles of the Nervous System	3
Biol 3421	Introduction to Neuroethology	3
Biol 3422	Genes, Brains and Behavior	3
Biol 349	Microbiology	4
Biol 4023	How Plants Work: Physiology, Growth and Metabolism	3
Biol 4030	Biological Clocks	3
Biol 451	General Biochemistry	4
Biol 4580	Principles of Human Anatomy and Development	3
Biol 4810	General Biochemistry I	3

One of the following Biol 300+ courses (Area C in Biology):

Code	Title	Units
Biol 3220	Woody Plants of Missouri	3
Biol 3501	Evolution	4
Biol 370	Animal Behavior	3
Biol 4181	Population Genetics	3
Biol 4182	Macroevolution	3
Biol 419	Community Ecology	3
Biol 4195	Disease Ecology	4
Biol 472	Behavioral Ecology	4

One additional Biol 300+ major-track course (may include Biol 500):

Please refer to the Biology Course Listings (p. 8) in this *Bulletin*.

One of the following EnSt or EEPS 300+ courses:

Code	Title	Units
EEPS 317	Soil Science	3
EEPS 323	Biogeochemistry (only if not already taken for chemistry requirement)	3
EEPS 340	Minerals, Rocks, Resources and the Environment	4
EEPS 353	Earth Forces	4
EEPS 385	Earth History	3
EEPS 409	Surface Processes	3
EEPS 428	Hydrology	3
EEPS 442	Aqueous Geochemistry	3
EEPS 486	Paleoclimatology	3
EnSt 364	Field Methods for Environmental Science	3
EnSt 365	Applied Conservation Biology	3

Additional Information

Research: Research opportunities are available during the student's first and second years through Biol 200; such opportunities are available during the third and fourth years through Biol 500. A research emphasis in the major requires at least 6 credits (two semesters) of Biol 500 research and an approved senior thesis on this research, which is presented at the undergraduate symposium. The research emphasis is acknowledged on the degree as a research milestone.

Senior Honors: Biology majors are encouraged to work for senior honors, which require a 3.30 grade point average in biology, a 3.30 GPA in nonbiological sciences (mathematics, chemistry and physics courses), and a 3.65 overall GPA at the time of graduation. Also required are 6 units of Biol 500 research and an approved thesis from this work, equivalent to the research emphasis described in the preceding paragraph. Students interested in senior honors should begin Biol 500 no later than the spring of their junior year.

The Department of Biology awards the Marian Smith Spector Prize to an undergraduate who has an excellent academic record and who submits an outstanding honors thesis; it also awards the Ralph S. Quatrano Prize to the student whose thesis shows the greatest evidence of creativity in design, research methodology and/or broader scientific implications. The Harrison D. Stalker Prize is awarded to a graduating senior whose college career is distinguished by scholarship, service and breadth of interest.

Minors

The Minor in Biology

Units required: 18 units of biology and 14 units of chemistry

Required courses:

Code	Title	Units
Biol 2960	Principles of Biology I	4
Biol 2970	Principles of Biology II	4
Chem 111A	General Chemistry I	3
or Chem 105	Introductory General Chemistry I	
Chem 112A	General Chemistry II	3
or Chem 106	Introductory General Chemistry II	
Chem 151	General Chemistry Laboratory I	2
Chem 152	General Chemistry Laboratory II	2
Chem 261	Organic Chemistry I with Lab	4
Total Units		**22**

Elective courses:

The minor requires 10 advanced units in biology selected from the following:

Code	Title	Units
Biol 3010	Biotechnology Project	3
Biol 3058	Physiological Control Systems	2
Biol 3100	R Workshop in Biology	1
Biol 3110	Vertebrate Structure Laboratory	4
Biol 3151	Endocrinology	3
Biol 3220	Woody Plants of Missouri	3
Biol 3221	Research and Public Education in the Arboretum	3
Biol 324	Human Genetics	3
Biol 328	Principles in Human Physiology	4
Biol 334	Cell Biology	3
Biol 3411	Principles of the Nervous System	3
Biol 3421	Introduction to Neuroethology	3
Biol 3422	Genes, Brains and Behavior	3
Biol 3423	Behavioral Genetics Laboratory	3
Biol 347	Darwin and Evolutionary Controversies	3
Biol 3481	Parasitology	3
Biol 349	Microbiology	4
Biol 3491	Microbiology Laboratory	3
Biol 3492	Laboratory Experiments with Eukaryotic Microbes	3
Biol 3493	Bacterial Bioprospecting and Biotechnology	3
Biol 3501	Evolution	4
Biol 354	Physics of Living Systems	3
Biol 360	Biophysics Laboratory	3
Biol 370	Animal Behavior	3
Biol 381	Introduction to Ecology	3
Biol 4023	How Plants Work: Physiology, Growth and Metabolism	3
Biol 4030	Biological Clocks	3
Biol 404	Laboratory of Neurophysiology	4

Biol 4071	Developmental Biology	3
Biol 4072	Regenerative and Stem Cell Biology	3
Biol 4181	Population Genetics	3
Biol 4182	Macroevolution	3
Biol 4183	Molecular Evolution	3
Biol 419	Community Ecology	3
Biol 4193	Experimental Ecology Laboratory	4
Biol 4195	Disease Ecology	4
Biol 4220	Practical Bioinformatics	4
Biol 424	Immunology	4
Biol 4242	Virology	3
Biol 4270	Problem Based Learning in Biomedical Sciences	3
Biol 4271	The Science of Cats	3
Biol 4310	Biology of Aging	3
Biol 4342	Research Explorations in Genomics	4
Biol 434W	Research Explorations in Genomics (Writing Intensive)	4
Biol 4344	Epigenetics	3
Biol 4381	Cell-Based Tissue Engineering and Regenerative Medicine	3
Biol 4492	Infectious Diseases: History, Pathology, and Prevention	3
Biol 451	General Biochemistry	4
Biol 4522	Laboratory in Protein Analysis, Proteomics and Protein Structure	3
Biol 4523	Molecular Methods in Enzyme Analysis	4
Biol 4525	Structural Bioinformatics of Proteins (Writing Intensive)	4
Biol 4540	Physics of Living Systems	3
Biol 4580	Principles of Human Anatomy and Development	3
Biol 4715	Basic Cancer Biology	3
Biol 4716	Advanced Cancer Biology	3
Biol 472	Behavioral Ecology	4
Biol 4810	General Biochemistry I	3
Biol 4820	General Biochemistry II	3
Biol 4833	Protein Biochemistry	3

Additional Information

All courses used for the biology minor must be taken for a letter grade. A grade of C- or better must be earned in all of these courses. A student may not receive credit for both Biol 370 and Biol 472 or for both Biol 4342 and Biol 434W.

The Minor in Bioinformatics

Mindful of the emerging opportunities at the interface of biology and computer science, the Department of Biology and the Department of Computer Science & Engineering have fashioned the minor in bioinformatics. This program serves students from both departments as well as other students from the natural sciences and engineering with an interest in this field.

Units required: 23 to 24 units, as described below

Core courses:

Code	Title	Units
Biol 2960	Principles of Biology I	4
Biol 2970	Principles of Biology II	4
CSE 131	Introduction to Computer Science	3
CSE 247	Data Structures and Algorithms	3
ESE 326	Probability and Statistics for Engineering	3
or Math 2200	Elementary Probability and Statistics	
or Math 3200	Elementary to Intermediate Statistics and Data Analysis	
or Math 3211	Statistics for Data Science I	
or DAT 120 & DAT 121	Managerial Statistics I and Managerial Statistics II	
Total Units		**17**

Advanced biology elective: Choose one of the following:

Code	Title	Units
Biol 3492	Laboratory Experiments with Eukaryotic Microbes	3
Biol 4181	Population Genetics	3
Biol 4220	Practical Bioinformatics	4
Biol 4342	Research Explorations in Genomics	4
Biol 437	Laboratory on DNA Manipulation	4
Biol 4525	Structural Bioinformatics of Proteins (Writing Intensive)	4

Computer Science & Engineering elective: Choose one of the following:

Code	Title	Units
CSE 514A	Data Mining	3
CSE 584A	Algorithms for Biosequence Comparison	3
or Biol 5504	Algorithms for Biosequence Comparison	
CSE 587A	Algorithms for Computational Biology	3

Additional Information

It is anticipated that, for those students majoring in biology or computer science & engineering (CSE), some portion of the introductory sequence will overlap with the courses required for the major and that these courses will be applicable to both the major and

the minor. Upper-level courses in biology and CSE used to fulfill the minor requirements may not be used to fulfill the requirements of another major or minor in Arts & Sciences. A minimum grade of C- is required for all courses to count toward the minor.

Courses

Visit online course listings to view semester offerings for L41 Biol (https://courses.wustl.edu/CourseInfo.aspx?sch=L&dept=L41&crslvl=1:4).

L41 Biol 1103 Medical Imaging of the Human Body
A multimedia exploration of the human body via state-of-the-art imaging techniques, including CT, MRI, Ultrasound, and PET scans. The investigative challenge of diagnostic medical imaging is examined and common health issues including sports injuries, heart disease, stroke, cancer, arthritis, as well as early detection screening tests are discussed. Material is presented in a uniquely interactive and enjoyable manner. Prereq: one year high school or entry-level college biology.
Credit 3 units. A&S IQ: NSM BU: SCI

L41 Biol 112 First-Year Seminar: Introduction to Problem-Based Learning in Biology
In this course, students take responsibility for their own active, inquiry-based learning on biological problems. Instructors will guide small groups of 8-10 students in researching issues of biological importance using primary literature as their principal resource. Learning to read and interpret research articles from scientific literature is emphasized. Topics covered in this class have included: neurological disorders, infectious diseases, CRISPR, cancer, and stem cell therapy among others. Students should have a strong background in general biology. They will be challenged to use critical and creative thinking in both independent and group work. Enrollment limited. Intended for but not limited to prospective biology majors. Prerequisite: high school biology, preferably an Honors or AP class. Course is for first-year, non-transfer students only.
Credit 3 units. A&S: FYS A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 1122 Introduction to Critical Thinking in Biology
Official description: This course is for first-year, non-transfer students only. This course uses thought-provoking questions in biology to develop analytical skills, at the same time understanding what level of content is needed to address such questions. Each class will involve discussion of the questions as well as lecture material as background. It will thus provide an early exposure and springboard into the translation of biology content to problem-solving. The skills learned will be applicable to future challenges The course focuses on molecular biology and processes central to all organisms on earth. The last component of the course will focus on microbiological research, gaining knowledge of the research enterprise to generate new knowledge and the primary literature (published manuscripts). Prerequisite: Limited to 10 students. Freshman with an interest in biology career (e.g. graduate or health professions). The course is also designed to help students prepare for Biology 2960, which is offered each spring semester. Intended for students without strong AP Biology preparation, which is helpful for success in Biology 2960. Credit 3 units.
Credit 3 units. A&S IQ: NSM Art: NSM

L41 Biol 1260 First-Year Seminar: The Secret Lives of Plants
This course is designed to familiarize undergraduate students with the fascinating lives of plants, their evolution, their remarkable structural and morphological diversity, how they grow, and how they have been modified to feed the planet. Topics include how plants can survive with just water, minerals and light; how they transport water astonishing distances; their unusual sex lives; why they make seeds; how they can grow nearly forever; how they survive extreme environments without running to hide; why they synthesize caffeine, nicotine, THC, and opiates; how they defend themselves from pathogens without an immune system; how they sense their environment without dedicated sensory organs; how they have been modified by humans to provide food, fiber, and fuel; and how genetically modified (GMO) crops are made and their implications related to the environment and society. The overall goals are to enhance students' understanding and appreciation of the plant kingdom, to help young scientists understand the primary scientific literature, and to serve as a starting point for possible careers in plant biology. Class includes field trips to the Missouri Botanical Gardens and to a local plant biotech company/institute. Where appropriate, the class will also emphasize key differences between plants and animals. This course is primarily for first-year students interested in majoring in biology, with a possible emphasis on plants. This course is also for those that want to know more about where their food comes from, how these amazing creatures survive and flourish, and how GMO crops are engineered. Upper-level students with an interest in food and sustainable agriculture but not necessarily focusing on plants will also be welcome. The course will have a lecture/discussion/hands-on format for two of the three hours per week. Students will present 20-minute papers discussing topics relevant to their interests for the remaining hour (two students per class). Prerequisites: Students must have taken both biology and chemistry in high school and at least one at the AP or IP level, or they must have taken Biol 2960 or Chem 111/112. This course can be taken by both first-year and upper-level undergraduates, with a preference given to first-year students.
Credit 3 units. A&S: FYS A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 131 Biology in the News
Students explore a number of biology topics that are frequently discussed in the media. We begin with an investigation into how to evaluate scientific claims reported in written (e.g., news articles, blogs, social media posts), visual (e.g., YouTube videos, Instagram posts) and audio media (e.g., podcasts). We then explore the topics of genetic modification, GMOs, cloning, and direct-to-consumer home DNA testing kits. Finally, we investigate medical topics, including cancer, vaccines and antibiotic resistance. We emphasize critical thinking and reasoning as it applies to the acceptance or rejection of scientific claims presented in popular media formats. This course is intended for students not majoring in biology and who would like to learn more about scientific topics portrayed in the media as controversial and under debate.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 144 Ampersand: The Biology of Cancer Part I
Cancer is the second-leading cause of death worldwide. In spite of focused research efforts, cancer still poses a unique biomedical puzzle as it is now recognized that cancer is not a single disease, but rather a collection of many disorders with underlying mechanistic complexities that can affect most tissues in the human body. This interactive first-semester course provides an introductory overview of the biology of human cancers. We touch upon background topics in DNA structure and replication, gene regulation and transcription, protein synthesis, mutations and DNA repair, but the primary focus is on the genetic and molecular changes that normal cells undergo during transformation into malignant tumors. Part I highlights the first three (of eight) central characteristics of cancer (known as the "hallmarks of cancer"): sustained proliferation, evasion of growth suppression, and replicative immortality. The course is a mix of lectures, student-led discussions/presentations, and activities. Lectures provide an overview of each topic, while activities and discussions of cutting-edge oncology topics in the news and primary literature familiarize students with current trends in cancer research as well as enhance reading and critical analysis skills. Students choose a specific topic/theme within the cancer paradigm for further study and near the end of

the semester prepare a presentation to the class on the implications for cancer survivorship. Prerequisite: High school biology and chemistry; AP or Honors biology is highly recommended. Enrollment is limited to 20 students and restricted to first-year students in the "Hallmarks of Cancer & Patient Care" program.
Credit 4 units. A&S: AMP A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 1440 Ampersand: The Biology of Cancer Part II
TBD
Credit 4 units. A&S: FYS A&S IQ: NSM

L41 Biol 1441 Ampersand: Frontiers in Cancer Research and Treatment
Cancer as a disease has touched countless people in every country and every lifestyle. Cancer is not one single disease; rather, it is a collective scourge of many underlying disorders. Over the years, biomedical research has led to a fuller understanding of cancer etiology and spawned new diagnostic and treatment strategies to better manage and treat this condition. More recently, the launch of the Precision Medicine Initiative by the National Cancer Institute has led to unprecedented insights into the cellular signaling pathways that drive the development and progression of cancer. Furthermore, the current onset of "omics" technology and high-throughput biological readouts has opened the possibility of precisely identifying molecular changes and affected metabolic pathways in individual cancers, paving the way for precision medicine and patient care. In this second semester, we will build upon our foundational understanding of cancer and explore recent and groundbreaking advances in cancer research and therapies. The course is driven largely by student-led presentations and discussions with a mix of faculty lectures and guest seminars. Students work in teams and take responsibility for their own active, inquiry-based learning by examining various cancer topics using primary literature as the principle resource. Learning to read, interpret, and assemble a presentation from scientific literature and biomedical research is emphasized. Student teams choose a hypothesis-driven topic of interest in the field of oncology for further study and, near the end of the semester. prepare a written report and oral presentation to the class outlining its background, central hypothesis-driven question(s), experimental rationale/strategy, research data, scientific conclusion, and future direction. Prerequisite: BIOL 144. Enrollment is limited to students in the Hallmarks of Cancer & Patient Care program. Limited to 20 students.
Credit 3 units. A&S: AMP A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 1500 First-Year Opportunity: Molecular Biology of Genetic Disease
This course is for first-year, non-transfer students only. Students gain a fluency in biological language, methods, and reasoning as applied to human health. We study the molecular, cellular, and physiological perspectives for each health-related topic, and examine data and methods that support this knowledge. We emphasize problem-solving and reasoning as it applies to understanding biological processes. The content and problem-solving work are designed to help students prepare for Biology 2960, which is offered each spring semester. Intended for students without strong AP Biology preparation, which is helpful for success in Biology 2960
Credit 2 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 171 First-Year Opportunity: Neuroscience Futures I: How Do We Learn About the Brain?
In this seminar course for first-year students, students learn about how neurobiologists conduct and communicate research. We focus our discussion on primary research papers written by neurobiologists. Discussion then focuses on the formulation of scientific questions, evaluation of evidence, and interpreting data within the context of a broader field. Course is for first-year, non-transfer students only. Must be taken credit/no credit.
Credit 1 unit. A&S: FYO Arch: NSM Art: NSM

L41 Biol 1770 First-Year Opportunity: The Biology of Dog Breeds
This freshman seminar uses the topic of dog behavior and genetics to teach fundamental scientific tools and to engage students in contributing to the building of an online public resource that summarizes the scientific literature on breeds. Our first task is learning to read and dissect primary scientific literature. We parse out the difference between scientific questions, hypotheses, and predictions through a guided case-study exercise. We then apply the experience to outlining primary research articles, identifying the key components of the author's arguments, and summarizing the results and implications. The second half of the semester is spent searching the scientific literature, sorting information into the new dog breed resource, and presenting results to peers around the seminar table. Course is for first-year, non-transfer students only.
Credit 2 units. A&S: FYO A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 1771 Special Topics in Biology: Plant-Microbe Interactions
Microbial organisms play very important roles in the lives of plants and animals. For example, in nature as well as in agricultural settings, the communities of microorganisms that grow near or on plants influence the growth and overall health of these plants. These plant-associated microbial communities are highly complex, and they are comprised of thousands of different species, including bacteria and fungi. However, neither the role of individual microbial species within the larger microbial community nor how such a community is beneficial to plants is well understood. Each year, students in this course explore a different topic related to interactions between plants and their associated microbes. During the 2020-21 academic year, our research will focus on virulence mechanisms used by the plant pathogen *Pseudomonas syringae* to promote disease in plants. Recent research in the Kunkel lab has revealed that the plant hormone auxin promotes disease development in interactions between *P. syringae* strain PtoDC3000 and one of its host, *Arabidopsis thaliana,* a weedy plant in the mustard family. Auxin acts through at least two different mechanisms to promote disease: 1) suppressing defense responses in the plant and 2) regulating gene expression in the pathogen. We will investigate this second activity by screening for and characterizing PtoDC3000 mutants that do not properly respond to auxin. Students will spend two hours per week in the lab carrying out bacteriological and molecular biology experiments. Over the course of the semester, students will be exposed to a variety of fundamental topics in biology, including bacteriology, plant growth and development, pathogenic plant-microbe interactions, and key concepts in genetics, molecular biology and biochemistry. The students will also meet with Dr. Kunkel for one hour per week to discuss a variety of topics chosen to explore, including 1) basic concepts in chemistry, biochemistry, and molecular biology; 2) learning and study strategies; and 3) other topics related to thriving at Washington University. This is a research-based laboratory course offered by Dr. Barbara Kunkel in the Department of Biology. The small class size and laboratory setting of the course is intended to foster the development of student-professor mentoring relationships. The weekly time commitment involves two hours in the lab and one hour of discussion. Class size is limited to four students. Prerequisite: Permission of instructor.
Credit 1 unit. Arch: NSM Art: NSM

L41 Biol 1772 Special Topics in Biology: Plant-Microbe Interactions

This is a research-based laboratory course offered by Dr. Barbara Kunkel in the Biology Department. The small class size and laboratory setting of the course is intended to foster development of student-professor mentoring relationships. Time commitment (weekly): 2 hours in lab, 1 hour of discussion (1 unit, P/F). Class size: 4 students Prerequisite: Permission of Instructor Research Question. Microbial organisms play very important roles in the lives of plants and animals. For example, in nature as well as in agricultural settings, the communities of microorganisms that grow near or on plants influence the growth and overall health of these plants. These plant-associated microbial communities are highly complex, and are comprised of thousands of different species, including bacteria and fungi. However, neither the role of individual microbial species within the larger microbial community, nor how such a community is beneficial to plants, is well understood. Each year the students in Bio1771 explore a different topic related to interactions between plants and their associated microbes. During the 2020/2021 academic year our research will focus on virulence mechanisms used by the plant pathogen Pseudomonas syringae to promote disease in plants. Recent research in the Kunkel lab has revealed that the plant hormone auxin promotes disease development in interactions between P. syringae strain PtoDC3000 and one of its host, Arabidopsis thaliana, a weedy plant in the mustard family. Auxin acts through at least two different mechanisms to promote disease, including 1) suppressing defense responses in the plant and 2) regulating gene expression in the pathogen. We will investigate this second activity by screening for and characterizing PtoDC3000 mutants that do not properly respond to auxin. Students will spend two hours per week in lab carrying out bacteriological and molecular biology experiments. Over the course of the semester, students will be exposed to a variety of fundamental topics in biology, including: bacteriology, plant growth and development, pathogenic plant-microbe interactions, and key concepts in genetics, molecular biology and biochemistry. The students will also meet with Dr. Kunkel for one hour per week to discuss a variety of topics chosen to explore: i) basic concepts in chemistry, biochemistry and molecular biology, ii) learning and study strategies, and iii) other topics related to thriving at WUSTL.
Credit 1 unit.

L41 Biol 181 First-Year Opportunity: Introduction to Cutting-Edge Research in Biology

A lecture course intended for first-year students that focuses on the practice and culture of biological research. Active researchers describe the biological context of their research, the specific questions they have formulated, the means by which they pursue the answers, and their data and conclusions. The focus is on process: how biologists pursue their profession, what goes on in a research setting. Additional topics of clinical and contemporary interest are often included. Students are expected to attend all lectures. Enrollment is restricted to first-year, non-transfer students.. Must be taken Credit/No Credit.
Credit 1 unit. A&S: FYO A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 1811 First-Year Opportunity: Research and Conservation in Zoos and Botanical Gardens

An introduction to the world of zoos and botanical gardens. Students will learn of the diverse and cutting-edge ways in which scientists and conservationists study the world's biological diversity and work to conserve it. Taking advantage of two world-class institutions a short distance from the Danforth Campus, the class will meet every week at an off-campus site (primarily the Saint Louis Zoo and Missouri Botanical Garden, but also several other institutions) to hear lectures from leading authorities at these institutions, as well touring facilities to see first-hand how research is conducted and how these institutions work to preserve endangered species. Students will write three short papers; each paper will be based upon a class lecture and its associated readings. Must be taken Credit/No Credit. Course is for first-year, non-transfer students only.
Credit 2 units. A&S: FYO A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 191 Ampersand: Phage Hunters

This is a research-based laboratory course for first-year students. Students join a national experiment organized by HHMI, with the goal of isolating and characterizing bacteriophage viruses found in the soil in the St. Louis area. Laboratory work includes isolation and purification of the student's own phage, DNA isolation and restriction mapping, and EM characterization of the phage. Several Washington University phages are selected for genome sequencing over winter break and then annotated in the spring in Biol 192 Phage Bioinformatics. Students who successfully isolate and annotate a phage may become co-authors on a scientific paper. Prerequisites: High school courses in biology and chemistry, with at least one at the AP or International Baccalaureate level, and permission of instructor. This course involves one hour of lecture, one hour of discussion, and three hours in the lab per week; it is for first-year students in the Phage Hunters Program only.
Same as L61 FYP 1910
Credit 3 units. A&S: AMP A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 192 Ampersand: Phage Bioinformatics

This is a research-based laboratory class for freshmen. Students join a national experiment organized by HHMI, with the goal of genomic characterization of a local phage. Laboratory work focuses on learning computer-based tools for genome analysis followed by annotation and comparative analysis of the genome of a phage (bacterial virus) that was isolated during the fall semester at Washington University and sequenced over winter break. Prerequisites: high school courses in biology, chemistry, and physics (at least one at the AP or International Baccalaureate level); permission of the instructor. Limited to 40 students; preference given to those completing Biol 191 Phage Hunters. One hour lecture, one hour discussion, and three hours lab per week.
Same as L61 FYP 1920
Credit 3 units. A&S: AMP A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 200 Introduction to Research

This is an introduction to laboratory and field research in biology for first- and second-year students. Students work under the supervision of a mentor in a setting of established, ongoing research. Prerequisites: less than 60 units completed; permission of mentor and the department. For online enrollment instructions, visit the Bio 200/500 webpage (https://pages.wustl.edu/Bio_200-500_independent_research/register/). Students are registered by the department after approval is granted. Registration may not appear in WebSTAC until mid-semester. Credit/no credit only.
Credit variable, maximum 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 200N Introduction to Research in Neuroscience

This course provides an introduction to research in neuroscience under the supervision of a faculty mentor. Students work under the supervision of a mentor in a setting of established, ongoing research. Prerequisite: less than 60 units completed and permission of the mentor and the department. For online enrollment instructions, visit https://sites.wustl.edu/bio200500independentresearch/. Students are registered by the department after approval is granted. Registration may not appear in WebSTAC until mid-semester. Credit/No credit only. Course may not be taken for a letter grade.
Credit variable, maximum 3 units.

L41 Biol 200S Summer Introduction to Research
Summer research under the supervision of a faculty mentor. Prerequisites: first-year or sophomore standing and permission of mentor and the department. Credit to be determined in each case, usually 3 units/summer; may be repeated for credit during different summers. Credits are received during the fall semester after the summer research. The application deadline and registration information can be found on the Bio 200/500 course website (https://pages.wustl.edu/Bio_200-500_independent_research/). Credit/no credit only.
Credit variable, maximum 3 units. A&S IQ: NSM

L41 Biol 200U Summer Introduction to Research in Neuroscience
Summer research in neuroscience under the supervision of a faculty mentor. Prerequisites: first-year or sophomore standing and permission of the mentor and the department. Credit to be determined in each case, usually 3 units/summer. Course may be repeated for credit in different summers. Credits are received in the fall semester following the summer research. The application deadline and registration information can be found on the Biol 200/500 course website: https://sites.wustl.edu/bio200500independentresearch. Credit/no credit. Course may not be taken for a letter grade.
Credit variable, maximum 3 units.

L41 Biol 2010 Ampersand: The Science of Biotechnology
Biotechnology is truly interdisciplinary, incorporating a myriad of pieces from biology, chemistry, engineering, physics, computer sciences, management, public policy, and law that apply the scientific process to societal challenges. This course introduces topics for science and engineering majors with an interest in biotech, and it teaches scientific concepts to business students considering careers in biotech management and entrepreneurship. Students who complete Biol 2010 understand key science concepts, how discoveries lead to applications addressing global challenges, how to effectively use a variety of resources to explore connections between science and biotech business, how to synthesize information from different fields, and how to exhibit strong teamwork skills and communicate information in written and oral forms. This course also provides a gateway for students interested in the two-year Biotech Explorers Program. The first two weeks of the course introduce students to the history of biotechnology, the Biotech Explorers Program, and the use of case studies. The remainder of the course uses a series of four three-week units that combine lecture material, in-class group assignments, and readings to introduce the science and scope of biotechnology. For each unit, student teams also develop short case studies of St. Louis biotech companies and present their findings to the class. A series of site visits introduce students to the vibrant St. Louis biotech community. This course is for students in the Biotech Explorers Program only.
Credit 3 units. A&S: AMP A&S IQ: NSM BU: SCI

L41 Biol 2020 Ampersand: Biotechnology Entrepreneurs Seminar
Although the biotech industry is science-based, the risks of product and technology development, legal issues, and market pressures make the landscape full of uncertainty. Lectures and textbooks fall short of delivering true insight about the process and challenges of bringing ideas to real-world products. This second semester freshman seminar course is designed to develop an appreciation of how biotech companies achieve their goals by engaging students through interactions with experienced executives and entrepreneurs, whose shared knowledge and stories add depth and context to the learning process. This 1-credit seminar course introduces students to the basics of innovation and entrepreneurship as a framework for marketable discoveries, builds an appreciation of how biotech companies start, obtain funding, and navigate intellectual property, provides an overview of career options in biotech, and insight on the hiring process. Prerequisites: Students need to have completed Biol 2010: The Science of Biotechnology for enrollment in this course and be currently enrolled in Biol 2960: Principles of Biology I. Limited to 20 students.
Credit 1 unit. A&S: FYS

L41 Biol 2111 Nutrition
This introductory course examines nutrition as an interdisciplinary science. Topics include the chemistry, function, and metabolism of nutrients; regulations of food intake; food habits; digestion and absorption of nutrients; methods of determining the nutrient content of foods and nutrient requirements for humans and animals; comparative nutrition; problems of human malnutrition; relation of nutrition to disease; toxic materials in foodstuffs; economic, nutritional, and social problems involved in feeding the world population; and future possibilities for meeting nutritional needs of the world's population.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 212 uSTAR Seminar
This seminar course is designed for students who are part of the uSTAR Program at Washington University. The course will provide a formal setting to guide this population into becoming successful researchers in the academic community, with an additional goal of increasing their PhD pursuits. Students in the course will be exposed to scholarly discussions through student-selected journal readings. The course will discuss the different approaches taken to scientific inquiry and the dissemination of knowledge, in addition to the topic of integrity in research and important ethical issues that impact scientific investigation. Students will be exposed to topics relating not only to their area of study but to that of their peers as well. Student presentations on both scholarly journal readings and their own research will enable them to develop the ability to effectively communicate research to a broad audience. From this course, the uSTAR students will develop the skills to read, understand and critically evaluate publications, and they will build a broad understanding of research in multiple fields within the natural sciences. Students will also come away with a greater understanding of the ethical issues that face the scientific community on a daily basis.
Credit 1 unit.

L41 Biol 2121 Research Seminar for Vagelos Fellows
The course will orient Fellows to the specific research environment of their labs and provide them tools to succeed. It will feature short seminars from world-renowned DBBS faculty and DBBS alums. Speakers will emphasize both their science and their career route into academic research, including challenges. This will expose students to multiple paths into and academic careers associated with biosciences graduate training. Diverse speakers will emphasize the desirability and attainability of research training and careers. This course will also include information on the research enterprise, mentorship expectations, rigorous experimental design, quantitative thinking, techniques, rigorous analysis, posing a scientific question, and communication skills. 2.0 units
Credit 2 units. A&S IQ: NSM

L41 Biol 2431 Ampersand: Pathfinder - A Sense of Place: Discovering Missouri's Natural Heritage
This is the first course in the Pathfinder program, and it will introduce students to their new home for the next four years. This interdisciplinary course will cover Missouri geology, climate, archaeology, and native megafauna. We will explore many of the habitats found in Missouri (prairie, forest, glade, and stream) and the biology of our diverse plant and animal wildlife (arthropods, mollusks, fish, salamanders, lizards, birds, and mammals). This will provide a foundation that will inform the study of ecology, policy and management in other courses. In addition to weekly lectures and discussions, students in this course will visit

sites across the state during three weekend camping trips and two one-day trips. Attendance on field trips is an essential component of the course. Course enrollment is open only to students admitted into the Pathfinder Fellowship program.
Same as L61 FYP 121
Credit 3 units. A&S: AMP A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 244 Ampersand: The Oncology Healthcare Team
It's news no one wants to hear: "You have cancer." A cancer diagnosis can be overwhelming. The physical and emotional effects that come with this disease and its treatment can be significant. People often need the experience and skills of several different medical specialists to navigate and treat cancer. The various medical professionals involved in cancer care make up the oncology healthcare team.
In this third-semester course, we will partner with Siteman Cancer Center and its affiliates to explore the multitude of professions that constitute the oncology healthcare team. In bi-weekly rotations, students will be introduced to various aspects of cancer-patient care and treatment through members of the oncology healthcare team, including oncologists, pathologists, surgeons, clinical geneticists, nurses, psychologists, and public health professionals. The course is a mix of guest lectures, discussions, site visits, activities, and shadowing healthcare professionals. Students will reflect on their experiences in weekly journal entries and must submit a final reflection paper that is due at the end of the semester, synthesizing semester experiences with core competencies for individuals desiring to enter a health profession. Prerequisites: Biol 144 and Biol 1441. Enrollment is limited to students in the "Hallmarks of Cancer & Patient Care" program.
Credit 2 units. A&S IQ: NSM

L41 Biol 265 Experience in the Life Sciences
Earn credit for non-classroom learning in the life sciences in a variety of activities arranged by the student: for example, students may accompany a Washington University faculty physician on rounds and prepare a paper on an organ system or disease, participate in a clinical or applied ecological study and report on it, or participate in science outreach teaching. Participants must meet regularly with a supervisor and commit at least 140 hours over two semesters. A work plan is approved prior to registration. A progress report is due after one semester, and a final paper is due after two semesters. This course does not count toward the major. Students are registered by the department after approval is granted. Credit/no credit only.
Credit 1.5 units.

L41 Biol 2651 MedPrep I: The Lecture Series
This is a unique lecture series taught by a physician, a former medical school course master, and a member of the Committee on Admissions for the School of Medicine. Through a weekly two-hour lecture, this course gives students accurate, honest, and detailed information regarding every step of the medical school application and admissions process, the entire educational process (including medical school and residency training), and the pros and cons of life as a physician. MedPrep I is particularly useful for first-year students and sophomores in that it reviews the common pitfalls encountered by unsuccessful applicants to medical school and outlines the steps to take in each year of college to be a successful applicant when the time comes. There is no outside course work and no exams. Attendance at all classes is required. There is a $10 course fee used for guest speaker stipends, guest speaker travel to St. Louis, audiovisual needs, and other course-related items. For more information, please see the MedPrep website: medprep.wustl.edu.
Credit 1 unit.

L41 Biol 2652 Pediatric Emergency Medicine Research Associates Program: Experiences in Life Sciences
The Pediatric Emergency Medicine Research Associates Program (PEMRAP) offers undergraduate premedical students an opportunity to participate in clinical, patient-oriented research projects in a hospital setting. Students have the opportunity to work in the St. Louis Children's Hospital Emergency Department, a nationally recognized pediatric emergency medicine and trauma care facility. A number of research projects are currently underway in various areas of pediatric emergency medicine. Research Associates are expected to work two four-hour shifts per week in the St. Louis Children's Hospital Emergency Department and to attend a weekly two-hour lecture. Lectures are given by Emergency Department faculty members. This program offers students the unique opportunity to be a vital part of the Emergency Department research team. In addition, students' experiences in this course may help them to determine if medicine is truly the career path they wish to pursue. Prerequisite: Sophomore level or higher, and permission of Instructor. Registration is done through this website: http://pediatrics.wustl.edu/pemrap. This course may not be taken concurrently with Biol 2654 MedPrep II.
Credit 3 units.

L41 Biol 2654 MedPrep II: The Shadowing Experience: Emergency Medicine
This course offers students a real-world, behind-the-scenes experience of a life in medicine. For three hours every other week, students shadow physicians in the Charles F. Knight Emergency and Trauma Center of Barnes-Jewish Hospital, the main teaching hospital of the Washington University School of Medicine. In addition to the shadowing, there is a required class session each week. Because of the orientation material presented, excused absences will not be granted for the first two sessions for any reason whatsoever, including illness or emergency. There is no outside course work and no exams. There is a $25 course fee for a MedPrep shirt and other course-related items (e.g., audiovisual materials), and HIPAA training and PPD testing are required. For more information and to register for this course, interested students should visit the MedPrep website at medprep.wustl.edu. Registration is done through the website, not through WebSTAC. Prerequisites: Biol 2651 and sophomore standing or above. During the summer semester, students may take Biol 2651 and Biol 2654 concurrently.
Credit 1 unit.

L41 Biol 2656 Introduction to Health Professions: Audiology, Occupational Therapy, Pharmacy, and Physical Therapy
This course provides students interested in health professions with an overview of occupational therapy, physical therapy, audiology, and pharmacy. Students gain a better understanding of the scope of practice, markets, and skills required to succeed in these professions. Students learn about graduate and professional education options and how to build a competitive application for these programs. Finally, students participate in self-directed learning experiences (which may include in-person or virtual shadowing, attending professional presentations, meeting with health care professionals or graduate students, or sitting in on graduate-level classes) and culminate their study with an inter-professional education session with a panel of faculty from the different health professions. Students finish the course with a better understanding of whether a career in health professions is right for them.
Credit 1 unit.

L41 Biol 2658 Pediatric Emergency Medicine Research Associates Program: Experiences in Life Sciences (PEMRAP II)
PEMRAP II is a continuation of Biol 2652 Pediatric Emergency Medicine Research Associates Program: Experiences in Life Sciences. Returning PEMRAP Research Associates (RAs) actively participate in new and ongoing research projects in various areas of pediatric

emergency medicine. RAs assist during the active period of patient enrollment through screening of Emergency Deparment (ED) patients for study eligibility, reading information about the studies to the patients, collecting data regarding patient history and certain physical examination findings, and generally facilitating the study enrollment process. PEMRAP Returning RAs are vital members of the ED research team in the St. Louis Children's Hospital Emergency Department. Returning RAs assist in training and mentoring incoming PEMRAP students (Biol 2652) in ED protocol, work approximately one four-hour shift per week in the ED, record shift activities and hours worked on a daily Shift Log form, and participate in the physician shadowing program (as offered). Returning RAs are responsible for meeting hospital non-appointee requirements and staying current with new study protocols by attending or viewing new study presentations for PEMRAP students. These lectures are given by Pediatric Department faculty members to introduce the basics of the clinical research process, specific studies, and pediatric illness. The RA position carries with it important responsibility requiring maturity, initiative, diligence, and excellent interpersonal skills. There is no outside course work and no exams. Full participation is required. 45 shift hours = 1 credit. Students may repeat this course for a maximum of 6 credits. Course may not be taken concurrently with Biol 2651, Biol 2652, or Biol 2654. Enrollment with permission of instructor. Prerequisite: Biol 2652 (PEMRAP I). Pass/fail, 1 to 2 units per semester.
Credit variable, maximum 2 units.

L41 Biol 265S Summer Experiences in Life Sciences
Earn credit for clinical research and other non-classroom learning in the life sciences during the summer. The variety of activities arranged by the student with their WashU faculty mentor have included but are not limited to: participation in clinical research or applied ecological research and report on it; shadow a physician on rounds or in clinic; prepare a paper on an organ system or disease; participate in science outreach teaching, etc. Participants must meet regularly with the faculty mentor or designee and commit to at least 140 hours over two semesters. An application is required each semester which includes a work plan, that must approved prior to registration. A semester Summary Report is due after one semester and a Final Summary Report after two semesters. Bio 265 does not count toward the Biology major/minor. Credit: 1.5 units per semester, contingent upon completion of two semesters. For more information and to access the application, please go to: https://sites.wustl.edu/bio265/. Students are registered by the Biology department after faculty mentor and course master approval is granted. Summer Application Deadline - First Friday of June. Credit/No Credit only.
Credit variable, maximum 1.5 units.

L41 Biol 2950 Introduction to Environmental Biology
Introduction to Environmental Biology is designed to teach important principles of environmental biology and general science literacy skills. We cover the foundational biological principles and contemporary issues within four main topics: human population growth, transfer of energy and carbon in the ecosystem, biodiversity, and food production. We focus on the biological principles involved as we examine these topics in the context of some contentious and confusing issues related to environmental biology in everyday life. The science literacy skills that you master in this course will help you address the issues you face in your everyday life regarding scientific and pseudoscientific claims about the environment and society and will form the foundation for your development as a critical consumer of science information in the media. This course is required for all environmental biology majors and environmental studies minors. We recommend you take this course in your first- or second-year if possible. If your interests align and your schedule allows, we recommend co-enrolling in EnSt 215: Introduction to Environmental Humanities.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 2960 Principles of Biology I
This course is an introduction to biological molecules and biochemical strategies employed by the three domains of life. The flow of genetic information within cells is discussed in the context of cellular structure, organization, and function. The investigation and manipulation of genetic information by molecular genetic technologies, such as recombinant DNA, forms the final phase of the course. Labs reinforce concepts from lectures and explore common laboratory techniques and computer-based resources. Prerequisites: Chem 111 and Chem 112 (concurrently).
Credit 4 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 2970 Principles of Biology II
A broad overview of genetics, including Mendelian assortment, linkage, chromosomal aberrations, variations in chromosome number, mutation, developmental genetics, quantitative genetics, population genetics, mechanisms of evolution, and phylogenetics. Three lecture/problem solving sections and one laboratory period per week. Does not fulfill the laboratory requirement of the biology major. Prerequisite: Biol 2960 or permission of instructor. This course must be taken for a grade to count toward the Biology major.
Credit 4 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 3010 Biotechnology Project
This second-year Biotech Explorers Pathway (BEP) course introduces students to the process used to generate project ideas, write proposals, and evaluate concepts, with peer evaluation applied at all steps of the process. Students completing Biol 3010 will gain experience in science proposal writing with peer review, public speaking, team building, and leadership training. The first four weeks of the course will focus on individual pre-proposal brainstorming, writing, and pitching, while the remainder of the course will be dedicated to the development of full proposals by teams of students. This 3-credit project development course complements introductory courses by making connections between fields and building teams of students with experience in the process that nurtures ideas to products. Prerequisites: Biol 2010 and Biol 2020. Writing intensive. Limited to 20 students.
Credit 3 units. A&S IQ: NSM, WI Arch: NSM Art: NSM BU: SCI

L41 Biol 303A Human Biology
How did Elvis, Socrates and Babe Ruth die? How did David Letterman and Dick Cheney survive? In this course we work toward understanding the biology behind human health and disease. We examine cases from the news, literature and history. We work like detectives to understand how and why the characters were affected and healed or died. This course is designed for students who do not plan to major in science, and no prior science background is expected. Prerequisite: sophomore standing or permission of instructor. A student may not receive credit for both Biol 303A and Biol 100A, 2960, 2970, or UCollege B320, B3201, B321, B3211.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 3041 Plant Biology and Genetic Engineering
A 4-credit lecture course that provides an introduction to plant development, genetics, physiology and biochemistry with emphasis on processes that can be manipulated or better understood through genetic engineering. The course is divided into three sections. The first section of the course discusses basic plant biology, development and genetics. The second part emphasizes gene structure, expression and cloning as well as methods for introducing foreign DNA into plant cells and regenerating fertile plants in tissue culture. During the third part of the course we discuss a variety of examples of genetically engineered traits, including: herbicide resistance; fruit ripening; pathogen and/

or insect resistance; and the use of plants for production of industrial and pharmaceutical compounds. Friday discussion sections focus on critical reading of the primary literature related to the material covered in lecture. Prerequisites: Biol 2960 and Biol 2970.
Credit 4 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 3058 Physiological Control Systems
Systems physiology with emphasis on human physiology.
Prerequisites: Biol 2960 and Chem 112A.
Credit 2 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 307A Human Variation
A survey of human biological diversity, considering its adaptive and taxonomic significance from the perspective of origins and distribution of traits and adaptation. Prerequisite: Anthro 150A or introductory biology.
Same as L48 Anthro 307A
Credit 3 units. A&S IQ: NSM, AN, SD Arch: NSM Art: NSM BU: SCI

L41 Biol 3100 R Workshop in Biology
Biologists in all areas increasingly find that they have the need and opportunity to work with large data sets. The goal of this 1-credit course is to provide students with an opportunity to gain skills in data analysis and presentation using R, a free software environment for statistical computing and graphics (https://www.r-project.org/). Topics include an introduction to basic programming in R, data types and manipulation, graphics, hypothesis testing and statistics, and applications to various fields of biology ranging from ecology to genomics. The course consists of 10 two-hour workshops that include a brief introduction to key concepts in R and applications in biology, followed by interactive, hands-on tutorials. Prerequisite: concurrent or prior course in statistics (Math 2200 or Math 3200) or permission of instructor.
Credit 1 unit.

L41 Biol 3110 Vertebrate Structure Laboratory
A lecture/laboratory course designed to provide an integrative framework for how vertebrate form and function evolved. Weekly lectures emphasize development and the relationship between the structural and functional design of organ systems, the importance of these relationships in maintaining homeostasis while providing opportunity for adaptation, and examples of how vertebrate organ systems communicate to accomplish functional and physiological integration. 1.5 hour lecture and 5 hours lab each week. Prerequisite: Biol 2970.
Credit 4 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 3151 Endocrinology
An overview of mammalian endocrine systems with an emphasis on human physiology and development. The interplay between systemic, local cell and tissue interactions as well as the cell and molecular events associated with hormone action are discussed. Examples of endocrine evolution and pathological conditions related to endocrine imbalances also are included. Prerequisite: Biol 2970.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 3160 Beyond the Evidence
Why, when all evidence points to the growing threats of climate change, is it so difficult to create movement toward addressing it? Why, when we have so much evidence that vaccines reduce illness and death and are extremely safe, do individuals still choose not to vaccinate their children? What if I told you that the scientific evidence does not matter? Over the last few decades, not better education, nor guilt, nor fear has worked to produce change on important environmental and public health issues. In this class, we will explore how values, beliefs, emotions and identity shape how we process information and make decisions. We will explore themes of moral world view, cognitive linguistics and framing, cognitive dissonance, risk perception, empathy, habit changes, and difficult dialoguing through the case studies of climate change and vaccination. Course activities will consist of regular reading, some online research, reflective journaling at home, and engaging in conversation during class. There are no prerequistes, but the class is designed for fourth-year students in environmental majors and pre-health studies.
Same as L82 EnSt 316
Credit 3 units. A&S IQ: SSC Arch: SSC Art: SSC BU: BA EN: S

L41 Biol 3171 Biology for Climate Change Solutions
Human-induced climate change poses a pressing and pervasive threat to both human populations and to the biological world. The challenges of climate change are manifest and well known, increasing temperatures, greater variability of weather, sea level rise, leading to a host of consequences. Adapting to and mitigating climate change are essential activities for confronting the threats of climate change. The biological sciences offer great potential for addressing these threats. This course focus on efforts in biological research to adapt and to mitigate climate change. Topics will range across the biological sciences from microbial engineering and biotechnology to zoonotic diseases and one health, to ecosystem function and conservation of biodiversity. The course consists of lectures, discussion of assigned readings, and class projects. Class projects focus on science topics that addresses new approaches to climate adaptation and mitigation and constitute both of a written paper and class presentation. The goals of this class are: (1) to develop an understanding of basic climate science and the biological aspects of climate change, (2) to develop knowledge of the biological efforts towards adaption and mitigation for climate solutions. The class is open to both non-science and science majors. The course does not count for the biology major. 3 units credit. Class cannot be taken pass fail. Small class. Not for biology major credit
Credit 3 units. A&S IQ: NSM

L41 Biol 3180 Domestication: The Evolution of Our Multispecies Family
This course explores the evolution of the plants, animals, and microbes in human-mediated ecosystems. We call these evolutionary relationships domestication and they are at the heart of humanity's successful adaptation to nearly every ecosystem on Earth. From our millennia-deep friendship with gregarious wolves, to corn's continental conquests, to 'the industrial microbiome,' this course will ask how other species have evolved in response to human societies, and how societies have been shaped by these relationships. We will primarily draw on concepts and data from anthropology and evolutionary biology to understand the process of domestication.
Same as L48 Anthro 3180
Credit 3 units. A&S IQ: LCD, SSC Arch: SSC Art: SSC BU: BA

L41 Biol 3220 Woody Plants of Missouri
Washington University's Danforth Campus is home to more than 4000 trees and is now a registered arboretum. This urban forest ecosystem has been carefully curated and managed to provide habitat diversity, shade, rainwater mitigation, and aesthetic beauty. In this course, students will study the biology of woody plants in the classroom and in our arboretum. Specifically, students will learn woody plant systematics, physiology, and ecology as well as applied and hands-on techniques. Students will learn to collect forestry data and to identify trees by leaf, bud, bark, fruit and crown. They will learn to plant, propagate, and care for trees and other woody plants. They will also contribute to the ongoing research in our arboretum and to the education of their peers and campus visitors by adding new trees to the arboretum collection and by monitoring the campus trees as they learn to collect data on growth and phenology. Students who successfully complete this course will be eligible to join the Danforth Arboretum

"Loraxes" for the remainder of their time at Washington University. Loraxes will be arboretum ambassadors and will be called upon from time to time to lead tours of the arboretum for prospective students, science outreach, or members of the campus community. Prerequisite: Biol 2960. (Biology Major Area C)
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 3221 Research and Public Education in the Arboretum
Washington University's Danforth Campus is home to more than 4000 trees and is now a registered level II arboretum. This urban forest ecosystem has been carefully curated and managed to provide habitat diversity, shade, rainwater mitigation, as well as aesthetic beauty. The arboretum is also an institutional structure to support education, research and public service. This course combines theory and hands-on practice. In this course you will: Learn about the history and philosophy of public natural history museums, botanical gardens, arboreta, and zoos Learn about arboreta and public gardens around the world Learn field techniques for monitoring the growth and assessing the health of trees o Apply those techniques by contributing to the bio-monitoring and tracking of the trees in the Danforth Campus Arboretum Learn about the pedagogy of public education in museums, zoos and arboreta o Apply the pedagogic practices to development of public education campaigns in the Danforth Campus Arboretum o Apply those practices by serving as an outreach ambassador and leading tours through the Danforth Campus Arboretum Prerequisite: Biology 3220
Credit 3 units. A&S IQ: NSM

L41 Biol 324 Human Genetics
Broad coverage of the role of genetics in medicine, with a focus on the application of genomic technologies to the understanding of human disease. Areas covered include the identification of human disease genes, modern cytogenetics, risk assessment in pedigrees, biochemical genetics, imprinting, mitochondrial genetics, gene therapy, complex inheritance, assisted reproduction, prenatal diagnosis, immunity, cancer, and pharmacogenetics. The profound ethical and legal considerations raised by modern genetic technologies are also discussed. (Biology Major Area A)
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 328 Principles in Human Physiology
This course is designed to provide students with an understanding of the function, regulation and integration of the major organ systems of the body. Course content includes neural and hormonal homeostatic mechanisms, and study of the circulatory, respiratory, digestive, urinary, musculoskeletal, nervous, endocrine, immune and reproductive organ systems. Mechanisms of exercise physiology are integrated throughout the course. Prerequisite: Biol 3058 or equivalent.
Credit 4 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 334 Cell Biology
Eukaryotic cell structure and function viewed from the perspective of modern cell biology. Lectures cover such topics as membrane transport; endocytosis and secretion; intracellular trafficking; hormones and signal transduction; extracellular matrix and tissue formation; cytoskeleton and motility; and cell cycle, apoptosis and the cellular basis of disease. Prerequisite: Biol 2970.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 3411 Principles of the Nervous System
This course will provide a broad introduction to neuroscience, starting at the level of cellular and molecular neuroscience, and ultimately ending at systems and theoretical neuroscience, with emphasis on the organization of the mammalian central nervous system. Topics will include neuronal structure, the action potential, information transmission between neurons, sensory/motor systems, emotion, memory, disease, drugs, behavior, and network dynamics. A fundamental goal of this course is to provide students with the ability to approach complex problems using the scientific method and to understand the limits of knowledge. This course will also expose students to some of the neuroscience community at WashU. Bio 2960, Bio 2970 recommended, Bio 3058 recommended or Psych 3401 and permission of instructor. (Biology Major Area B)
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 3421 Introduction to Neuroethology
The neural mechanisms of animal behavior from an evolutionary and ecological perspective. Topics include: contributions of model systems to understanding fundamental properties of nervous system structure and function; electrical signals of sensory cells, neurons and muscle; neural processing of sensory input; neural control of behavioral output; anatomy and physiology of sensory and motor systems; learning and memory; evolution of neural circuits. Prerequisite: one of the following courses: Biol 3058, Biol 3411 or Psych 3401.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 3422 Genes, Brains and Behavior
Genetic studies of physiological systems underlying animal behavior, including the genetic basis for normal and abnormal behaviors in animals and humans. Topics include: history of behavioral genetics; the ongoing debate about "nature vs. nurture"; contributions of genetic model systems including the nematode *Caenorhabditis elegans*, the fruit fly *Drosophila melanogaster*, zebrafish, the mouse *Mus musculus* and other animal models; molecular mechanisms underlying the evolution of behavioral phenotypes; the emerging role of epigenetics in regulating nervous-system functions and behavior; the use of genetic and genomic analyses in studies of human behavior and psychiatric disorders. Prerequisite: Biol 2970.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 3423 Behavioral Genetics Laboratory
This course introduces students to fundamental concepts of how genes govern behavior by using the model system Drosophila melanogaster. Students learn modern and classic laboratory techniques, including fly crossing, genetic screens, behavioral assays, microscopy, and electrophysiology. Specifically, we use the GAL4/UAS system to assess the role of microRNAs in a variety of fly behaviors. A primary goal of the course is to develop real-world research skills by having students design, propose, and execute a set of novel research questions. Statistical analysis and interpretation of student data are emphasized. To build a solid conceptual background, lectures are given once per week, and students read, analyze, and discuss primary research articles. Understanding is assessed through journal club reports and presentations, research reports, and a final presentation of experimental results. This course is designed for upper-level students who have taken Biol 2960 and Biol 2970.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 343A Plants, Environment and Civilization
Human life, health, and civilization depend on plants. This course introduces basic plant biology, the role of plants in natural ecosystems, and the various uses of plants in both traditional cultures and in developed countries. Topics include the medicinal uses of plants, domestication of plants for agriculture, biotechnology and plant conservation. Prerequisite: Junior standing or permission of instructor. Does not count toward upper-division credits required for the major.
Credit 3 units. A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 347 Darwin and Evolutionary Controversies
Focus is on controversies in evolutionary biology from Darwin's day to the present. Most of the controversies concern scientific issues such as Kelvin's estimate of age of the earth, Jenkin's argument against blending inheritance, neutral variations, effects of isolation on the role of selection, mass extinction and "nemesis," but some address social issues such as evolutionary ethics and "scientific creationism." Emphasis in the readings is on primary sources, including Darwin's Origin of Species. Writing Intensive. (Biology Major Area C)
Credit 3 units. A&S IQ: NSM, WI Arch: NSM Art: NSM BU: SCI

L41 Biol 3481 Parasitology
This course introduces students to the fundamentals of parasitism. Throughout the semester, students not only learn about parasite biology (examples: parasite life cycles, host immune responses, parasite evasion mechanisms), but also how parasites make a broader impact (examples: co-evolution of hosts and parasites, parasites as indicators of environmental health, the challenge of parasite control). Topics include, but are not limited to, parasite diversity and classification, life cycles, host evasion mechanisms, pathology, disease, control, types of hosts and their immune responses, and the impact that parasites have on ecology and conservation biology. 3.0 Credit Hours. Prerequisites: Principles of Biology I (Biol 2960) and II (Biol 2970) (Biology Major Area A)
Credit 3 units. A&S IQ: NSM Art: NSM

L41 Biol 349 Microbiology
This 4-credit lecture course focuses on the molecular biology of bacteria, archaea and viruses. Topics include: the bacterial cell cycle, gene regulation, stress response, cell-cell communication, viral and bacterial pathogenesis, microbial ecology, and metabolic diversity. Friday tutorials stress analysis of the primary literature with an emphasis on current research related to material covered in lecture. Prerequisites: Biol 2960 and 2970, or permission of instructor.
Credit 4 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 3491 Microbiology Laboratory
After introducing students to the basics of bacterial growth and maintenance, this laboratory course employs microscopy, genetics, cell biology, and genomics to explore various aspects of bacterial physiology, structure, and identification. Students will present their findings throughout the semester in both written and oral formats. Roughly one hour of lecture and five hours of laboratory work are required per week. This course fulfills the upper-level laboratory requirement for the biology major. Prerequisite: Biol 2970. Biol 349 also recommended.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 3492 Laboratory Experiments with Eukaryotic Microbes
This research-intensive course provides an introduction to diverse molecular and cell biology techniques used in model experimental organisms to explore fundamental biological questions. Experiments are performed using selected fungi and protozoans commonly used in major research efforts. Emphasis is placed on choosing the appropriate organism for the question posed using the most current technologies. Each semester, one cellular process is studied in detail and original research is carried out. Prerequisites: Biol 2960 and 2970 and permission of instructor — contact early to ensure enrollment. One hour of lecture and six hours of laboratory a week. Fulfills the upper-level laboratory requirement for the biology major. Enrollment limited to 12.
Credit 3 units. A&S IQ: NSM, WI Arch: NSM Art: NSM BU: SCI

L41 Biol 3493 Bacterial Bioprospecting and Biotechnology
Many bacteria are essential in food industry (fermentation of meats, cheeses and beverages), agriculture (crop protection against weeds, pathogenic bacteria, and fungi), biotechnology (producing fine chemicals, cofactors, amino acids, and industrial enzymes) and the pharmaceutical industry (producing clinical antibiotics, anticancer, antiviral, veterinary, and immunomodulatory drugs). This laboratory course examines how basic biological understanding can lead to discovery of bacterial products, enzymes and activities useful to humankind. We combine core concepts from biochemistry, bacterial genetics, bioinformatics, chemistry and enzymology to study bacteria from the genus Streptomyces and close relatives. Lines of inquiry include environmental isolations, molecular toolbox and host development, plus bioinformatic and laboratory-based analyses of secreted proteins and antibiotics. Prerequisites: Biol 2960 and 2970. One hour of lecture and six hours of laboratory per week. This course fulfills the laboratory requirement for the biology major. Enrollment limited to 16.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 3501 Evolution
A general survey of evolutionary biology, covering both micro- and macroevolution. Topics include natural selection, genetic drift, gene flow, sexual selection, kin selection, pathogen evolution, speciation, phylogenetics, molecular evolution and evolutionary-developmental biology. Weekly discussion sections focus on analysis of recent studies related to lecture topics. Prerequisite: Biol 2970. (Biology Major Area C)
Credit 4 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 354 Physics of Living Systems
One of the grand challenges in contemporary biophysics is placing our understanding of cellular systems on a firm quantitative footing. How does the collective activity of molecules enable the cell to sense its environment, make decisions, grow and develop? This course, aimed at physical and life science students, will serve as an introduction to the physical principles and mathematical techniques underlying the analysis of systems and synthetic biology. Topics will include modeling gene and signaling networks, the regulation of intracellular structures, and pattern formation in development. Students in this course can expect to learn both analytical and computer simulation approaches to fundamental problems in biology, biophysics, and biotechnology. Graduate students will explore the subject in more depth. Pre-requisites: Prerequisite: Physics 191 - 192 or Phys 193 - 194 or Physics 197-198 or Phys 205 - 206. or Math 217 or Math 309, or permission of instructor. 3 units
Same as L31 Physics 354
Credit 3 units. A&S IQ: NSM Arch: NSM BU: SCI EN: BME T, TU

L41 Biol 360 Biophysics Laboratory
This laboratory course consists of "table-top" experiments in biological physics that are designed to introduce the student to concepts, methods, and biological model systems in biophysics. Most experiments combine experimentation with computer simulations. The list of available experiments includes electrophysiology, human bioelectricity, optical tweezers, ultrasonic imaging, mass spectrometer, and viscosity measurements. Prerequisites: Physics 191-192 or Phys 193-194 or Physics 197-198 or Phys 205-206 or permission of instructor.
Same as L31 Physics 360
Credit 3 units. A&S IQ: NSM, AN Arch: NSM Art: NSM

L41 Biol 363 The Neuroscience of Movement: You Think, So You Can Dance?
Although humans have expressed themselves through movement throughout time, only recently have neurophysiological investigative techniques allowed us to glimpse the complex neural processes that allow the coordination and integration of thought, action, and

perception. This course introduces students to the nascent yet growing field of dance neuroscience. In part one of this course, we explore fundamental concepts of motor control, including how our central nervous system integrates information to allow us to maintain posture and balance, to coordinate our limbs to external rhythms, and to move our bodies gracefully and expressively through space and time. In part two, we explore theoretical frameworks of motor learning as they pertain to movement. We delve into the neuromechanisms underlying common tools that dancers and athletes use to improve motor performance and how dance training induces neuroplasticity in brain structure and function. In part three, we explore the neural underpinnings of aesthetic appreciation while watching dance, including the action observation network and affective responses to art. Required work includes short assignments, a final project and presentation on a topic of your choice related to the course focus, and a few movement workshops (for which dance training is not required). Prerequisite: introductory course in dance, biology, or neuroscience, or permission from the instructor.
Same as L29 Dance 363
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 370 Animal Behavior
This course examines animal behavior from an evolutionary perspective and explores the relationships between animal behavior, ecology, and evolution. Topics include foraging behavior, mating systems, sexual selection, predator-prey relationships, cooperation and altruism, competition and parental care. A student may not receive credit for more than one of the courses Biol 370, Biol 372 and Biol 472. Prerequisite: Biol 2970 or permission of instructor. (Biology Major Area C)
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 373W Laboratory on the Evolution of Animal Behavior (Writing Intensive)
This course explores the costs, benefits, and constraints that drive the evolution of animal behavior. It is divided into four modules that cover a range of common empirical and numerical tools in modern evolutionary biology (no prior experience in any of the following topics is necessary): (1) a brief overview of basic statistics and a tutorial in R; (2) an experimental lab on agonistic behavior in crickets; (3) a computer simulation lab on the evolution of animal communication; and (4) a phylogenetic comparative analysis lab exploring the topic of sexual selection. Laboratory modules are hands-on and student driven. They begin with an overview of relevant literature and a discussion of key questions that have been addressed experimentally in that field. Students are then encouraged (and guided) to apply these concepts to the design, execution, and analysis of individual and/or collaborative research projects. In the process, they learn how to apply some of the latest numerical and/or empirical research tools in evolutionary biology. A majority of class time is devoted to active learning through the collection and analysis of data (each lab module lasts four weeks). The course also includes weekly presentations by the instructor and class discussions on topics that help place the students' work into the broader context of evolutionary theory. Prerequisites: Biol 2970 and Psych 100B or permission of instructor. This course is writing intensive.
Credit 3 units. A&S IQ: NSM, WI Arch: NSM Art: NSM BU: SCI

L41 Biol 381 Introduction to Ecology
This course explores the central theories and principles in ecology and evolution as well as the use of these principles to study and predict human-induced environmental changes. It emphasizes understanding species interactions and population dynamics in biological communities, and the relationships between communities and their environment. It regularly touches on applications of these principles such as ecological responses to global climate change, consequences of habitat fragmentation, disease ecology, and conservation medicine. Principles of experimental design, quantitative data analysis and interpretation, and mathematical models are critical to the field of ecology, and they are also emphasized throughout the course. Class meetings will include lectures, class activities, computer simulation labs, and smaller group discussions to familiarize students with peer-reviewed journals, scientific writing, and current issues in ecology. Assignments include regular homework reading, occasional problem sets, participation in tutorials/discussions, and a small term-paper. Prerequisite: Biol 2970 or Biol 2950 or permission of instructor.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 387 Undergraduate Teaching
Exceptional undergraduates serve as teaching assistants for laboratory and/or discussion sections in departmental courses. Normally 2 or 3 units are given per semester, subject to the approval of the instructor and the department. Credit may not be counted toward fulfilling the biology major; application form in Department of Biology Student Affairs office. Prerequisite: permission of instructor. Credit/no credit only.
Credit variable, maximum 3 units. A&S IQ: NSM

L41 Biol 388 Undergraduate Teaching
Exceptional undergraduates serve as teaching assistants for laboratory and/or discussion sections in departmental courses. Normally 2 or 3 units are given per semester, subject to the approval of the instructor and the department. Credit may not be counted toward fulfilling the biology major; application form in Department of Biology Student Affairs office. Prerequisite: permission of instructor. Credit/No Credit only.
Credit variable, maximum 3 units. A&S IQ: NSM Art: NSM

L41 Biol 3900 Science for Agriculture and Environmental Policy
Government policies at the local, state, and national levels determine and regulate activities that range from local farmers markets to U.S. membership in the Paris Climate Agreement. Science can and should play a critical role in developing policy. This course focuses on the biological science behind policies for climate change and agricultural practice as well as the role of various organizations in providing science for policy. Now is a particularly interesting time for science-based policy with the election of a new U.S. President and the elevation of the President's science advisor to Cabinet level. This course is divided into three parts. First, we review how policy is developed and how various agencies and actors affect policy. The next section looks at biological topics that have policy implications. These case studies are presented by expert speakers who have had experience in various science-related roles in the federal government, foundations, professional associations, advisory organizations, and scientific publications. Finally, students conduct individual research projects on a science topic that affects current legislative efforts, either state or national. Students investigate the basic science of their chosen topic and how this could affect proposed legislation. As part of the research project, students give a class presentation, lead a class discussion, and write a term paper on the foundational biological science. The goals of this course are as follows: (1) to develop an understanding of how science is used to develop policy by examining case studies presented by experts; and (2) to critique a proposed science-based policy either at the state or federal level.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 4023 How Plants Work: Physiology, Growth and Metabolism
This course introduces students to the fundamentals of how plants grow, metabolize and respond to their environment. Topics to be covered include the conversion of light energy into chemical energy through photosynthesis and carbon fixation, nitrogen assimilation, water and mineral uptake and transport, source-sink relationships

and long-distance transport of carbon and nitrogen, cell growth and expansion, hormone physiology and physiological responses to a changing environment. Prerequisite: Biol 2960 and Biol 2970, or permission of instructor. (Biology Major Area B)
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 4030 Biological Clocks
Biological clocks are the endogenous oscillators that coordinate physiological and behavioral rhythms in nearly all organisms. This course examines how these rhythms are generated and regulated. The material includes molecular, cellular and systems physiology and the relevance of biological timing to ecology and health in everything from protozoans to plants to people.
Credit 3 units. A&S IQ: NSM Art: NSM

L41 Biol 404 Laboratory of Neurophysiology
Neurophysiology is the study of living neurons. Students record electrical activity of cells to learn principles of the nervous system including sensory transduction and coding, intercellular communication and motor control. The course meets for 9 hours each week. Students may leave the lab for up to 2 hours. Prerequisites: Biol 3411 or Psych 4411 and permission of Student Coordinator, Erin Gerrity. Biol 3411 may be taken concurrently.
Credit 4 units. A&S IQ: NSM, WI Arch: NSM Art: NSM

L41 Biol 4071 Developmental Biology
An introduction to the molecular and cell biology of animal development. The course is divided into three broad sections: (1) an introduction to the major cell-cell signaling systems used during development and their study in model organisms; (2) molecular studies of early vertebrate development; and (3) the biology of stem cells. The focus is on molecular approaches applied to important model systems but framed in classical concepts. Prerequisites: Biol 2970 and Biol 334; a course in biochemistry is recommended. Small class.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 4072 Regenerative and Stem Cell Biology
Regeneration is a very complex, post-embryonic developmental phenomenon, where organisms replace lost body parts and organs upon injury. However, we still know very little about why some animals are so successful at regenerating whole bodies and organs, while other animals (like humans) have limited or no capacity to do so. This course covers regeneration and stem cell biology across different levels of biological organization (e.g. cell, organ, limb regeneration.) and across the animal phylogeny. Students learn about mechanisms of regeneration at the cellular and molecular level, and how these mechanisms vary among organisms. In addition to the general principles of stem cells and regenerative biology, the course will be a good introduction to animal diversity and evolutionary developmental biology (evo-devo). Students will read and discuss primary literature, and write up their own experimental design to test hypotheses. Prerequisites: Bio 2970 (Principles of Biology 2 - Genetics) (Biology Major Area B)
Credit 3 units. A&S IQ: NSM Art: NSM

L41 Biol 4132 Plant Diversity and Evolution
This course is an in-depth exploration of the diversity and evolution of vascular plants. The course focuses mainly on flowering plants because of their dominant role on our planet, but lycophytes, ferns, and gymnosperms are studied as well. A phylogeny of vascular plants provides the framework for their evolution and diversification. Related subjects, including phylogenetics, biogeography, herbaria, nomenclature, species concepts, and pollination biology are also presented. The weekly lectures/discussions and (three hour) lab function in tandem and it is the responsibility for the student to integrate information from the lectures with the abundant materials presented in lab. The lecture will take place on main campus at WashU, and the lab sessions will make use the abundant and exceptional living and preserved materials at the Missouri Botanical Garden. The intended audience is advanced undergraduates and graduate students. Prerequisite: Bio 2970 or Permission of Instructor. Small Class. Credit.
Credit 3 units. A&S IQ: NSM

L41 Biol 4181 Population Genetics
An introduction to the basic principles of population and ecological genetics. Mechanisms of microevolutionary processes; integrated ecological and genetic approach to study the adaptive nature of the evolutionary process. Prerequisite: Biol 2970.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 4182 Macroevolution
An advanced introduction to the study of macroevolutionary patterns and processes with emphasis on the systematic methodology employed. Topics: theories of classification, phylogenetic reconstruction, testing of historical hypotheses, hierarchy theory, adaptation, extinction, speciation, developmental mechanisms of organismal evolution, biogeography. Prerequisite: permission of instructor.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 4183 Molecular Evolution
A rigorous introduction to the study of evolution at the molecular level. Topics include the origin, amount, distribution and significance of molecular genetic variation within species, and use of molecular data in systematics and in testing macroevolutionary hypotheses. Prerequisite: Biol 2970 or permission of instructor.
Credit 3 units. A&S IQ: NSM Art: NSM

L41 Biol 419 Community Ecology
Community ecology is an interdisciplinary field that bridges concepts in biodiversity science, biogeography, evolution and conservation. This course provides an introduction to the study of pattern and process in ecological communities with an emphasis on theoretical, statistical and experimental approaches. Topics include: ecological and evolutionary processes that create and maintain patterns of biodiversity; biodiversity and ecosystem function; island biogeography, metacommunity dynamics, niche and neutral theory; species interactions (competition, predation, food webs), species coexistence and environmental change. The class format includes lectures, discussions, and computer labs focused on analysis, modeling and presentation of ecological data using the statistical program R. Prerequisites: Biol 2970 (required), Biol 381 (recommended), or permission of instructor. (Biology Major Area C)
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 4193 Experimental Ecology Laboratory
The goal of this course is to provide skills in the design, interpretation, and written presentation of ecological and evolutionary experiments, with emphasis on sampling methodology, hypothesis testing, and data analysis. A key objective of this course is to familiarize students with the importance of statistics and experimental design as unified tool, rather than two separate processes. We will practice how to abstract theories, hypotheses, predictions, mathematically, how to contrast them with data, and interpret the results. The course does not seek to be exhaustive of all experimental designs or statistical techniques, nor intensive in any given one. Rather, its focus is on providing the tools and concepts for the critical evaluation, choice, interpretation and further independent learning of the experimental and statistical tools needed for research. Practical analysis of data will be taught in program R, but no prior knowledge is required. During the course, students will plan and execute their own ecological studies, within the limitations of the

current pandemic. This is a writing intensive course and grades are based on written assignments, including final projects, and in-class participation. This course fulfills the upper-level laboratory requirement for the Biology major. Prerequisites: Permission of instructor and at least one of the following: Bio Bio 3501, Bio 372, Bio 381, Bio 419, or Bio 472. Enrollment is limited to 10 students. Credit 4 units.
Credit 4 units. A&S IQ: NSM, WI Arch: NSM Art: NSM

L41 Biol 4195 Disease Ecology
Disease ecology is an interdisciplinary field that bridges concepts from fields including population ecology, community ecology, landscape ecology, and evolutionary biology. This course provides an introduction to the study of infectious diseases, with an emphasis on theoretical, experimental, and quantitative approaches. The course will integrate studies of infectious diseases from across disciplines including human epidemiology, veterinary medicine, wildlife epidemiology, plant pathology, parasitology, and ecology. Prerequisites: Biol 2970 required, Biol 381 recommended, or permission of instructor.
Credit 4 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 4202 Anthropological Genetics
This course examines the principles of evolutionary genetics as applied to complex characters such as morphology, behavior, life history and disease. Mathematical models of quantitative inheritance and evolution are discussed. Special topics include kin selection, sexual dimorphism and conservation genetics. Prerequisite: Anthro 150A or introductory biology.
Same as L48 Anthro 4202
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 4220 Practical Bioinformatics
From medicine to genomics to ecology, all fields of biology are now generating large and complex datasets that can only be analyzed using computational approaches. This course introduces computational techniques and perspectives to biologists that are new to computational thinking. Students will learn how to design research workflows, decompose complex problems into simpler solvable units, and apply scientific computing principles to research. In addition, students will practice foundational computing skills, such as using the UNIX operating system on research clusters, writing custom analysis programs with shell scripts and with Python, and summarizing and visualizing analysis output. The laboratory exercises build on one another, culminating in the construction of a bioinformatics pipeline that can process and analyze molecular data. Students will apply their newly learned computational skills and use their pipeline to analyze virus sequence evolution and explore evolutionary models. Prerequisites: Biol 2970; Math 132 (Calculus II); Math 223 (Calculus III) or Math 2200 (Elementary Probability); CSE 131 (Computer Science I; suggested course); permission of instructor. Credit/no credit.
Credit 4 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 424 Immunology
Basic molecular and cellular aspects of the vertebrate immune system with emphasis upon the interrelationships of non-specific and specific host defense against disease, the nature of immunological specificity and its underlying molecular biology. Includes complement systems, immunochemistry, the nature of cellular activation and effector generation, immunodeficiency, tolerance, tissue transplantation, hypersensitivity, immune regulation and specific diseases illustrative of the successes and failures of the immune system. Case studies will be presented by the students on an array of immune system disease. Prerequisites: Biol 2970 and Chem 262. Interested Juniors in their second semester are particularly encouraged to register for this course.
Credit 4 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 4242 Virology
Viruses are all around us and play key roles in health, evolution, ecology, agriculture, and can even completely disrupt societies. In this course, we explore the wide array of viruses, the basics of their structure, the infection cycle, their role in human health, and how we can adapt viruses for uses in research, agriculture, and biotechnology. Emphasis is on animal viruses, specifically medically relevant viruses, including HIV and SARS-CoV-2, and recent advances in virology. While primarily a lecture-based course, students present on a relevant virus and read primary literature. Prerequisite(s): Either BIOL349 (Fundamentals of Microbiology) or BIOL334 (Cell Biology).
Credit 3 units. A&S IQ: NSM Art: NSM

L41 Biol 4270 Problem Based Learning in Biomedical Sciences
Groups of 5-8 students are presented with medical case studies that are then researched and discussed under faculty guidance. Students take major responsibility for their own learning within their team. Prerequisite: Biol 2970; some experience in molecular biology. A biology or science background is required. Same content as discontinued course Biol 427, but not Writing Intensive. Not available to students who have credit for Biol 427.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 4271 The Science of Cats
This capstone-style course will give students the opportunity to apply what they've learned in topics as diverse as speciation, molecular evolution, community ecology and animal behavior to investigate and analyze questions concerning the biology of a species near and dear to the hearts of many, Felis catus, the domestic cat. Over the last several decades, scientists have studied cats in the same way they have studied lizards, birds, flies and many other species. This cat research allows questions of broad scientific interest to be addressed using cutting-edge methods, including (but not limited to): what is a species? How do new species arise? How do we determine when, where and from what species the cat evolved? How do we determine if a trait (e.g., response to catnip) evolved as an adaptation driven by natural selection? How do we determine the impact of an invasive species on local ecosystems? How does domestication occur and is the cat actually domesticated? Is the behavior of domestic cats a legacy of their evolutionary past or does it represent adaptation to living with humans? What role, if any, can genetic engineering play in decreasing feral cat populations and developing new breeds of cats with desirable traits.
Credit 3 units. A&S IQ: NSM

L41 Biol 429 Cellular Transformations
Cellular Transformations is a course developed for students interested in using emerging technologies and cross-disciplinary approaches in design production and implementation. This course allows each student to develop abstract thinking and learn modern design and fabrication processes including digital media and 3D technologies. In this course, students learn the basic principles underlying biological architecture, with a particular emphasis on structures and processes responsible for complex architectures within cells. Students then use biological design principles as inspiration for their individual projects. Through digital modeling and scanning of biological structures, each student develops a transformation process that analyzes the performative aspects of a new emerging design. These designs are modeled through CADCAM (laser cutting) and Rapid Prototyping (3D Printing) for physical outputs. Prerequisites: Biol 2970 or Biol 334.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 4310 Biology of Aging
This course provides concepts and examples of the biology of aging. We discuss current literature with emphasis on theoretical causes of aging and the practical implications of these theories. Major topics include the biochemical processes of aging, cell cycle senescence, age-

related organ dysfunction, interventions to alter the aging process, and medical illnesses associated with aging (e.g., Alzheimer's disease, the dementias). We also study animal and human models for extending longevity, and current approaches for dealing with the aging process are included. Prerequisites: Biol 2960 and Biol 2970 or equivalent; Chem 105 and Chem 106 or equivalent are recommended.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 4342 Research Explorations in Genomics
A collaborative laboratory investigation of a problem in comparative genomics utilizing a variety of bioinformatics tools to manage and investigate large data sets (currently including genomic sequences, gene predictions, sequence conservation, and gene expression). In spring 2018, the research problem involved improving the sequence of a region of the *Drosophila eugracilis* genome and working with one of these sequences to examine patterns of genome organization, gene structure, and gene regulation. Prerequisites: Biol 297A, Chem 111/112, Chem 151/152. Although Biol 3371 or Biol 437 and some familiarity with computers would be advantageous, this is *not* required. Fulfills the upper-level laboratory requirement for the biology major.
Credit 4 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 4344 Epigenetics
Introductory course in epigenetics - the layer of chemical information that sits on top of the genome - that switch genes 'on' or 'off'. Will introduce how the epigenome, in collaboration with the genome, controls versatile biological processes and cell fates. Will also cover the latest advances of how humans can control their own epigenetic destiny by lifestyle, diet, and other environmental factors. Learning Objectives: Recognize and summarize the difference between genetics and epigenetics, Apply the basic knowledge of epigenetic mechanism and illustrate how their misregulations cause abnormal development and diseases, Critically review and discuss epigenetic literature, Design epigenetic experiments and interpret the results of those experiments, Graduate student specific: Demonstrate the ability to clearly communicate epigenetic research in both oral and written formats. Prerequisite: Biology 2960 and Biology 2970 (or consent of instructor) (Biology Major Area A)
Credit 3 units. A&S IQ: NSM Art: NSM

L41 Biol 434W Research Explorations in Genomics (Writing Intensive)
Content equivalent to Biol 4342. Students electing the writing option are required to revise each of three papers (on finishing of their fosmid; gene finding in a human/chip comparison; and annotating their fosmid) at least once.
Credit 4 units. A&S IQ: NSM, WI Arch: NSM Art: NSM

L41 Biol 437 Laboratory on DNA Manipulation
This course provides investigation-driven research on the experimental manipulation of DNA and RNA molecules. This includes the construction, isolation, and analysis of plasmids, RNA, PCR products, and DNA sequencing. Molecular cloning (genetic engineering), gene knockouts (mutants), RNA isolation, RT-PCR, and microarray projects are performed. Prerequisites: Biol 2960 and Biol 2970. One hour of lecture and six hours of laboratory each week. This course fulfills the upper-level laboratory requirement for the biology major. Enrollment is limited to 12. A laboratory fee is required for students who are not full-time Washington University undergraduates.
Credit 4 units. A&S IQ: NSM Art: NSM

L41 Biol 4381 Cell-Based Tissue Engineering and Regenerative Medicine
This course focuses on how new directions in cellular, molecular and developmental biology are interfacing with advances in biomaterials tissue engineering, innovative devices, and advanced technologies (such as 3D printing and CRISPR) to replace, restore, and/or correct genetic, acquired, or damaged tissues and organs. Coverage includes the rapidly expanding use of types of stem cells and their preparation alone or in concert with biomaterial scaffolds, nanomaterials, and growth factors. Tissue engineered therapies for cancer, diabetes, autoimmune disorders and other conditions are reviewed. Examples of tissue engineering approaches for regeneration of nerves, cardiovascular, kidney, cartilage, bone, ligament, tendons, and skin are discussed in some detail. Regulatory issues, ethical guidelines, and commercial perspectives will be woven into our discussions. Prerequisites: Biol 2970, Biol 3058, Biol 334. (Biology Major Area B)
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 4492 Infectious Diseases: History, Pathology, and Prevention
Leveraging the primary research literature, this course examines the history and pathology of infectious disease, the development of antibiotics and vaccines, the rise of antibiotic resistance, and the emergence and reemergence of diseases including Zika virus, malaria, and tuberculosis. In addition to gaining insights into the underlying causes and treatment of infectious disease, students will hone their ability to identify important biological questions, develop testable hypotheses, design experiments tailored to particular questions, and evaluate results. Through a series of written and oral assignments, students develop the skills to communicate about science effectively to both the research community and the general public. Prerequisites: One semester of Biol 500: Independent Research or equivalent is required. Preference will be given to students who have completed Biol 349 Fundamentals of Microbiology. Area A. Writing intensive.
Credit 3 units. A&S IQ: NSM, WI Arch: NSM Art: NSM BU: SCI

L41 Biol 451 General Biochemistry
A study of structure-function relationships as applied to carbohydrates, proteins, and lipids; intermediary metabolism of principal cellular components; and general aspects of regulation. Prerequisites: Biol 2970, Chem 262, and permission of department. Recommended for students who have achieved grades of B or better in the prerequisites. Students may not receive credit for both Biol 4801 and Biol 451.
Credit 4 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 4522 Laboratory in Protein Analysis, Proteomics and Protein Structure
In this laboratory course, students learn principles and methods of protein quantitation, protein purification, assessment of purity using SDS-polyacrylamide gel electrophoresis, separation of complex protein mixtures by 2-dimensional gel electrophoresis, definition of units of enzymatic activity, and identification of proteins using antibodies and/or mass spectrometry. The final part of the course introduces students to concepts of structural biology including protein crystallization, X-ray crystallography and computer modeling of protein structures. Fulfills the upper-level laboratory requirement for the biology major. Prerequisites: Chem 252 and either Biol 451 or Biol 4501/Chem 456. Permission of instructor required. Limit: eight students. Eight hours of laboratory/lecture per week.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 4523 Molecular Methods in Enzyme Analysis
Understanding enzyme structure and function is essential for many important drug-design projects. This course focuses on common methods used to investigate enzyme active sites to elucidate binding interactions between small molecules and enzymes. Students use three-dimensional protein viewing software to design and model modifications to an enzyme active site, and they then perform those modifications using recombinant DNA technology and site-directed mutagenesis. This course also introduces other commonly used methods to assay active-site metals, characterize inhibitors, overexpress and purify proteins, and use ultraviolet spectroscopy to analyze enzyme activity. This is an investigative course in which students complete collaborative research projects in small groups. It fulfills the upper-level laboratory requirement for the generic biology major and the biochemistry track; intended for students who have no other courses that fulfill these requirements. Prerequisite: Biol 2970. Limit 12 students.
Credit 4 units. A&S IQ: NSM Arch: NSM BU: SCI

L41 Biol 4525 Structural Bioinformatics of Proteins (Writing Intensive)
In this investigative laboratory course, students will be given high-quality, experimentally determined, three-dimensional structural coordinates, and they will use cutting-edge bioinformatics tools and methods to evaluate and analyze these datasets. Some topics to be covered include structural validation, protein-structure prediction, domain and motif recognition, secondary structure prediction, protein-protein and protein-ligand interactions, protein and structure-based sequence alignments, inferring protein function from structure, electrostatic interactions, and threading and homology modeling. Upon completing their analyses, students will be responsible for writing a manuscript that will be submitted to a scientific journal for publication. Prerequisites: Biol 2960 and Chem 262. This course fulfills the upper-level laboratory requirement for the biology major.
Credit 4 units. A&S IQ: NSM, WI Arch: NSM Art: NSM BU: SCI

L41 Biol 4540 Physics of Living Systems
Contents are the same as Phys 354. Graduate students will explore the subject in more depth. Pre-requisites: Prerequisite: Physics 191 - 192 or Phys 193 - 194 or Physics 197-198 or Phys 205 - 206. or Math 217 or Math 309, or permission of instructor. 3 units
Same as L31 Physics 454
Credit 3 units. A&S IQ: NSM Arch: NSM EN: TU

L41 Biol 4580 Principles of Human Anatomy and Development
This course will discuss the anatomy of most of the functional systems of the human body. Topics covered will include the peripheral nervous system, respiration, circulation, the skeletal system, the gastro-intestinal tract, the urogenital system, the male and female reproductive systems, locomotion, manipulation, mastication, vocalization, the visual system, the auditory system and the olfactory system. Selected topics in human embryology will also be introduced. The course provides valuable preparation for any student interested in human biology, anthropology, medicine or the health sciences.
Same as L48 Anthro 4581
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 4582 The Physiology and Biophysics of Consciousness
This course will explore the questions surrounding the search to understand the biophysical substrate of consciousness. Some areas to be explored include the following: (1) Can consciousness be addressed like any other biological property in the sense that it has evolved by natural selection and that some elements of it are present in simple model systems, such as the fruit fly? Can insight be gained studying simple model systems? (2) Where in the brain is consciousness? What is the pattern of neurological events that occurs during consciousness? Is the brain activity that generates consciousness localized or distributed? Does it involve interacting brain regions? Does the brain activity that generates consciousness migrate to different brain regions? (3) How does the dynamic core hypothesis of Edelman relate to these questions? What can functional brain imaging add to these questions? Are gamma waves involved in higher mental activity, and do they promote synchronized firing of neurons from different brain areas? How does this relate to the binding problem? (4) How does the brain's ability to function as a computer relate to consciousness? In many respects, the brain functions like a computer using electrical signals called *action potentials.* Action potentials in neuronal networks function in a way that is analogous to how DC electrical impulses function in computer circuits. What is the output of computation in an electrical device? What are the theoretical limitations regarding what computation can achieve? Does electrical activity in the brain have a fundamentally different purpose in addition to computation? (5) Is our knowledge of the physical world too primitive and incomplete for us to understand consciousness? The brain is an electronic device, and consciousness clearly depends on its electrical activity. However, electrical forces are poorly understood, both in the context of classical physics and quantum physics. Will understanding consciousness have to wait for a unified theory that more accurately describes electrical forces? Prerequisites: Biol 3411 or equivalent; college-level physics, some knowledge of computers.
Same as L64 PNP 402
Credit 2 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 4715 Basic Cancer Biology
More than two thirds of all people know someone who has cancer. This course provides students with a more extensive understanding of what cancer is and how it affects the human body. We will discuss the history of cancer research, the many different types of human cancers, and basic chemotherapeutics. The topics will be presented in a basic scientific nature, with an emphasis on gaining a broad understanding of the subjects. Prerequisite: Biol 2960 or equivalent. Not available to students who have credit for Biol 144 or Biol 1440.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 4716 Advanced Cancer Biology
This advanced course provides students with a more in-depth understanding of the molecular mechanisms of cancer. We will discuss tumor suppressors, oncogenes, signaling pathways, animal models in cancer, and novel targeted cancer therapies being developed by biotechnology and pharmaceutical companies. Prerequisite: Biol 144, Biol 1440 or Biol 4715.
Credit 3 units. A&S IQ: NSM BU: SCI

L41 Biol 472 Behavioral Ecology
This course examines animal behavior from an evolutionary perspective and explores the relationships between animal behavior, ecology and evolution. Topics include mating systems, sexual selection, parental care, kin selection, and cooperation. There is a strong active learning component. Prerequisite: Biol 2970 or permission of instructor.
Credit 4 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 4810 General Biochemistry I
The first part of a two-semester survey of biochemistry. This course covers biological structures, enzymes, membranes, energy production and an introduction to metabolism. Prerequisites: Biol 2960 and Chem 262. Large class.
Same as L07 Chem 481
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 4820 General Biochemistry II
Biochemistry explores the chemistry of life processes at the molecular level. This course is the second semester of a two-semester General Biochemistry sequence (Chem481/482 or Bio4810/4820). Prerequisites include Chem481/Bio4810 and Chem262 or instructor permission. The first semester of the Biochemistry sequence covered the basics of the topic with an emphasis on the structures, functions, and interactions of biomolecules including proteins, nucleic acids, carbohydrates, and lipids. This second semester course will emphasize metabolism, the biosynthetic (anabolism) and degradation (catabolism) pathways that provide the energy of life and define the molecules associated with healthy and disease states.
Same as L07 Chem 482
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 4830 Bioenergy
This course presents a broad overview of the flow of energy, captured from sunlight during photosynthesis, in biological systems, and it discusses the current approaches to utilize the metabolic potentials of microbes and plants to produce biofuels and other valuable chemical products. An overall emphasis is placed on the use of large-scale genomic, transcriptomic, and metabolomic datasets in biochemistry. The topics covered include photosynthesis; central metabolism; the structure and degradation of plant lignocellulose; and the microbial production of liquid alcohol, biodiesel, hydrogen, and other advanced fuels. Course meets during the second half of the spring semester. Prerequisite: Biol 4810 or permission of instructor.
Credit 2 units. A&S IQ: NSM Art: NSM

L41 Biol 4833 Protein Biochemistry
The focus of this course is protein biochemistry, and is intended to build upon General Biochemistry (Chem 481). In this course we will focus on protein structure, folding, and techniques to purify and characterize protein activity. We will progress from initial studies to first understand protein fold and function to current efforts to better characterize protein structure-function relationships. We will also highlight human diseases that are underpinned by protein misfolding. This course will focus on reading and understanding primary literature, including landmark papers along with more recent work. During the second half of the semester, each student will select a paper and prepare a written analysis of that paper. The student will then present the paper and lead a journal club style discussion of the paper. Prerequisites: Chem 481 or instructor's permission.
Same as L07 Chem 483
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 487 Undergraduate Teaching
Exceptional undergraduates serve as teaching assistants for laboratory and/or discussion sections in departmental courses. Normally 2 or 3 units are given per semester, subject to the approval of the instructor and the department. Credit may not be counted toward fulfilling the biology major; application form in Department of Biology Student Affairs office. Prerequisite: permission of instructor. Credit/no credit only.
Credit variable, maximum 3 units.

L41 Biol 488 Undergraduate Teaching
Exceptional undergraduates serve as teaching assistants for laboratory and/or discussion sections in departmental courses. Normally 2 or 3 units are given per semester, subject to the approval of the instructor and the department. Credit may not be counted toward fulfilling the biology major; application form in Department of Biology Student Affairs office. Prerequisite: permission of instructor. Credit/No Credit only.
Credit variable, maximum 3 units.

L41 Biol 493 Seminar in Advanced Biology
In special cases, credit may be given for individual study. Topics of study and credit must be arranged with a faculty sponsor and approved by the department.
Credit variable, maximum 4 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 4933 Molecular Biology on the Cutting Edge
Recent biomedical discoveries have been greatly advanced through the development of innovative, state-of-the-art techniques. For example, Nuclear Magnetic Resonance (NMR) has proved to be an invaluable tool in both efforts to determine the atomic structure of proteins and small molecules, as well as in clinical settings, as MRI to identify tumors that would otherwise go unnoticed. This course introduces students to a variety of cutting-edge laboratory techniques, and discusses the impact of these techniques on biology and medicine. Students have the unique opportunity to learn from graduate students employing these approaches in their doctoral studies. Topics to be covered include: high-throughput sequencing of genetic disorders, x-ray crystallography, and single molecule force spectroscopy by AFM. Weekly classes consist of a 30-45 minute presentation on a particular technique, followed by a 60-minute discussion of the assigned readings. Prerequisites: Biol 2960 and 2970 and at least one semester of Biol 500 or equivalent research experience approved by the course master.
Credit 2 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 4934 Neuroscience Futures II
Students in this course engage with the neuroscience community both at Washington University and beyond by attending, summarizing and discussing neuroscience seminars on campus throughout the semester. Specifically, students are expected to attend three neuroscience seminars over the course of the semester and submit summaries of each seminar. Students meet twice during the semester, in week 5 and week 11, for guided discussion of the science in the seminars they attended. Additionally, students in this seminar attend two combined classes with Neuroscience Futures 1 during the first and last weeks of the semester. In both meetings, students have an opportunity to give brief presentations on their own research. The last class combines short student presentations with a keynote address from an invited speaker from within or outside the Washington University neuroscience community.
Credit 1 unit.

L41 Biol 4935 Research Perspectives
Critical reading, writing, statistics, and effective communication are all part of research and are the focus of this course, with topics changing each semester but always including a poster presentation and weekly writing. Enrollment is by permission of instructor.
Credit variable, maximum 2 units. A&S IQ: NSM

L41 Biol 4936 Seminars in Ecology and Evolution
What: At least once a week there are seminars from researchers in ecology or evolution. These seminars are given by local people and by visitors. This semester there are also a number of presentations by job candidates. The point of these seminars is to learn about exciting research. What questions are they asking? What are they discovering? What new scientific stories can we hear about ecology or evolution? What makes up these fields anyway? The seminars are often followed by receptions which are a chance to get to know each other better and to ask questions. This course invites undergraduates to listen to these presentations and write about them. After all, this is a major part of the ideas climate at WashU. It would be a great idea to get in the habit of going to seminars, with this course, or without. In addition to attending

seminars, we will meet three times during the semester, early on and a couple of times later. When: Most seminars are at 4:00 on Thursdays, though some are on other days. The three meetings will be arranged at a time that works for the students in the course. Small class. No final.
Credit 1 unit.

L41 Biol 4937 Journal Club on Current Topics in Microbiology and Infectious Disease

We read, analyze, and discuss recent primary literature drawn from the field of microbiology. These papers represent the seven broad "Topics" of microbiology, as defined by the American Society for Microbiology (https://asm.org/): -Antimicrobial Agents & Resistance -Applied & Environmental Microbiology -Clinical & Public Health Microbiology -Clinical Infections & Vaccines -Ecology, Evolution, & Biodiversity -Host-Microbe Biology -Molecular Biology & Physiology Each week we discuss a single primary research paper, with special emphasis placed on analyzing and interpreting data and figures. Some assignments include supplementary videos or readings to provide the background knowledge required to understand a particular paper. To ensure that students have sufficient prior exposure to microbiological concepts, Biology 349: Foundations of Microbiology is a prerequisite for this course. At the conclusion of the semester, students should have achieved the following objectives: 1. Gain insight into the breadth of research performed within the field of microbiology. 2. Develop skills required to comprehend and to analyze primary research literature.
Credit 1 unit.

L41 Biol 500 Independent Research

Research under the supervision of a faculty mentor. Prerequisites: junior or senior standing and permission of mentor and the department. Credit/No Credit or Audit grade options; credit to be determined in each case, usually 3 units/semester and not to exceed 3 units/semester; may be repeated for credit. Because this course has a large number of sections, some sections are listed and enrolled as Bio 500A. If work is to be submitted for Latin honors, see p. 3 of the Department of Biology Handbook for Majors, Latin Honors Through a Biology Major Program. The handbook can be found online at: https://wustl.app.box.com/s/d63rx5o0kygqtsv899eyhax5v31gvy1a. Arrangements for registration should be completed during the preregistration period through the Bio 500 course website https://pages.wustl.edu/Bio_200-500_independent_research.
Credit variable, maximum 3 units.

L41 Biol 500A Independent Research

Research under the supervision of a faculty mentor. Prerequisites: junior or senior standing and permission of mentor and the department. Credit/No Credit or Audit grade options; credit to be determined in each case, usually 3 units/semester and not to exceed 3 units/semester; may be repeated for credit. 500A is equivalent to Bio 500. If work is to be submitted for Latin honors, see p. 3 of the Department of Biology Handbook for Majors, Latin Honors Through a Biology Major Program. The handbook can be found online at: https://wustl.app.box.com/s/d63rx5o0kygqtsv899eyhax5v31gvy1a. Arrangements for registration should be completed during the preregistration period through the Bio 500 course website: https://pages.wustl.edu/Bio_200-500_independent_research.
Credit variable, maximum 3 units.

L41 Biol 500N Independent Research in Neuroscience

Research in neuroscience under the supervision of a faculty mentor. Prerequisites: junior or senior standing and permission of mentor and the department. Credit/no credit or audit grade options; credit to be determined in each case, usually 3 units/semester and not to exceed 3 units/semester; may be repeated for credit. If work is to be submitted for Latin honors, see page 3 of the Department of Biology Handbook for Majors, Latin Honors Through a Biology Major Program (PDF) (https://wustl.app.box.com/s/2n0gj01opcwiovb6hs26yj1jfovw09lg/). Arrangements for registration should be completed during the preregistration period through the Biol 500 course website (https://pages.wustl.edu/Bio_200-500_independent_research/).
Credit variable, maximum 3 units.

L41 Biol 500S Summer Independent Research

Summer research under the supervision of a faculty mentor. Prerequisites: junior or senior standing and permission of mentor and the department. Credit to be determined in each case, usually 3 units/summer; may be repeated for credit in different summers. Because this course has a large number of sections, some sections are listed and enrolled as Bio 500T. Credits are received in the fall semester following the summer research. If work is to be submitted for Latin honors, see p. 3 of the Department of Biology Handbook for Majors, Latin Honors Through a Biology Major Program. The handbook can be found online at: https://wustl.app.box.com/s/d63rx5o0kygqtsv899eyhax5v31gvy1a. Arrangements for registration should be completed no later than the end of Summer Session I through the Bio 500 course website: https://pages.wustl.edu/Bio_200-500_independent_research. Credit/No Credit or Audit grade options. Course may not be taken for a letter grade. 1-3 units
Credit variable, maximum 3 units.

L41 Biol 500U Summer Independent Research in Neuroscience

Summer research in neuroscience under the supervision of a faculty mentor. Prerequisites: junior or senior standing and permission of mentor and the department. Credit to be determined in each case, usually 3 units/summer; may be repeated for credit in different summers. Credits are received in the fall semester following the summer research. If work is to be submitted for Latin honors, see page 3 of the Department of Biology Handbook for Majors, Latin Honors Through a Biology Major Program (PDF) (https://wustl.app.box.com/s/2n0gj01opcwiovb6hs26yj1jfovw09lg/). Arrangements for registration should be completed no later than the end of Summer Session I through the Biol 500 course website (https://pages.wustl.edu/Bio_200-500_independent_research/). Credit/no credit or audit grade options. Course may not be taken for a letter grade.
Credit variable, maximum 3 units.

L41 Biol 501 Human Anatomy & Development

Study of the human body primarily by dissection; extensive use of X-rays and CT scans. Emphasis on functional and clinical aspects of anatomy. Prerequisite: This course is restricted to first year medical students. Same as L48 Anthro 502 and M05 AnatNeuro 501A.
Credit 6 units.

L41 Biol 5011 Ethics & Research Science

Exploration of ethical issues which research scientists encounter in their professional activities. Topics will include, but are not limited to: student-mentor relationships, allegations of fraud, collaborators' rights and responsibilities, conflicts of interest, confidentiality, publications. Case study and scenario presentations will provide focus for discussions. Prerequisite, open to graduate students engaged in research. Six 90 minute sessions.
Credit 1 unit.

L41 Biol 5014 Biotech Industry Innovators

Late one Friday afternoon in April 1976, the late venture capitalist Robert Swanson met with biochemist Herb Boyer, PhD, at his UCSF lab. Swanson had requested 10 minutes of Boyer's time; when the meeting ended, three hours later, the foundations had been laid for the formation of Genentech, the first biotechnology company, and the beginnings of the biotechnology industry. This course, The Basics of Bio-Entrepreneurship, investigates issues and choices that

inventor/scientists encounter when considering the applications and commercialization of early stage scientific discoveries. This course is intended for anyone interested in working in the medical device, life-, bio-, or pharma-sciences industries as a founder, scientist, entrepreneur, manager, consultant, or investor. It focuses on the decision processes and issues that researchers and their business partners face when considering how a discovery might best be moved from academia to successful commercialization.
Credit 3 units.

L41 Biol 502 General Physiology
This course applies the fundamental physiological mechanisms of cell biology to the functions of the major organ systems of the body, namely, the cardiovascular, renal, respiratory, gastrointestinal, and endocrine systems. The course is intended primarily for first-year medical students. The Physiology and Microscopic Anatomy courses are closely coordinated within the same schedule. Course continues into the spring semester with a different schedule. Prerequisite, Biol 5061 or the equivalent and permission of course director.
Credit 6 units.

L41 Biol 5051 Foundations in Immunology
Designed for graduate students and medical students as an in-depth introduction to immunology. Topics: antibody structure and genetics, B and T cell receptor, structure and recognition, major histocompatibility complex and antigen processing, cytokine signaling and regulation of the immune response, innate immunity, humoral and cellular effector mechanisms. Discussion Group will meet once a week on Thursdays from 10:00-12:00 p.m. Prerequisite: Introductory Biochemistry and/or Genetics helpful, permission of instructor.
Credit 4 units.

L41 Biol 5053 Immunobiology I
Immunobiology I and II are a series of two courses taught by the faculty members of the Immunology Program. These courses cover in depth modern immunology and are based on Janeway's Immunobiology 8th Edition textbook. In Immunobiology I, the topics include: basic concepts in immunology, innate immunity: the first lines of defense, the induce responses of innate immunity, antigen recognition by B-cell and T-cell receptors, the generation of lymphocyte antigen receptors, antigen presentation to T lymphocytes and signaling through immune system receptors. In Immunobiogy II the topics include: the development and survival of lymphocytes, T cell-mediated immunity, the humoral immune response, dynamics of adaptive immunity, the mucosal immune system, failures of host defense mechanisms, allergy and allergic diseases, autoimmunity and transplantation, and manipulation of the immune response. These courses are open to graduate students. Advanced undergraduate students may take these courses upon permission of the coursemaster. Prereq: DBBS students and advanced undergraduates with permission.
Credit 4 units.

L41 Biol 5054 Immunobiology II
Immunobiology I and II are a series of two courses taught by the faculty members of the Immunology Program. These courses cover in depth modern immunology and are based on Janeway's Immunobiology 8th Edition textbook. In Immunobiology I, the topics include: basic concepts in immunology, innate immunity: the first lines of defense, the induce responses of innate immunity, antigen recognition by B-cell and T-cell receptors, the generation of lymphocyte antigen receptors, antigen presentation to T lymphocytes and signaling through immune system receptors. In Immunobiogy II the topics include: the development and survival of lymphocytes, T cell-mediated immunity, the humoral immune response, dynamics of adaptive immunity, the mucosal immune system, failures of host defense mechanisms, allergy and allergic diseases, autoimmunity and transplantation, and manipulation of the immune response. These courses are open to graduate students. Advanced undergraduate students may take these courses upon permission of the coursemaster. Prereq: DBBS students and advanced undergraduates with permission.
Credit 4 units.

L41 Biol 5068 Fundamentals of Molecular Cell Biology
This is a core course for incoming graduate students in Cell and Molecular Biology programs to learn about research and experimental strategies used to dissect molecular mechanisms that underlie cell structure and function, including techniques of protein biochemistry. Enrolling students should have backgrounds in cell biology and biochemistry, such as courses comparable to L41 Biol 334 and L41 Biol 4501. The format is two lectures and one small group discussion section per week. Discussion section focuses on original research articles. Same as M15 5068 and M04 5068.
Credit 4 units.

L41 Biol 5069 Expanding the Central Dogma: Detours Between Genome and Proteome
How many genes are in the genome? That number is only the beginning of the story leading to a regulated, functional proteome. Recent discoveries suggest that the production and regulation of a functional proteome is quite complex. Several emerging themes may serve to regulate transcription and translation in ways we hadn't considered. In this course we will take a look at these exciting new discoveries and recent twists on existing knowledge that increase our understanding of how the cell responds to internal and environmental changes. Prerequisites: Nucleic Acids.
Credit 2 units.

L41 Biol 5075 Fundamentals of Biostatistics for Graduate Students
This course is designed for first-year DBBS students who have had little to no prior experience in programming or statistics. The course will cover common statistical practices and concepts in the life sciences, such as error bars, summary statistics, probability and distributions, and hypothesis testing. The class will also teach students basic programming skills for statistical computation, enabling them to retrieve and analyze small and large data sets forom online databases and other sources.
Credit 2 units.

L41 Biol 5077 Pharmaceutical Research and Development: Case Studies
The course will provide an overview of the history of pharmaceutical research and development activities, with emphasis upon understanding a blend of the scientific, public health, regulatory and business decisions that have shaped the pharmaceutical industry over the past eight decades. Particular emphasis will be placed on understanding how past trends have raised questions about the sustainability of the enterprise. Although no prerequisites are formally requires, the course will blend basic understanding of scientific and medical terminology with an understanding of the commercial and policy decision-making processes that govern the pharmaceutical and biotechnology enterprises. The course will provide an overview of the history of pharmaceutical research and development activities, with emphasis upon understanding a blend of the scientific, public health, regulatory and business decisions that have shaped the pharmaceutical industry over the past eight decades. Particular emphasis will be placed on understanding how past trends have raised questions about the sustainability of the enterprise. Although no prerequisites are formally requires, the course

will blend basic understanding of scientific and medical terminology with an understanding of the commercial and policy decision-making processes that govern the pharmaceutical and biotechnology enterprises.
Credit 2 units.

L41 Biol 5079 The Science, Medicine and Business of Drugs & Vaccines
The course will provide an overview of the history of research and development in the biotechnology and pharmaceutical industries, with emphasis upon understanding a blend of the scientific, public health, regulatory and business decisions that have shaped the pharmaceutical industry over the past eight decades. Particular emphasis will be placed on understanding how past and ongoing trends have raised questions about the sustainability of the enterprise. Although no prerequisites are formally required, the course will blend basic understanding of scientific and medical terminology with an understanding of the commercial and policy decision-making processes that govern the pharmaceutical and biotechnology enterprises.
Credit 2 units.

L41 Biol 5084 Single Molecule Biophysics Journal Club
Molecular motors in the cell harness chemical energy to generate mechanical work in a host of processes including cell motility, DNA replication and repair, cell division, transcriptional regulation, and intracellular transport. The purpose of this course is to discuss recent advances in the field of molecular motors. Special emphasis will be placed on understanding and criticially evaluating single molecule studies. The course will consist of both journal club presentations and small group discussions.
Credit 1 unit.

L41 Biol 5098 Graduate Research Fundamentals
This course introduces first-year Ph.D. students to the foundational skills, knowledge, and habits of mind required of successful independent biological scientists: 1) Social dynamics in the scientific research enterprise 2) Epistemology and ethics of bioresearch methods 3) Development and communication of research questions and results 4) Interdisciplinary scientific thinking. Class sessions and homework introduce these topics; major assignments prompt student to connect them with the broader scope of graduate training in lab rotations, course work, and interdisiplinary scientific seminars. the interactive, student-driven class structure facilitates autodidactic development while integrating small group activities and peer mentoring from advanced DBBS students. Prerequisite: Students must be enrolled in a graduate program through the Division of Biology & Biomedical Sciences.
Credit 0.5 units.

L41 Biol 5123 Experimental Hematopoiesis Journal Club
Journal club in which papers that describe significant advances in the field of experimental hematopoiesis are discussed. Students are expected to present one paper per semester and attend the weekly (1 hour) session. No prerequisites.
Credit 1 unit.

L41 Biol 5125 Student-Run Cell Biology Journal Club
Participants (students) present summaries of current research published in various journals in the field of cell biology. A large component of this journal club includes coaching in oral presentation. Students receive one credit for regular participation and for making one presentation.
Credit 1 unit.

L41 Biol 5128 Cell Biology of Extracellular Matrix Journal Club
This journal club covers a broad range of topics related to extracellular matrix and cell-cell communication, including the fields of biochemistry, molecular biology, cell biology, and developmental biology. Speakers give a brief background to introduce the topic and then focus on one paper from the current literature. Presentations are given by students, faculty, and post-doctorates. Students receive 1 unit of credit for regular participation and for making one presentation.
Credit 1 unit.

L41 Biol 5130 Plant Diveristy and Evolution
This course is an in-depth exploration of the diversity and evolution of vascular plants. The course focuses mainly on flowering plants because of their dominant role on our planet, but lycophytes, ferns, and gymnosperms are studied as well. A phylogeny of vascular plants provides the framework for their evolution and diversification. Related subjects, including phylogenetics, biogeography, herbaria, nomenclature, species concepts, and pollination biology are also presented. The weekly lectures/discussions and (three hour) lab function in tandem and it is the responsibility for the student to integrate information from the lectures with the abundant materials presented in lab. The lecture will take place on main campus at WashU, and the lab sessions will make use the abundant and exceptional living and preserved materials at the Missouri Botanical Garden. The intended audience is advanced undergraduates and graduate students. Prerequisite: Bio 2970 or Permission of Instructor. Small Class. Credit. Same as L41 Biol 4132
Credit 3 units. A&S IQ: NSM

L41 Biol 5137 Ion Channels Journal Club
Weekly presentations of recent papers on mechanisms of ion channel function and membrane excitability, as well as the role of channel defects in human and model diseases, with lively group discussions the norm! Once per semester, each participant will choose a paper and present it to the group.
Credit 1 unit.

L41 Biol 5138 Journal Club for the Molecular Mechanism of Aging
Why do we age? What causes aging? How is our life span determined? This journal club will address such fundamental, but challenging questions of aging and longevity. Recent studies on aging and longevity are now unveiling regulatory mechanisms of the complex biological phenomenon. We'll cover the latest progress in this exciting field and stimulate discussions on a variety of topics including aging-related diseases. One hour of paper presentation or research talk and discussion per every two weeks. Prerequisite: Basic knowledge of molecular biology and genetics of model organisms, such as yeast, C. elegans, Drosophila and mouse. Registered students are expected to have at least one presentation for 1 unit credit.
Credit 1 unit.

L41 Biol 5142 Cell & Molecular Biology of Bone
The course is designed around a core of general lectures, each supplemented by two to four student presentations, from the recent literature. Topics include, but are not limited to, bone cell ontogeny, integrin/cadherin-based signal transduction, hormonal regulation, and cell:cell communication. Prerequisite: Biol 5068 or consent of coursemaster.
Credit 2 units.

L41 Biol 5145 Nanomedicine Applications
Biomedical applications of nanotechnology. This course is intended to survey the field of nanobiomedicine in a lecture format given by invited experts. Topics will range from multimodality imaging to targeted therapeutics to molecular diagnostics. Benefits and toxicities will be presented and the translational aspects of commercialization of nanosystems for medical use will be covered.
Credit 1 unit.

L41 Biol 5146 Principles and Applications of Biological Imaging
Principles and Applications of Biological Imaging will introduce the interdisciplinary nature of the imaging sciences and conduct a comprehensive survey of the array of interrelated topics that define biological imaging. The course will cover the basics of the optical, magnetic resonance, CT, SPECT and PET imaging modalities, and microscopy, while focusing on applications of imaging to different disease states, such as oncology, neurology, cardiology and pulmonary diseases. Prerequisites. One year each of Biology, Chemistry, Physics and Calculus.
Credit 3 units.

L41 Biol 5147 Contrast Agents for Biological Imaging
Contrast Agents in Biological Imaging will build the chemistry foundations for the design and use of contrast agents in imaging applications such as nuclear medicine, magnetic resonance imaging (MRI) and optical imaging. The course will include lectures on the design of radiopharmaceuticals for gamma scintigraphy and positron emission tomography, MRI contrast agents and agents for optical imaging, including bioluminescence and fluorescence microscopy. Prereqs: one year of general chemistry, one semester of organic chemistry.
Credit 3 units.

L41 Biol 5148 Metabolism Journal Club
The purpose of the Metabolism Journal Club is to introduce the graduate students to advanced topics spanning the biochemistry, cell biology and genetics of cellular and whole body metabolism. Under the guidance of the course directors (Drs. Ory and Schaffer), students will select recent topical articles for discussion in the weekly journal club. Students will be expected to provide a succinct introduction to the topic and lead discussion of the data presented in the journal article. Students will be evaluated on the basis of their presentation and their participation in the seminar throughout the semester. Prerequisites: Successful completion of Fundamentals of Molecular Cell Biology (Bio 5068) and Nucleic Acids and Protein Biosynthesis (Bio 548).
Credit 1 unit.

L41 Biol 5149 High Throughput, High Content, Assay Development, Screening & Target Validation-Principle & Practice
The objective of our course is to introduce students to the world of automation-based discovery science. We will discuss the power of this approach, its constraints and their practical solutions. Specifically, we will introduce the class to the range of available assay tool kits (detection modalities), and the principles that apply towards assay development, library selection (compound, RNAi) and the translation of benchtop methods to automated platforms. We will also discuss sources of error and statistical tools for analyzing large datasets, the hit validation process and lead optimization. Along the way, we will hear from individual investigators describing their own academic or industry screens and critique the growing literature describing results born from high throughput/high content approaches. We realize that high throughput screening raises philosophical issues such as the merit of discovery science vs. hypothesis-driven research, big science, the role of technology in opening new fields of research, etc. We encourage the students to engage with us in these debates while covering the nuts and bolts of high throughput experiments. Minimum enrollment is 5; those interested should contact the coursemaster before May 2011. Prerequisites: Sound foundation in at least one of: biochemistry, cell biology, developmental biology, microbiology, virology, statistics or computational biology.
Credit variable, maximum 2 units.

L41 Biol 5151 RNA Biology Journal Club
The purpose of the RNA Biology Journal Club is to introduce the graduate students to advanced topics spanning the bioinformatics, biochemistry, cell biology and genetics of RNA biology. Under the guidance of the course directors (Drs. Ory and Schaffer), students will select recent topical articles for discussion in the weekly journal club. Students will be expected to provide a succinct introduction to the topic and lead discussion of the data presented in the journal article. Students will be evaluated on the basis of their presentation and their participation in the seminar throughout the semester. Prerequisites: Successful completion of Fundamentals of Molecular Cell Biology (Bio 5068) and Nucleic Acids and Protein Biosynthesis (Bio 548).
Credit 1 unit.

L41 Biol 5152 RAD Journal Club (Regeneration, Aging, and Development)
Focuses on developing a dialog around current topics in developmental and regenerative biology at the molecular, cellular and systems levels.
Credit 1 unit.

L41 Biol 5161 Lymphoid Organogenesis: Ontogeny, Inflammation and Cancer
This course will cover the topic of the role of cytokines and innate immune cells in orchestrating the development of important lymphoid structures that form the physical scafffold for the unfolding immune response. The roles of TNF family member, molecular addressins, and integrins will be covered in the development of Lymph node structures. The regulation of cellular trafficking and the basis of chemokine actions will be covered. The development of tertiary lymphoid organs and associated vascular structures will be covered in terms of their ontogeny and their role in infections and in tumor metastasis.
Credit 3 units.

L41 Biol 5171 Medical Immunology
An introduction to basic concepts in immunology and immunopathology. Lectures focus on antigen-antibody interactions, immunoglobulin structure and genetics, the cellular basis of the immune response and immune regulation, T cell effector mechanisms, the inflammatory response, complement, the positive and negative roles of hypersensitivity, and immune deficiency. Prerequisite, some background in biochemistry and genetics helpful. Restricted to medical students only except in unusual circumstances, with permission of coursemaster. Offered during the first half of the second medical semester. Three-four lecture hours a week, two 2-hour lab periods, four 1-hour clinical discussion groups.
Credit variable, maximum 3 units.

L41 Biol 5190 Community Ecology
Community ecology is an interdisciplinary field that bridges concepts in biodiversity science, biogeography, evolution and conservation. This course provides an introduction to the study of pattern and process in ecological communities with an emphasis on theoretical, statistical and experimental approaches. Topics include: ecological and evolutionary processes that create and maintain patterns of biodiversity; biodiversity and ecosystem function; island biogeography, metacommunity dynamics, niche and neutral theory; species interactions (competition, predation, food webs), species coexistence and environmental change.

The class format includes lectures, discussions, and computer labs focused on analysis, modeling and presentation of ecological data using the statistical program R. Prereq: Bio 2970 required, Bio 381 recommended, or permission of instructor. (Biology Major Area C)
Same as L41 Biol 419
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 5191 Pathobiology of Human Disease States
Three human disease states will be discussed in detail. Topics will include background clinical and epidemiological information, followed by a detailed examination of the molecular and cellular events that underlie the disease state. Examples of pertinent topics include Alzheimer's disease, AIDS, leukemia, cystic fibrosis, sickle cell anemia, diabetes, etc. Prerequisite: Must be a Markey Pathway student.
Credit 2 units.

L41 Biol 5192 Cancer Biology Journal Club
This journal club covers current papers in molecular oncology, cancer genetics and contemporary molecular biology. Presentations will be given by students, post-docs and faculty, then discussed.
Credit 1 unit.

L41 Biol 5193 Frontiers in Human Pathobiology
Leading physician-scientists from the Washington University community will present state-of-the-art lectures on important areas of human pathobiology in which they are expert. This program will provide graduate students, post-doctoral fellows, and medical students with a "cutting-edge" introduction to important biological principles relevant to human diseases. Prerequisites: Graduate or medical student in good standing at WUMS.
Credit 1 unit.

L41 Biol 5196 Special Emphasis Pathway in Cancer Biology
This course is designed to present pre- and postdoctoral trainees with an organized educational format to explore major contemporary topics in cancer biology. The elective will provide an integrated view of cancer research including basic science, translational science, and clinical investigation. Approximately 60 minutes will be devoted to a didactic presentation by a faculty member with interaction by the participants. The remaining 30 minutes will be used to discuss a pivotal research paper from this field, preselected by the faculty member. Outside reading (30-60 min/week) will be required.
Credit 2 units.

L41 Biol 5201 Membrane Protein Biophysics Journal Club
Cells are encapsulated by lipid bilayers providing a physical barrier for the passage of charged molecules and ions in and out of the cell. the proteins that reside within this layer of oil are called membrane proteins, and they act as the molecular gatekeepers, controlling the passage of ions, nutrients, waste products and signaling elements, across cell membranes. This journal club focuses on examining key literature in the field that investigates how membrane proteins fold, adopt certain structures, and how they function inside of the strange envrionment of the lipid membrane. The papers will be selected from biophysical studies that combine new and notable research with key historical work, for a broad perspective of the science being conducted in this complex and emerging field. Special emphasis will be placed on emerging topics, such as regulation of protein function by lipid composition, membrane protein synthesis and folding, cutting-edge developments in membrane biophysics. The course will consist of both journal club presentations, as well as small group discussions in the form of "chalk-talks."
Credit 1 unit.

L41 Biol 5215 Thursday Development Rave
Travel the Medical School to gain hands-on experience with new techniques and approaches to developmental biology. We will emphasize a different approach in which doing goes hand-in-hand with asking. Developmental biology can be fun...so...no note taking allowed; we'll give you the notes. Bring your curiosity. Food, beverages, and music are all part of the mix. You will learn! Due to the nature of the class, size will be limited. Prerequisite, Graduate standing and coursemaster approval required.
Credit 2 units.

L41 Biol 5217 Special Topics in Microbial Pathogenesis
Primarily for graduate and MSTP students, this course involves oral presentation and discussion of current research articles on pathogenic microorganisms (bacteria, viruses, parasites, and fungi). Discussion will include design of specific aims for research proposals. Emphasis will be on literature that addresses the cellular and molecular basis of host-pathogen interactions. Students are expected to prepare all articles covered and to participate actively in each discussion. Prerequisite: advanced elective course "Molecular Microbiology and Pathogenesis" or permission of instructors. Class meets twice per week for 1.5 hours each.
Credit 2 units.

L41 Biol 5222 Introduction to SAS for Biomedical Researchers
This course is a hands-on introduction to analyzing data using the SAS programming language and procedures. SAS stands for Statistical Analysis System and is one of the most powerful statistical packages used to analyze biological (and other) data sets in a meaningful way. The course will train students how to create, manage, manipulate, store, retrieve, and analyze SAS data sets as well as how to produce graphs and reports from different types of data sets. Critically, the course will also teach students the fundamental concepts of key statistical tests (e.g.: t-test, Chi-square test, ANOVA and non-parametric tests), and therefore provide students the intellectual foundation from which to identify the most appropriate statistical test depending on the specific data set to be analyzed. Upon completion of the course, students should have a basic understanding of how to use the SAS program and be able to use SAS to work with various types of data to perform routine statistical analyses and testing. In addition, the course should facilitate the future ability of students to use SAS to manipulate and analyze the ever increasingly large data sets common in essentially all genome-wide approaches.
Credit 2 units.

L41 Biol 5224 Molecular, Cell and Organ Systems
This course will introduce Ph.D. and MSTP students to fundamental problems in cell and molecular biology at the systems level. The course is divided into 5 themes: 1) microbial systems; 2) organ development and repair; 3) cardiovascular system and disease; 4) tumor & host systems; and 5) metabolic systems and disease. Topics within each theme highlight current research concepts, questions, approaches and findings at the molecular, cellular and physiological levels. Students will write an original research grant proposal on a topic of their choosing in one of the 5 themes. Students will critique proposals anonymously in an NIH-like study section. Prereqs; Fundamentals of Molecular Cell Biology and Nucleic Acids and Protein Synthesis.
Credit 3 units.

L41 Biol 5235 Genetics Journal Club
This journal club will be focused on the Genetics department seminar series. Students will present one or a few recent papers by the seminar speaker scheduled for that week. Students will provide a brief written evaluation (on a form that will be provided) of their peers' presentations, and the faculty advisors will meet with each student after the presentation to provide feedback.

Credit 1 unit.

L41 Biol 5246 Coding and Statistical Thinking in the Neurosciences
Students will larn common programming constructs and how to visualize and analyze data. Coding will be integrated into a statistics curriculum introducing summary statistics, probability distributions, simulation and hypothesis testing, and power analysis for experimental design.
Credit 1 unit.

L41 Biol 5255 Experimental Skeletal Biology Journal Club
The journal club, which meets weekly, focuses on cellular and molecular biology of the skeleton. Emphasis is placed on gaining insights into normal skeletal homeostasis as well as systemic disorders of bone. Papers presented for review are selected from the most competitive journals. Participants are encouraged to "think outside of the box" and discuss novel molecular discoveries that may impact bone cell function. Prerequisite, permission of instructor.
Credit 1 unit.

L41 Biol 5261 Molecular Mechanisms of Immunological Diseases
Advanced immunology students will be exposed to human diseases that appear to have an immunological basis. In addition to lectures and evaluation of recent clinical and relevant basic immunology literature, an emphasis will be placed on direct encounters with patients and pathologic material when feasible, providing students with a human aspect to discussions of immune pathogenesis. Diseases covered will include those with known causes such as AIDS and autoimmune disorders such as systemic lupus erythematosus and rheumatoid arthritis for which a molecular basis is not fully understood. Other areas may include asthma and tissue transplantation where effector mechanisms are better characterized. Since most of these disorders have no cure or are imperfect clinical entities, the class will discuss research areas that may be fruitful and lead to improved diagnosis and treatment. Prerequisite: Foundations of Immunology or permission of instructor.
Credit 2 units.

L41 Biol 5262 Human Immunobiology
Advanced immunology students will be exposed to clinical manifestations of human diseases which have an immunological base, such as rheumatoid arthritis, systemic lupus erythematosus, juvenile rheumatoid arthritis, allergy and asthma, by interacting with physicians seeing these patients in the outpatient clinic. One credit, satisfactory/unsatisfactory. Prerequisite, Molecular Mechanisms of Immunological Diseases or consent of instructor and HIPAA training. Spring semester; schedule to be arranged.
Credit 1 unit.

L41 Biol 5272 Advanced Topics in Immunology
This course uses a journal club format to discuss contemporary issues in the cell and molecular biology of the immune system. Discussions focus on the use of current approaches to analyze the cellular and molecular basis of immunity. Topics include mechanisms of antigenic specificity, diversity, cell communication, differentiation, activation, and effector activity. Prerequisite, Bio 5051 and permission of instructor.
Credit 2 units.

L41 Biol 5282 Chromatin Structure and Gene Expression
This special topics course will use "Epigenetics" ed. By Allis, Jenuwein, Reinberg, and Caparros (2007, Cold Spring Harbor Laboratory Press) as the organizing text. Each week a faculty member will provide a background lecture on an important topic or model system, and a student will present and lead discussion of a paper from the current scientific literature related to the previous week's background lecture. Topics to be considered will include background on chromatin structure, histone modifications and histone variants; epigenetic regulation in yeast, other fungi, ciliates, flies, mammals and plants; dosage compensation in different systems; DNA methylation and imprinting in mammals; stem cells, nuclear transplantation and reprogramming; and the epigenetics of cancer and other human diseases (some variation in topics in different years). Students enrolled in the course will be required to present one paper and to come prepared to each session, with a question for discussion. Prerequisite, BIO 548 Nucleic Acids and Protein Biosynthesis.
Credit 2 units.

L41 Biol 5284 Current Research in Chromatin, Epigenetics and Nuclear Organization
This journal club considers papers from the current literature on chromatin structure and function, with an emphasis on regulation of transcription, epigenetics and genomics. Presentations are given by students, postdocs and faculty, with discussion by all. Students enrolled for credit are expected to attend regularly, and to present a minimum of one paper during the term, with consultation and critique from the faculty.
Credit 1 unit.

L41 Biol 5285 Current Topics in Human and Mammalian Genetics
This course aims to provide both biologists and those with mathematical backgrounds with a basis in mammalian genetics. The course will include the following modules: Nucleic acid biochemistry; Gene and chromosome organization; Introduction to Human Genetics; Mutations and DNA repair; Cancer Genetics; Genomic methodologies; Biochemical genetics; Murine Genetics; Epigenetics; Neurodegenerative diseases; Mitochondrial disorders; Pharmacogenetics; Introduction to human population genetics; Applications of modern human genetics; Introduction to web-based informatics tools for molecular genetics. One of the required courses in the Quantitative Human Statistical Genetics graduate program.
Credit 3 units.

L41 Biol 5288 Special Topics in Molecular Genetics
A special topics course with lectures and discussion on the molecular basis of cancer including cell cycle regulation, tumor suppressor genes, tumor invasion, angiogenesis, immune evasion, resistance to apoptosis, signaling, imaging, gene expression, chromosomal translocations, and viral oncology.
Credit 2 units.

L41 Biol 5303 Protein NMR Journal Club
This journal club covers the recent literature on protein NMR with a focus on using NMR to study protein function, NMR dynamics, and novel methods that expand the range of systems accessible to solution NMR studies. Students, postdocs and faculty discuss a recent paper and present background information on the relevant technical aspects of NMR. Students receive 1 credit for participation and presenting one paper.
Credit 1 unit.

L41 Biol 5304 Introduction to Biomedical Data Science I
This course is designed primarily for individuals who wish to learn the research tools and approaches required for biomedical informatics-based research and who have little or no computational experience using command line shells, programming, and databases.
Credit 4 units.

L41 Biol 5310 Biology of Aging
This course provides concepts and examples of the biology of aging. We discuss current literature with emphasis on theoretical causes of aging and the practical implications of these theories. Major topics include the biochemical processes of aging, cell cycle senescence, age-related organ dysfunction, interventions to alter the aging process, and medical illnesses associated with aging (e.g., Alzheimer's disease, the dementias). We also study animal and human models for extending longevity, and current approaches for dealing with the aging process are included. Prerequisites: Biol 2960 and Biol 2970 or equivalent; Chem 105 and Chem 106 or equivalent are recommended.
Same as L41 Biol 4310
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 5311 Dynamics in Mesoscopic Molecular Systems
This course will provide a background in the theory of the dynamics of mesoscopic systems and introduction to methods for measuring the dynamics of these systems. It will include measurement methods, some of which are in common use and others that have only recently been introduced. This course would be useful for biophysics students and others that are interested in molecular processes and mechanisms in small systems such as cells. Prerequisites, Physical Chemistry.
Credit 3 units.

L41 Biol 5312 Macromolecular Interactions
This course will cover equilibria, kinetics and mechanisms of macromolecular interactions from a quantitative perspective. Thermodynamics, multiple binding equilibria (binding polynomials), linkage phenomena, cooperativity, allostery, macromolecular assembly, analysis of binding isotherms, enzyme catalysis and mechanism, steady-state and pre-steady-state kinetics, kinetic simulation, and isotope effects. Prerequisite, physical chemistry, biochemistry, calculus, and organic chemistry. 3 class hours per week.
Credit 3 units.

L41 Biol 5317 The RNA World
Current biology and biochemistry of RNA. Prerequisite, Bio 548 or consent of instructor.
Credit 2 units.

L41 Biol 5318 DNA Repair
This course is an advanced graduate course that explores all aspects of DNA damage and the cellular responses to DNA damage. It is designed for graduate students who have a working knowledge of Chemistry, Molecular Biology and Cellular Biology, and for interested postdocs and researchers. Specific topics that will be covered are: The chemical basis of DNA damage, specific DNA repair mechanisms, cell cycle responses to damage, translesion DNA replication and mutagenesis, and human diseases related to defects in DNA damage response. The course consists of a lecture module, open to all, and a discussion module for registered students. In addition, several invited speakers in the field of DNA repair will give seminars and meet with registered students for discussion. Students will present and discuss research papers. Grades will be given based on student presentation and participation. Prerequisite; Permission of instructor.
Credit 2 units.

L41 Biol 5319 Molecular Foundations of Medicine
This course will cover fundamental aspects of biochemistry and cell biology from a medical perspective. The course begins with a treatment of protein structure and the function of proteins in the cytoskeleton and cell motility. The principles of enzyme kinetics and regulation are then discussed and basic pathways for the synthesis and metabolism of carbohydrates and lipids are introduced. This leads in to a discussion of membrane structure and the function cellular organelles in biological processes including energy production, protein degradation and protein trafficking. Prerequisite: Two semesters of organic chemistry. Coursemaster approval is required. Please note: This course is given on the medical school schedule and so it begins 8 days before the grad school schedule.
Credit 3 units.

L41 Biol 5327 Optical Spectroscopy: Theory and Applications
Spectroscopic methods to be covered include fluorescence, both ensemble and single molecule, and absorption (circular dichroism); fluorescence correlation spectroscopy will also be discussed. The quantum chemistry /physics behind these methods will be reviewed. Prerequisite: Consent of instructor.
Credit 2 units.

L41 Biol 5328 Structural Biology Journal Club
Multi-laboratory research colloquia for DBBS graduate students focused on structural biology and complementary biophysical techniques. Course credit requires student presentation for credit.
Credit 1 unit.

L41 Biol 5329 Mathematical Methods for Biophysics and Biochemistry
The purpose of this course is to introduce the basic concepts of mathematical physics to students in the context of problems they are likely to encounter in their course work and research. Specifically, the course will introduce analytical and numerical mathematical methods in linear and matrix algebra, ordinary and partial differential equations, and linear transform methods relevant to the fields of biophysics and biochemistry. By the end of the course, the students should have a good grasp of these basic techniques, their application to biological problems, and related software and computational resources.
Credit 3 units.

L41 Biol 5335 Linkage Theory and Experiment
The course will cover basic concepts of linkage and their application to the analysis of protein function and interactions. The course is meant to expose students in Biochemistry to the conceptual framework behind current approaches to the study of protein function and interactions, using a very simple mathematical treatment (no knowledge of calculus required) and the discussion of specific biological systems. Topics to be covered include: 1. Linkage cycles; 2. Allostery and cooperativity; 3. Site-specific linkage; 4. Epitope mapping using Ala-scanning mutagenesis; 5. Double-mutant cycles; and 6. Rational protein engineering. Prerequisite: Basic knowledge of protein structure and function.
Credit variable, maximum 1.5 units.

L41 Biol 5336 Computational Biophysics Journal Club
This course covers a combination of classic and recent publications on computational methods for studying biomolecules. Students participating for credit will be required to present at least once.
Credit 1 unit.

L41 Biol 5342 Macrophage Biology
This special topics course will examine aspects of cell and molecular biology of the macrophage; endocytosis, phagocytosis, adhesion, motility, signal transduction, antigen processing, lysosomes, intracellular parasitism. Prerequisite, Molecular Cell Biology (Bio 5068) or Foundations in Immunology (Bio 5051). Two hours a week.
Credit 2 units.

L41 Biol 5344 Epigenetics
Introductory course in epigenetics - the layer of chemical information that sits on top of the genome - that switch genes 'on' or 'off'. Will introduce how the epigenome, in collaboration with the genome, controls versatile biological processes and cell fates. Will also cover the latest advances of how humans can control their own epigenetic destiny by lifestyle, diet, and other environmental factors. Learning Objectives: Recognize and summarize the difference between genetics and epigenetics, Apply the basic knowledge of epigenetic mechanism and illustrate how their misregulations cause abnormal development and diseases, Critically review and discuss epigenetic literature, Design epigenetic experiments and interpret the results of those experiments, Graduate student specific: Demonstrate the ability to clearly communicate epigenetic research in both oral and written formats. Prerequisite: Biology 2960 and Biology 2970 (or consent of instructor) (Biology Major Area A)
Same as L41 Biol 4344
Credit 3 units. A&S IQ: NSM Art: NSM

L41 Biol 5352 Developmental Biology
Analysis of a selected set of key processes in development, such as pattern formation, cell-cell signaling, morphogenesis, etc. The focus is on molecular approaches applied to important model systems, but framed in classical concepts. The discussion section provides instruction in presenting a journal club and writing a research proposal. Prerequisites, Molecular Cell Biology (Bio 5068) and Nucleic Acids (548).
Credit 3 units.

L41 Biol 5357 Chemistry and Physics of Biomolecules
This course covers three major types of biomolecular structures: proteins, nucleic acids, and membranes. Basic structural chemistry is presented as well as the biophysical techniques used to probe each type of structure. Selected topics covered include protein folding, protein design, X-ray crystallography, NMR spectroscopy, nucleic acid bending and supercoiling, nucleic acid:protein interactions, RNA folding, membrane organization, fluidity, permeability and transport, and membrane channels. The weekly discussion section will cover problem sets and present current research papers. This is one of the required courses for the biochemistry and for the molecular biophysics graduate programs. Prior course work in biochemistry and physical chemistry is recommended but not required.
Credit 3 units.

L41 Biol 5358 Biochemical and Biophysical Investigations of Infectious Diseases Journal Club
Biochemical and biophysical approaches continue to advance as powerful approaches to the understanding of human disease processes. This journal club covers recent papers in which these approaches address aspects of infectious diseases or inflammation. Students who enroll for credit will be expected to participate in weekly presentations and to present one to two papers along with accompanying background information. Prerequisites:Graduate standing in DBBS; prior introductory course work in biochemistry, physical chemistry, or Chemistry and Physics of Biomolecules (Biol 5357). Course work in microbiology or immunology is not required.
Credit 1 unit.

L41 Biol 5381 Mechanisms of Protein Targeting & Intercompartmental Transport
Recent advances regarding the molecular mechanisms responsible for targeting and intercompartmental transport of proteins to and between specific organelles, such as the endoplasmic reticulum, golgi apparatus, lysosomes, mitochondria, and nucleus. Particular emphasis on the development and use of cell-free systems that faithfully reconstitute key protein targeting and transport events. Material consists primarily of original research articles presented by students. Prerequisite, Molecular Cell Biology (may not be taken concurrently).
Credit 1 unit.

L41 Biol 5384 Advanced Cell Biology
A lecture/discussion course for graduate and MSTP students that focuses on current research directions in fundamental processes of cellular biology. Topics will be covered in depth over two week blocks and will include glycobiology, lipid homeostasis, protein degradation, and cell senescence. Emphasis on development of journal club presentation and grant writing skills. Prerequisite, Bio 5068 or permission of coursemasters.
Credit 3 units.

L41 Biol 5392 Molecular Microbiology & Pathogenesis
Course is devoted to studying microorganisms, particularly those that cause disease, with an emphasis on the molecular interactions between pathogens and hosts. First third of the course focuses on virology, second third on bacteriology and the last third on eukaryotic pathogens. Prereq, first semester core curriculum for Programs in Cell and Molecular Biology.
Credit 3 units.

L41 Biol 5393 Molecular Virology Journal Club
Journal club covering a broad range of topics in virology with an emphasis on pathogenesis or molecular biology of medically important viruses. A minimum of one student presentation with faculty critique. Prerequisite: Permission of instructor.
Credit 0.5 units.

L41 Biol 5394 Introduction to Metagenomics: The Study of Microbial Ecosystems
This course introduces students to key questions, approaches, and computational tools used to study the properties of microbial communities in their various habitats. Complex microbial ecosystems are found in a variety of terrestrial and oceanic environments as well as in the various body habitats of metazoan species including humans. These ecosystems, which are composed largely of microbial species that have never been cultured in a lab, are laboratories for the study of genome evolution (eco-genomics), ecological principles, and myriad biotransformations. In particular, many animals, including ourselves, have evolved to live with and benefit from the commensal microbial communities in their GI tracts. The study of microbial ecosystems gives rise to the field of metagenomics - the acquisition, identification, and functional and evolutionary analysis of the combined genomic sequences of a diverse population of organisms. Metagenomic analyses must contend with many challenges, including a high volume of genomic sequence data, fragmentary and incomplete sequences, and genomic heterogeneity of sampled organisms. To tackle these challenges, we must bring to bear computational tools that apply models of sequence evolution to interpret metagenomic sequence data. These interpretations form a basis for further investigation and hypothesis testing. Course content will include an overview of questions and major results in metagenomic research, along with an introduction to the experimental protocols and computational tools, models, and algorithms of metagenomic analysis. The class will have two 1.5 hour meetings per week for 14 weeks. Enrollment is limited to 25 students. Prerequisites: Graduate standing or permission of instructor. Some basic knowledge of biology is recommended. Students should know or be prepared to learn basic Python scripting to carry out some course assignments.
Credit 3 units.

L41 Biol 5397 Current Literature in Microbiology
Presentations by students on a broad range of topics of current interest in microbiology. The course will emphasize presentations and discussion skills. Credit requires attendance and participation at all sessions and one presentation. Prerequisites: L41 Biology and Biomedical Science Microbiology (349) and laboratory (3491).
Credit 1 unit.

L41 Biol 5398 Microbiology Program Grant Writing Workshop
This grant writing workshop will focus on defining identifying key unanswered questions from the literature, formulating hypotheses for testing, defining Specific Aims, and developing a research plan. Students will submit specific aims on a topic of their choice, receive critiques from faculty members, and develop a NIH-style proposal to investigate them. Students will participate in class discussions and a mock study section to evaluate proposals. Prerequisite, completion of the MMMP advanced elective, Bio 5392 Molecular Microbiology & Pathogenesis or permission of the coursemaster.
Credit 1 unit.

L41 Biol 5401 Introduction to Bioinformatics I
This year-long course for first-year BIDS PhD students introduces a broad spectrum of biomedical informatics theories and methods that support and enable translational research and, ultimately, precision health care. The course is organized into modules spanning levels of inquiry from biomolecules to patients to populations. For each module, a relevant set of biomedical informatics frameworks will be introduced and then demonstrated via experiential learning involving the analysis of a variety of biological, clinical, and population-level data sets.
Credit 4 units.

L41 Biol 5403 Introduction to Biomedical Data Science I
This course provides a hands-on introduction to fundamental principles of informatics and data analysis tools and methods. It is designed primarily for individuals who wish to learn the research tools and approaches required for biomedical informatics-based research and who have little or no computational experience using command line shells, programming, and databases.
Credit 4 units.

L41 Biol 5412 Tropical and Molecular Parasitology
Graduate level seminar course focusing on current scientific literature in molecular parasitology. The journal club will meet biweekly during the Fall and Spring semesters. Students will attend both semesters in order to receive one credit. The seminar series will run jointly with a research conference in Tropical and Molecular Parasitology. Outside speakers will be invited for the seminar series to emphasize important developments in tropical medicine and molecular parasitology. In advance of the invited speakers, topics will focus on their previous research publications. Prerequisites, BIO 5392 Molecular Microbiology & Pathogenesis.
Credit 0.5 units.

L41 Biol 5416 Molecular Microbiology & Pathogenesis Journal Club
Presentations by students on a broad range of topics of current interest in microbiology and pathogenesis including areas of research in bacteriology, mycology, parasitology, virology and immunology. The course will emphasize techniques used to give good presentations and scientific critique. Speakers provide a brief background to introduce the topic and then focus on one-two papers from the current literature. Credit requires attendance at all sessions and one presentation.
Credit 1 unit.

L41 Biol 5417 Hematology Division Journal Club: Current Topics in Biochemistry, Cellular, and Molecular Biology
This journal club covers a broad range of topics of current interest, including the fields of biochemistry, molecular biology, cell biology, developmental biology, and immunology. Speakers usually give a brief background to introduce the topic and then focus on one-two papers from the current literature. Presentations are given by graduate students, post-doctorates, and faculty. Each attendee presents two-three times per year. Participants are expected to attend all the sessions. This journal club was founded in 1966.
Credit 1 unit.

L41 Biol 5419 Seminars in Microbiology & Infectious Diseases
Work in-progress seminars by graduate students and postdoctoral fellows. Prerequisite: BIO 5392 Molecular Microbiology & Pathogenesis.
Credit 1 unit.

L41 Biol 5420 Membrane Protein Biophysics Journal Club
Cells are encapsulated by lipid bilayers providing a physical barrier for the passage of charged molecules and ions in and out of the cell. the proteins that reside within this layer of oil are called membrane proteins, and they act as the molecular gatekeepers, controlling the passage of ions, nutrients, waste products and signaling elements, across cell membranes. This journal club focuses on examining key literature in the field that investigates how membrane proteins fold, adopt certain structures, and how they function inside of the strange environment of the lipid membrane. the papers will be selected from biophysical studies that combine new and notable research with key historical work, for a broad perspective of the science being conducted in this complex and emerging field. Special emphasis will be placed on emerging topics, such as regulation of protein function by lipid composition, membrane protein synthesis and folding, and cutting-edge developments in membrane biophysics. The course will consist of both journal club presentations, as well as small group discussions in the form of "chalk-talks."
Credit 1 unit.

L41 Biol 5425 Immunology of Infectious Diseases Journal Club
The goal of this Journal Club (JC) is to provide 2nd year students in MMMP program a platform to discuss new and emerging concepts on mechanisms by which host immune responses mediate protection against infectious diseases. This exercise will also enable the student who attend the fundamental Immunology course to apply their knowledge to understand the basis for immunology of infectious diseases. The format will include faculty who will select cutting-edge papers and head the discussion during the JC session.
Credit 1 unit.

L41 Biol 5426 ID Gateway: Translational and Public Health Aspects of Basic Infectious Disease Research
This course provides an opportunity for students, postdoctoral fellows, infectious disease fellows and faculty to explore issues at the interface between patient care, public health and basic research in the area of microbial pathogenesis. Prerequisites, Application and L41 Bio 5392 or M30 526, or permission of instructor.
Credit 2 units.

L41 Biol 5445 DNA Metabolism Journal Club
Presentation of current research papers in DNA replication, DNA repair, and DNA recombination, with an emphasis on basic biochemical and biophysical approaches.
Credit 1 unit.

L41 Biol 5456 Advanced Crystallography
The advanced course in Protein Crystallography will address all aspects of modern protein crystallography including fundamentals of crystallography, the derivation of the structure factor and electron density equation, symmetry and space groups, direct methods, isomorphous replacement, molecular replacement, data collection, and crystal growing theory and techniques. Prerequisite, Physical Chemistry & Bio 5325 Protein Structure and Function. Two class hours per week.
Credit 2 units.

L41 Biol 5461 Molecular Recognition
The physical basis of recognition as exemplified in ligand binding to receptors is the focus with modeling of interactions between macromolecules of biological interest such as G-protein coupled receptors and ligands such as drugs, hormones, etc. Approaches to structure-based design of novel ligands as well as development of active site hypotheses when the three-dimension structure of the receptor is unknown will be developed. Emphasis will be placed on pharmacophore determination, receptor site modeling, three-dimensional quantitative structure-activity relationships, neural networks, de novo design, etc. Applications will be taken from biological systems of therapeutic interest such as inhibition of proteases (HIV protease, thrombin, collagenase, etc.), homology modeling of enzyme targets, design of minor groove ligands for DNA, etc. Each student should expect to complete a project applying one of the computational methods discussed. Two hours of lecture plus three hours of lab per week. Prerequisite, Physical Chemistry, basic Biological Chemistry. Course offered every other year. Minimum 5 students.
Credit 3 units.

L41 Biol 5464 Computational Biochemistry
This course covers the application of computer modeling and simulation to problems involving biological macromolecules of interest such as enzymes, receptors, nucleic acids, etc. Lectures discuss the theory and algorithms underlying a variety of simulation techniques. Alternative paradigms for modeling at differing levels of structural resolution will be emphasized. Topics examined in detail include molecular mechanics force fields, optimization, dynamics simulation, protein structure prediction, molecular recognition and homology modeling. Problem sets provide computer exercises designed to give students practice with actual programs and applications. Students are asked to complete a computational project of their choice using one of the methods discussed. Prerequisite: background in physical chemistry, multivariable calculus and basic computer usage. Minimum 5 students.
Credit 3 units.

L41 Biol 5466 Current Topics in Biochemistry
Special topics course offered every other week involving the discussion of research papers covering a broad range of topics in the field of biochemistry. Papers selected from the primary literature will be presented and discussed by students with guidance from the instructor. Emphasis will be placed on papers that illustrate the application of chemical approaches to important biological processes. Designed primarily for first- and second-year graduate students in the Biochemistry Ph.D. program. Prerequisites: coursemaster permission.
Credit 0.5 units.

L41 Biol 5468 Cardiovascular Biophysics Journal Club
This journal club is intended for beginning graduate students, advanced undergraduates, and MSTP students with a background in the quantitative sciences (engineering, physics, math, chemistry, etc). The subjects covered are inherently multidisciplinary. We will review landmark and recent publications in quantitative cardiovascular physiology, mathematical modeling of physiologic systems and related topics such as chaos theory and nonlinear dynamics of biological systems. Familiarity with calculus, differential equations, and basic engineering/thermodynamic principles is assumed. Knowledge of anatomy/physiology is optional.
Same as E62 BME 5911
Credit 1 unit.

L41 Biol 5469 Biochemistry, Biophysics, and Structural Biology Seminar
Student presentation of Biochemistry, Biophysics or Structural Biology topic. Second Year Students present from literature; senior students give formal research seminar. Attendance required of all BBSB Graduate Students. Prerequisites: BBSB Graduate Student.
Credit 0.5 units.

L41 Biol 5476 Modeling Biomolecular Systems I
This course covers the applications of computer modeling and simulation to problems involving biological macromolecules. Lectures will discuss the theory and algorithms underlying a variety of simulation techniques. Laboratory exercises and a student project will provide experience with software presently used in the field. Topics examined in detail include: computational tools, molecular visualization, simulation methodology, force field methods, optimization, experimental design, QSAR, scoring and screening of ligands, docking, structure databases, and refinement and prediction of structures. Prereqs: basic background in biochemistry and physical chemistry; ability to write simple computer programs in any language.
Credit 3 units.

L41 Biol 548 Nucleic Acids & Protein Biosynthesis
Fundamental aspects of the structure, biosynthesis, and function of nucleic acids and the biosynthesis of proteins. Emphasis on mechanisms involved in the biosynthetic processes and the regulation thereof. Lecture course supplemented with student discussions of research papers. Prerequisites: Biol 3371, Biol 451, Chem 481 or equivalent, or permission of instructor.
Credit 3 units.

L41 Biol 5483 Human Genetic Analysis
Basic Genetic concepts: meiosis, inheritance, Hardy-Weinberg Equilibrium, Linkage, segregation analysis; Linkage analysis: definition, crossing over, map functions, phase, LOD scores, penetrance, phenocopies, liability classes, multi-point analysis, non-parametric analysis (sibpairs and pedigrees), quantitative trait analysis, determination of power for mendelian and complex trait analysis; Linkage Disequilibrium analyses: allelic association (case control designs and family bases studies), QQ and Manhattan plots, whole genome association analysis; population stratification; Quantitative Trait Analysis: measured genotypes and variance components. Hands-on computer lab experience doing parametric linkage analysis with the program LINKAGE, model free linkage analyses with Genehunter and Merlin, power computations with SLINK, quantitative trait anaylses with SOLAR, LD computations with Haploview and WGAViewer, and family-based and case-control association anaylses with PLINK and SAS. The methods and exercises are coordinated with the lectures and students are expected to understand underlying assumptions and limitations and the basic calculations performed by these computer programs. Auditors will not have access to the computer lab sessions. Prerequisite: M21-515 Fundamentals of Genetic Epidemiology. For details, to register and to receive the required permission of the Coursemaster contact the MSIBS Program Manager (biostat-msibs@email.wustl.edu or telephone 362-1384).
Credit 3 units.

L41 Biol 5484 Genetics and Development of C. elegans Journal Club
Students will present a research paper (or present their current thesis research) and the appropriate background material.
Credit 1 unit.

L41 Biol 5486 Classic Experiments in Molecular Biology
A few key papers stand out as the historical foundations of molecular genetics. They illuminate the process of intuition, creative experimentation and insight that led to what we now accept as dogma in our field. This class, organized in the style of a journal club, will explore this history through presentations by students of these classic papers. Each student will be responsible for presenting one topic, consisting of 2 to 3 papers, placing them in their historical context through background reading from the contemporary literature, and in Judson's "The Eighth Day of Creation" and Cairns, Stent, and Watson's "Phage and the Origin of Molecular Biology." Prerequisite, graduate standing and BIO 548 and BIO 5491, or consent of instructors.
Credit 1 unit.

L41 Biol 5487 Genetics and Genomics of Disease
The course will cover the use of genomic and genetic information in the diagnosis and treatment of disease, with an emphasis on current practice and existing gaps to be filled to achieve precision medicine. Areas of discussion include: bioinformatics methods; assessment of pathogenicity; use and curation of disease variant databases; discovery of incidental findings; genomics applications in Mendelian disease, complex traits, cancer, pharmacogenomics, and infectious disease; design of clinical trials with genetic data; ethical and policy issues. Prerequisites: Genomics (Bio 5488), Advanced Genetics (Bio 5491), or Fundamentals of Mammalian Genetics (Bio 5285) or equivalent (permission from instructor)
Credit 2 units.

L41 Biol 5488 Genomics
This course is designed for beginning students who want to become familiar with the basic concepts and applications of genomics. The course covers a wide range of topics including how genomes are mapped and sequenced as well as the latest computational and experimental techniques for predicting genes, splice sites, and promoter elements. High throughput techniques for ascribing function to DNA, RNA, and protein sequences including microarrays, mass spectrometry, interspecies genome comparisons and genome-wide knock-out collections will also be discussed. Finally, the use of genomic techniques and resources for studies of human disease will be discussed. A heavy emphasis will be put on students acquiring the basic skills needed to navigate databases that archive sequence data, expression data and other types of genome-wide data. Through problem sets the students will learn to manipulate and analyze the large data sets that accompany genomic analyses by writing simple computer scripts. While students will become sophisticated users of computational tools and databases, programming and the theory behind it are covered elsewhere, in Michael Brent's class, Bio 5495 Computational Molecular Biology. Because of limited space in our teaching lab, enrollment for lab credit will be limited to 24 students. Priority will be given to students in the DBBS program. Others interested in the course may enroll for the lectures only. If you have previous experience in computer programming, we ask that you do not enroll for the laboratory credit. Prerequisites, Molecular Cell Biology (Bio 5068), Nucleic Acids (Bio 548) or by permission of instructor. Lecture 3 units of credit; lab 1 additional unit, space limited.
Credit variable, maximum 4 units.

L41 Biol 5489 Human Genetics Journal Club
In this biweekly journal club on Human Genetics we will present and discuss current cutting edge papers in human and mammalian molecular genetics. Students learn presentation skills, how to critique a paper and how to interact with a very active and critical audience. Prerequisites; Any person interested in the current state of the art in Human Genetics may attend this course. It is a requirement that all students wishing to earn credit in this course must present a 1.5 hour journal club talk and must regularly attend and participate in the journal club throughout the year.
Credit 0.5 units.

L41 Biol 5491 Advanced Genetics
Fundamental aspects of organismal genetics with emphasis on experimental studies that have contributed to the molecular analysis of complex biological problems. Examples drawn from bacteria, yeast, nematodes, fruit flies and mammalian systems. Prerequisite, graduate standing or permission of instructor.
Credit 3 units.

L41 Biol 5494 Quantitative Cardiovascular Physiology
The course will cover the mechanical, thermodynamic, electrical and pump function role of the heart as well as tissue elasticity, viscosity of selected media, aspects of the microcirculation, wave propagation. Mathematical modeling of various physiologic functions will be stressed. The connection between model prediction and comparison to in-vivo human physiologic data will be emphasized. The question of whether new physiology can be predicted from first principles will be considered.
Credit 3 units.

L41 Biol 5495 Computational Molecular Biology
This course is a survey of algorithms and mathematical methods in biological sequence analysis (with a strong emphasis on probabilistic methods) and systems biology. Sequence analysis topics include introduction to probability, probabilistic inference in missing data problems, hidden Markov models (HMMs), profile HMMs, sequence alignment, and identification of transcription-factor binding sites. Systems biology topics include the discovery of gene regulatory networks, quantitative modeling of gene regulatory networks, synthetic biology, and (in some years) quantitative modeling of metabolism. Prerequisite: CSE 131 or CSE 501N.
Credit 3 units. EN: BME T, TU

L41 Biol 5496 Seminar in Computational Molecular Biology
Students present current research papers and the appropriate background material in the field of Computational Biology. **Arts and Sciences students must take this course for credit; Engineering students must take this course Pass/Fail.**
Credit 1 unit.

L41 Biol 5497 Special Topics in Computational Molecular Biology
Indepth discussion of problems and methods in Computational Molecular biology. Each year three topics will be covered and those will change yearly. Prerequisite, Bio 5495 or instructor's consent.
Credit 2 units.

L41 Biol 5498 An Introduction to Genomic Analysis
Formal lectures will serve to highlight the role that genomic analysis currently plays in all areas of genetics. A series of lectures and demonstrations will introduce the students to many of the techniques presently used in genomic analysis. Prerequisite: Nucleic Acids (Biol 548) or approval of coursemaster. One hour lecture and 1 hour of laboratory demonstration/lecture each week.

Credit 2 units.

L41 Biol 5499 Cancer Informatics Journal Club
This journal club will explore current topics in cancer informatics. Current literature will be reviewed for advanced cancer genome analysis methods, statistics, algorithms, tools, databases, and other informatics resources.
Credit 1 unit.

L41 Biol 550 Medical Genetics
A significant portion of the first-year course in basic medical genetics devoted to human and clinical genetics, with emphasis on how genomic information will transform the practice of medicine. Topics covered include population genetics; molecular basis of mutations; human functional genomics; mouse models of human disease; pharmacogenomics; metabolic defects. Lectures, small group discussions, patient information session. Prerequisite: an introductory genetics course and permission of the instructor.
Credit 2 units.

L41 Biol 5501 The Biology and Pathology of the Visual System
The purpose of the course is to provide a fascinating view of vertebrate eye development, anatomy, physiology and pathology. Topics to be covered include the molecules that control eye formation, ocular stem cells, the physiology of transparency, hereditary ocular diseases, phototransduction, the neurobiology of the retina and central visual pathways, age-related eye diseases, and many others. The course is open to all second year graduates students and above. Ophthalmology residents and postdocs with an interest in vision are strongly encouraged to attend.
Credit 3 units.

L41 Biol 5502 Molecular Aspects of Vision
Seminar on useful research strategies used to elucidate the molecular basis of light detection including the biochemical, biophysical and electrophysiological events. Discussions of the molecular basis of inherited ocular cancer, color blindness and retinitis pigmentosis included. Prerequisite, 3 units of biochemistry.
Credit 3 units.

L41 Biol 5504 Algorithms for Biosequence Comparison
This course surveys algorithms for comparing and organizing discrete sequential data, especially nucleic acid and protein sequences. Emphasis is on tools to support search in massive biosequence databases and to perform fundamental comparison tasks such as DNA short-read alignment. Prerequisite: CSE 347 or permission of instructor. These techniques are also of interest for more general string processing and for building and mining textual databases. Algorithms are presented rigorously, including proofs of correctness and running time where feasible. Topics include classical string matching, suffix array string indices, space-efficient string indices, rapid inexact matching by filtering (including BLAST and related tools), and alignment-free algorithms. Students complete written assignments and implement advanced comparison algorithms to address problems in bioinformatics. This course does not require a biology background. Prerequisites: CSE 347 or instructor permission Revised: 2019-02-21 Same as E81 CSE 584A
Credit 3 units. EN: BME T, TU

L41 Biol 5505 Independent Study in Fundamentals of Molecular and Microbial Genetics
This literature-based course will introduce students to seminal and current studies in molecular and microbial genetics. Students will read and present a minimum of 12 landmark papers that helped shape our understanding of molecular and microbial genetics. Emphasis will be placed on students' ability to comprehend and explain these studies via chalk talks. All presentations will be given by students. Prerequisites: L41 5491 Advanced Genetics and permission from instructor.
Credit 2 units.

L41 Biol 5507 Genome Engineering Methods and Applications
This course will cover the basic principles of genome engineering with emphasis on Cas9/CRISPR technology. It will consist of discussion sessions in which students will present assigned manuscripts followed by a general discussion of the topic directed by the instructor. The course will cover the mechanisms of genome editing using host DNA repair systems, the function of Cas9, and how Cas9 can be harnessed to introduce defined mutations into almost any genome. The use of Cas9 to activate or repress genes, alter chromatin modifications, and the application of these Cas9 systems to conducting genome-scale screens in mammalian cells as well as its use in studying cell fate will be highlighted. Finally, we will study how Cas9 methodologies can be used to introduce disease-associated variants into pluripotent stem cells (e.g. iPSCs) that can be differentiated into disease-relevant cell for use in functional genomic studies.
Credit 1 unit.

L41 Biol 5508 ITVS Advanced Techniques
The Advanced Methods in Vision Science course provides ITVS students the opportunity to learn about advanced methods utilized in studies of the visual systems from the experts who perform the studies. These methods emerged from different disciplines (molecular biology, imaging, electrophysiology, machine learning), but provide critical details for understanding how the visual systems focuses and processes light stimuli. The course has two components. 1) A series of 90-minute structured discussions of advanced methods via foundational papers and recent applications of these methods. 2) A choice of two hands-on experiences with these methods in the instructor laboratories. We open the discussion section of the course to all students, postdocs, and faculty members (in this order) but cap the class size at 12 participants to facilitate interactions. Hands-on experiences are restricted to ITVS students. For hands-on experiences, each ITVS student chooses two techniques and spends a day in the laboratory of the respective instructor to gain practical experience with the experiments and analysis pipelines and discuss pitfalls and applications of the methods in detail. Through these components, the Advanced Methods in Vision Science course tries to accomplish three goals: 1) enable students to critically assess the literature through an understanding of strengths and limitations of advanced methods, 2) help students plan experiments involving these methods, and 3) facilitate collaborations with experts in the field that could enhance the science of the ITVS students.
Credit 3 units.

L41 Biol 5509 ITVS Project Building
The overall goal is to have intense guidance to construct a grant/fellowship application. Students should expect to have a near completed F30/F31 application by the end of this course Students will study previous F30/F31 applications and sit on a mock panel to review real world grants from their peers. They will use this experience to understand the reviewers perspective when writing fellowships and grants in the future. Students will draft all portions of a research proposal with feedback from their peers, the course instructor and faculty mentors.
Credit 1 unit.

L41 Biol 5511 Molekoolz
Behind in your reading? Molekoolz is dedicated to bringing you the latest and greatest from the past year. This year we return to our roots and bring you a dozen of the hottest molecules of '97/'98 and the biology that makes 'em great. Come join us as we explore the Ras pathway, the Notch pathway, TGFb signaling, the intrepid Hedgehog, those sneaky Wnt's, the latest in circadian rhythms, and many more of your favorites. All are welcome, but it will be aimed at advanced graduate students, postdox, and interested faculty. Two credits, contingent on attendance and reading of (short) assigned paper.
Credit 2 units.

L41 Biol 5512 Diseases of Membrane Transport & Excitability
Classes will consider the molecular basis of the disease as well as animal models and current clinical studies. Addressing studies from the level of basic biophysical and molecular properties of the underlying ion channels/transporters, to the cellular deflects, to organ and animal outcomes and therapies., which will encourage and force sutdents to develop their ability to integrate understanding at multiple levels. Students will be introduced to emerging ideas in clinical diagnosis, management and treatment, when appropriate, clinical specialists will allow student participants to directly observe and participate in the clinical experiences. Prerequisites, Bio 5068 Fundamentals of Molecular Cell Biology.
Credit 2 units.

L41 Biol 554 Neural Sciences
An integrated course dealing with the structure, function and development of the nervous system. The course will be offered in the Spring of the first year Medical School calendar. Prerequisite: Biol 3411 or Biol 501 and approval of the instructor.
Credit 5 units.

L41 Biol 5542 Neural Constructs of Spatial Orientation
The course will explore the neural mechanisms and perceptual constructs that underlie spatial orientation. The brain's capacity to use several sensory systems to integrate information relative to position in space, movement direction, and navigation will be examined. Quantitative models of sensory transduction and neural information coding for vestibular, visual, proprioceptive, and magnetoreception will be derived and tested in an effort to comprehend the global interactive representation of spatial orientation. The class will meet twice weekly where readings will be assigned from the extant literature and secondary sources. Materials will be provided. Previous experience with engineering systems analysis and MATLAB will be helpful, but not necessary.
Credit 3 units.

L41 Biol 5565 Oral Presentation of Scientific Data
Practical course on how to prepare and present scientific data to an audience. Prerequisite: First year neuroscience program courses. Meets once a week for 90 minutes.
Credit 1 unit.

L41 Biol 5571 Cellular Neurobiology
This course will present a fully integrated overview of nerve cell structure, function and development at the molecular and cellular level. Broad topics to be covered include gene structure and regulation in the nervous system, quantitative analysis of voltage- and chemically-gated ion channels, presynaptic and postsynaptic mechanisms of chemical neurotransmission, sensory transduction, neurogenesis and migration, axon guidance and synapse formation. Two lectures plus one hour of discussion per week for 14 weeks. There will be three exams, as well as homework problems and summaries of discussion papers. Prerequisites: graduate standing or permission of the instructor.
Credit 6 units.

L41 Biol 5572 Regenerative and Stem Cell Biology
Regeneration is a very complex, post-embryonic developmental phenomenon, where organisms replace lost body parts and organs upon injury. However, we still know very little about why some animals are so successful at regenerating whole bodies and organs, while other animals (like humans) have limited or no capacity to do so. This course covers regeneration and stem cell biology across different levels of biological organization (e.g. cell, organ, limb regeneration.) and across the animal phylogeny.
Credit 3 units.

L41 Biol 5577 Synapses Journal Club
Synaptic function and malleability are fundamental to nervous sytem function and disease. This is an advanced seminar in the development, structure, and function of the synapse in health and disease. It is a natural extension of topics covered in Bio 5571. It may be primarily of interest to students in the Neurosciences Program, but also to students in MCB, Development, Biochemistry, Computational Biology, and Molecular Biophysics. Generally a topic for the semester helps focus the group; past topics have included Synapses and Disease, Neurotransmitter Transporters, Glutamate Receptors, Dendrites, GABA receptors. Participants (students, postdocs, and faculty) alternate responsibility for leading critical discussion of a current paper. Active participation offers the opportunity for students to hone their critical thinking and presentation skills. Students enrolling for credit will be expected to attend each week, to lead discussion once per semester and to provide written critiques (1-2 pages each) of two papers. Prerequisites, Graduate standing in DBBS; Bio 5571 preferred.
Credit 1 unit.

L41 Biol 5581 Neural Basis of Accoustic Communications
Lectures and seminars in hearing and accoustic signals of animals, from invertebrates to humans. Structural and functional adaptation for processing the signals for communication and echolocation are considered. Prerequisite: Bio 3411 or Bio 3421, or a course comparable to Physiological Psychology. One two-hour class a week. Offered in the fall semester of odd numbered years.
Credit 2 units.

L41 Biol 5606 Cognitive Neuroscience of Human Memory
A survey of issues related to the cognitive neuroscience of human memory will be discussed including working and long-term memory. Reading will consist of classic works by James, Fuster, Goldman-Rakic, Milner, Squire as well as many contemporary articles that highlight hot issues and new techniques. Requirements will include readings, attendance, brief presentations, and active participation in classroom discussion. Prerequisite: Graduate standing. Same as L41 Biol 5606. Same as L33 Psych 5090
Credit 3 units.

L41 Biol 560A Special Topics in Nuclear Chemistry: Radiochemistry for the Life Sciences
This course will provide an introduction to nuclear science (e.g. radioactive decay, nuclear stability, interactions of radiation with matter) and followed by an overview of how radiochemistry is used in the life sciences. Lectures on radiolabeling chemistry with radionuclides used in medical imaging (single photon emission computed tomography (SPECT) and positron emission tomography

(PET) and their applications will be presented. In addition, lectures on radiochemistry with tritium (H-3) and C-14 will also be included. Additional applications include environmental radiochemistry as applied to nuclear waste disposal and biofuels.
Same as L07 Chem 536
Credit 2 units.

L41 Biol 5617 Development Biology PhD Program Seminar
In response to student feedback for additional training in Developmental Biology obtained from surveys and group meetings, we propose a new seminar course in Developmental Biology. This once a week course will introduce student in the Developmental, Regenerative, and Stem Cell Biology PhD Program both to the classical embryological experiments that deined key concepts in developmental biology, such as cellular fields, equivalence groups, cytoplasmic determinants, and the more modern experiments that uncovered the genetic and molecular basis of these processes. In general, the classes will be individual sessions on professional development, such as scientific presentation, how to navigate graduate school, etc.
Credit 1 unit.

L41 Biol 5619 Advanced Cognitive, Computational, and Systems Neuroscience
This course will develop critical thinking and analysis skills with regard to topics in Cognitive, Computational and Systems Neuroscience. Course format will be a series of modules composed of intensive, faculty-led case studies on interdisciplinary topics at the intersection of psychology, computation and neuroscience. The goal will be to highlight the benefits of integrative, interdisciplinary approaches, by delving into a small set of topics from a variety of perspectives, rather than providing a survey-level introduction to a broader set of topic areas. Modules will involve a combination of lectures and student-led discussion groups, with students further expected to complete a multi-disciplinary integrative final review paper. Case-study topics will vary somewhat from year to year, but are likely to include some of the following: temporal coding as a mechanism for information processing, coordinate transformations in sensory-motor integration, mechanisms of cognitive control, motor control strategies including application to neural prosthetics, and memory systems in health and disease.
Same as L33 Psych 519
Credit 3 units.

L41 Biol 5621 Computational Statistical Genetics
This course covers the theory and application of both classical and advanced algorithms for statistical modeling in genetics. Students learn how to derive, design and implement their own statistical genetics models through computer labs by writing their own software program from the basic model equations up to analyze one of four major term project datasets. Didactic lectures cover a wide range of important topics including: Maximum Likelihood theory, Frequentist vs. Bayesian approaches, Information Theory, Model Selection techniques, analysis methods for pedigrees vs. unrelated individuals, rare vs. common variant approaches, the E-M Algorithm, mixed model approaches, MCMC methods, Hidden Markov Models, Coalescent Theory, Haplotyping Algorithms, Epigenetic Analysis methods, Genetic Imputation Algorithms, Graphical Models, Decision Trees and Random Forests, Permutation/Randomization Tests, classification and Data Mining Algorithms, Population Stratification and Admixture Mapping Methods, Multiple comparisons corrections, and Power and Monte-Carlo simulation experiments. Same as M21-621
Credit 3 units.

L41 Biol 5622 Cognitive, Computational, and Systems Neuroscience Project Building
The goal of this course is to help students in the CCSN Pathway develop the critical thinking skills necessary to develop and implement high quality, interdisciplinary research projects. Throughout the course of the semester, each student will develop a research plan in their chosen area of interest. The plan will be developed in consultation with at least two faculty members (from at least two different subdisciplines within the pathway) as well as the other students and faculty participating in the course. The culmination of this course will be for each student to produce an NIH-style grant proposal on the research project of their choosing. For most students, this will serve either as their thesis proposal or a solid precursor to the thesis proposal. The course will be designed to help facilitate the development of such a research plan through didactic work, class presentations, class discussion, and constructive feedback on written work. The course will begin with a review of written examples of outstanding research proposals, primarily in the form of grant submissions similar to those that the students are expected to develop (i.e., NRSA style proposals, R03 proposals). Review of these proposals will serve as a stimulus to promote discussion about the critical elements of good research proposals and designs in different areas. Each student will be expected to give three presentations throughout the semester that will provide opportunities to receive constructive feedback on the development and implementation of research aims. The first presentation (towards the beginning of the semester) will involve presentation of the student's general topic of interest and preliminary formulation of research questions. Feedback will emphasize ways to focus and develop the research hypotheses into well-formulated questions and experiments. The second presentation will involve a more detailed presentation of specific research questions (along the lines of NIH-style Specific Aims) and an initial outline of research methods. The final presentation will involve a fuller presentation of research questions and proposed methods. Feedback, didactic work, and group discussion throughout the semester will include guidance on critical components of the development of a research plan, including how to perform literature searches, formulate testable hypotheses, write critical literature summaries, and design experiments and analyses. The course will meet once a week, with faculty members from different tracks within the Pathway present at each meeting. This will allow students to receive feedback from several perspectives. Prerequisite: Member of CCSN Pathway, permission of instructor.
Credit 3 units.

L41 Biol 5646 First-Year Fundamentals
This course will provide a two-part introduction to neuroscience research fundamentals. Namely, it will introduce elementary statistical analysis for neuroscience research as well as grant writing to support neuroscience-related research. Enrollment is limited to first-year neuroscience students.
Credit 0.5 units.

L41 Biol 5648 Coding and Statistical Thinking in the Neurosciences
Students are introduced to scientific programming in Python. Students will learn common programming constructs and how to visualize and analyze data. Coding will be integrated into a statistics curriculum introducing summary statistics, probability distributions, simulation and hypothesis testing, and power analysis for experimental design.
Credit 3 units.

L41 Biol 5651 Neural Systems
The course will consist of lectures and discussions of the sensory, motor and integrative systems of the brain and spinal cord, together with a weekly lab. The lectures will present aspects of most neural systems, and will be given by faculty members who have specific

expertise on each topic. The discussions will include faculty led group discussions and papers presented and discussed by students. The labs will include human brain dissections, examination of histological slides, physiological recordings, behavioral methods, computational modeling, and functional neural imaging.
Credit 4 units.

L41 Biol 5657 Biological Neural Computation
This course will consider the computations performed by the biological nervous system with a particular focus on neural circuits and population-level encoding/decoding. Topics include, Hodgkin-Huxley equations, phase-plane analysis, reduction of Hodgkin-Huxley equations, models of neural circuits, plasticity and learning, and pattern recognition & machine learning algorithms for analyzing neural data. Note: Graduate students in psychology or neuroscience who are in the Cognitive, Computational, and Systems Neuroscience curriculum pathway may register in L41 5657 for three credits. For non-BME majors, conceptual understanding, and selection/application of right neural data analysis technique will be stressed. Hence homework assignments/examinations for the two sections will be different, however all students are required to participate in a semester long independent project as part of the course. Calculus, Differential Equations, Basic Probability and Linear Algebra Undergraduates need permission of the instructor. L41 5657 prerequisites: Permission from the instructor
Same as E62 BME 572
Credit 3 units. EN: TU

L41 Biol 5663 Neurobiology of Disease
This is an advanced graduate course on the pathology of nervous system disorders. This course is primarily intended to acquaint Neuroscience graduate students with a spectrum of neurological diseases, and to consider how advanced neuroscientific approaches may be applied to promoting recovery in the brain. Topics will be presented by Washington University faculty members and include: neurooncology, stroke, retinal disease, perinatal brain injury, neurodegenerative disorders, neuroinflammation, epilepsy, and psychiatric disorders. The class will meet for 2 hours each week. Each session will be led by a faculty guest with expertise in a specific neurological or psychiatric disease. In the first hour, the speaker will discuss clinical manifestations and pathophysiology. Where possible, the clinical presentation will be supplemented with a patient demonstration or videotape. After a 30 minute break for pizza and soda, the second hour will follow a journal club format. Two or three students will review current papers assigned by the speaker or course director. This course is offered in alternate years. Prerequisite: Introductory neuroscience course at the graduate or medical school level.
Credit 2 units.

L41 Biol 5665 The Science of Behavior
The primary function of nervous systems is to control behavior. Understanding the links between brain and behavior requires an understanding of cognition-the computations performed by the brain, as well as the algorithms underlying those computations and the physical substrates that implement those algorithms. The goal of this course is to introduce students to the tools, concepts, and techniques for the experimental study of cognition and behavior in humans and nonhuman animals. We will focus on cognitive capacities that are well-developed in humans and can be compared with those of other species, to develop an understanding of how evolution shapes cognition and behavior. Students who complete this course will be able to ask questions and form hypotheses about the computations and algorithms underlying cognition and behavior, and to design experiments that test these hypotheses. PREREQ: Graduate standing or permission of the instructor
Same as L33 Psych 5665
Credit 3 units.

L41 Biol 5678 Clocksclub
Clocksclub focuses on recent advances in the study of biological timing including sleep and circadian rhythms. Participants discuss new publications and data on the molecules, cells and circuits underlying daily rhythms and their synchronization to the local environment. Students registered for this journal club will lead a discussion once during the semester. Prerequisites: BIO 2970 or permission of instructor.
Credit 1 unit.

L41 Biol 5682 Foundations in Biological Neural Computation
This course meets with E62 BME 572/L41 Biol 5657, Biological Neural Computation. Students in this Foundations course will not design and implement an independent modeling project. Instead they will complete directed simulation of classic models in computational and theoretical neuroscience. Graduate students in psychology or neuroscience who are in the Cognitive, Computational, and Systems Neuroscience pathway can take either this 2-credit Foundations course or the 3-credit full course to satisfy pathway requirements for a computational course. Prerequisites, Multivariate calculus and either biological or psychological foundations of neuroscience.
Credit 2 units.

L41 Biol 5691 Mathematics and Statistics of Experimental Neuroscience
This course will be open to the WU brain science community; first and second year graduate students are especially welcome. We aim to develop practical insights and strategies for experiment design, data reduction, and statistical tests. Topics will include foundations of statistical analysis; resampling and bootstrapping; multivariate analysis and dimension reduction; and applications appropriate for cellular and molecular, systems, imaging, and behavioral neuroscience. Prerequisites: Some calculus; some laboratory experience in neuroscience.
Credit 2 units.

L41 Biol 5702 Current Approaches in Plant and Microbial Research
This course is designed to introduce graduate students and upper-division undergraduates to contemporary approaches and paradigms in plant and microbial biology. The course includes lectures, in-class discussions of primary literature and hands-on exploration of computational genomic and phylogenetic tools. Evaluations include short papers, quizzes, and oral presentations. Over the semester, each student works on conceptualizing and writing a short NIH-format research proposal. Particular emphasis is given to the articulation of specific aims and the design of experiments to test these aims, using the approaches taught in class. Students provide feedback to their classmates on their oral presentations and on their specific aims in a review panel. Prereq: Bio 2970 or permission of the instructor.
Credit 4 units.

L41 Biol 5703 Experimental Design and Analysis in Biological Research
In-depth exploration of landmark and current papers in genetics, molecular and cell biology, with an emphasis on prokaryotes and eukaryotic microbes. Class discussions will center on such key discoveries as the chemical nature of genetic material, the genetic code, oxygen producing light-spectrum, cell-cell signaling, transcriptional regulation, the random nature of mutation, and cell cycle regulation. Emphasis will be placed on what makes a good question or hypothesis, expedient ways to address scientific problems, and creative thinking. The last third of the course will consist of student-run seminars on selected topics to increase proficiency in the synthesis of new material and public presentation skills.

Credit 2 units.

L41 Biol 5715 Basic Cancer Biology
More than two thirds of all people know someone who has cancer. This course provides students with a more extensive understanding of what cancer is and how it affects the human body. We will discuss the history of cancer research, the many different types of human cancers, and basic chemotherapeutics. The topics will be presented in a basic scientific nature, with an emphasis on gaining a broad understanding of the subjects. Prerequisite: Biol 2960 or equivalent. Not available to students who have credit for Biol 144 or Biol 1440.
Same as L41 Biol 4715
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 572 Seminar in Plant Biology
A weekly discussion of modern research in plant biology including topics in molecular genetics, development, biochemistry, physiology, population dynamics and plant-pathogen interactions. Credit will be contingent on one journal club presentation per student, regular attendance and active participation in group discussions.
Credit 1 unit.

L41 Biol 5721 Student-Run Plant Biology Journal Club
Students of the Plant Biology Program are responsible for organizing this journal club which highlights new papers that significantly advance our understanding of plants. Students arranging to give presentations should consult with one of the faculty organizers at least one week in advance of their talk to gain approval of their topic and the paper chosen. Students taking the journal club for credit are expected to attend regularly and to make one presentation per semester. Course meets on alternate Fridays. No prerequisites, open to all graduate students and to undergraduates who obtain permission from one of the faculty advisors.
Credit 1 unit.

L41 Biol 5723 Seminar in Plant and Microbial Bioscience
This course emphasizing presentation skill and critical analysis counts towards the PMB Graduate Program's journal club course requirement. Students will be responsible for dividing and presenting 30 current research publications selected by the course masters. In addition to assembling brief PowerPoint presentations providing background and significance for their assigned articles, students are expected to provide classmates with a 1 page primer and short list of relevant references
Credit 2 units.

L41 Biol 580 Seminar in Population Biology
This weekly seminar, covering different topics each semester, should be taken by graduate students in the program. Prerequisite: graduate standing or permission of the instructors.
Credit variable, maximum 3 units.

L41 Biol 5801 Biochemistry & Molecular Biophysics Seminar Journal Club
This will be a journal club-based seminar course mirroring the topics covered by Biochemistry and Molecular Biophysics (BMB) seminar speakers during the concurrent semester. Students will present a paper published by one of the BMB seminar speakers one-week ahead of that speaker's seminar. This will allow students and faculty to become more familiar with the research programs of BMB invited speakers, likely stimulating discussion within the Q&A period after the seminar, as well as during informal meet-the-speaker lunch sessions. Students will be evaluated on their journal club presentation, attendance and class participation.
Credit 1 unit.

L41 Biol 584 Climate Change Reading Group
The Climate Change Reading Group is made up of multi-disciplinary faculty and students from multiple institutions in St Louis: WUSTL, UMSL, SLU, Missouri Botanical Garden, Danforth Center, and more. Many of us in different labs, departments, and institutions around STL are actively investigating aspects and effects of climate change; this reading group provides a venue for interacting with others in the community. Subject matter within the context of Climate Change will be chosen each week by a different presenter. Students can join this reading group for 1 credit if they agree to read all papers, actively participate in discussions, find and present one high quality scientific paper on climate change in the field of their choice and moderate the discussion of this paper. The students will be evaluated on their participation, their understanding of the issues, and their presentation. Prerequisites: Contact the course coordinator.
Credit 1 unit.

L41 Biol 585 Seminar in Floristic Taxonomy
This weekly seminar provides an introduction to/overview of Plants, each semester progressively covering orders and families in a sequence derived from the Angiosperm Phylogeny Website (http://www.mobot.org/MOBOT/Research/APweb/welcome.html); in Spring 2015, the seminar will cover several crown orders of the monocots, including grasses and relatives. Weekly presentations include a summary of all relevant information (molecular, chemical, anatomical, embryological, morphological, ecological, geographical, historical/paleontological, etc.) about the plant group under consideration, review of the classification/phylogeny of the group, examination of fresh and/or preserved specimens, and discussion of relationships, human uses, and other relevant aspects of the biology of that group. Credit will be contingent on one (or two) seminar presentation(s) per student, regular attendance and active participation in group discussions.
Credit 1 unit.

L41 Biol 5862 Seminar on Professional Development for Graduate Students in Ecology, Evolution & Population Biology
This is a weekly discussion seminar course in which advanced graduate students and postdocs in STEM will discuss the practices of scientific teaching and basic professional development skills. Topics covered will include scientific teaching, active learning, assessment driven instruction, creation inclusive classrooms, preparing for job interviews, preparing grant proposals, and balancing family and work. There will be several panel discussions with invited speakers on a range of potential career options to STEM PhDs. Students will prepare or revise their professional portfolio materials over the course of the semester. The course is open to all DBBS graduate students and is required for GAANN fellows. Prerequisite: Graduate student status in the DBBS or permission of instructor.
Credit 1 unit.

L41 Biol 5866 Communicating Science: Writing for Multiple Audiences
This course introduces strategies for writing effectively and communicating scientific research to a variety of audiences. Students will learn to reduce jargon, explain scientific concepts in common language, write clearly and concisely, and use sentence structure to maximum efficiency. Written assignments emphasize the significance and innovation in scientific research that appeal to broad audiences, including: the general public, students, policy makers, grant reviewers, and journal editors. This course meets biweekly and consists of lectures and small group sessions. You must enroll in both the lecture session (section 1) and a small group (section A, B, C, or D).
Credit 1 unit.

L41 Biol 5867 Career Planning for Biological Scientists
This 6-week course will guide you through nationally recognized and evidence-based career exploration curricula. It is intended for DBBS Ph.D. students and bioscience postdocs who want to jump-start career planning and professional skills needed for a broad range of scientific careers. Topics include self-assessment, career exploration, and goal-setting for long-term success. You will work on a team to research the scientific career path of your choice. Each team will study the specific required knowledge, skills, and attributes of their career interest or employment sector. As part of this research project, you will complete a simulated job exercise and network with alumni or local leaders in your chosen field, gaining valuable real-world insights and creating essential professional connections. Meets October 22, 2018-December 3, 2018.
Credit 1 unit.

L41 Biol 590 Research
Credit to be arranged.
Credit variable, maximum 12 units.

L41 Biol 5901 Biomolecular Condensates Journal Club
Biomolecular condensates are non-stoichiometric assemblies of protein and nucleic acids that provide a means for cellular spatiotemporal organization. Over the last decade, a growing appreciation has emerged than many such condensates (which include nucleoli, stress granules, paraspeckles, or even transcriptional assemblies) may form in part via liquid-liquid phase separation, although this does not preclude other assembly mechanisms. A challenge for those new to this field reflects the need to apply ideas from condensed matter physics, biochemistry, physical chemistry, and cell biology. In this journal club we will focus on developing an understanding of the core concepts surrounding biomolecular condensates and phase transitions in biology by reading a mixture of cutting edge and more 'classic' (i.e. mid 2010s) literature.
Credit 1 unit.

L41 Biol 5902 Introduction to the Scholarship of Teaching and Learning
In this course, advanced graduate students and postdocs in STEM will 1) learn the fundamentals of the Scholarship of Teaching and Learning (SoTL)-which is the practice of developing, reflecting on, and evaluating teaching methods to improve student learning, 2) Develop a working knowledge of SoTL, which draws on research in education, STEM education, and cognitive science, 3) Understand how SoTL can lead to the dissemination of new knowledge to a broad audience of educators through publication and presentations., and 4) Develop the central elements of a SoTL project. These elements include articulating questions about classroom teaching that can be addressed in a SoTL research project; developing working hypotheses in response to the questions; designing an evaluative plan, including specific research methods, the type of data to be collected, and how the data will be analyzed in relation to the hypotheses; identifying and understanding necessary procedures to obtain IRB approval for the research. Prereqs: Must be an advanced graduate student or a postdoctoral appointee with some teaching experience, and must have completed 4 STEM Pedagogies workshops (2 are foundational topics) offered by The Teaching Center or received approval from one of the instructors. Same as U29 Bio 4902.
Credit 1 unit.

L41 Biol 590B Research
Credit to be arranged.
Credit variable, maximum 12 units.

L41 Biol 590C Research
Credit to be arranged.
Credit variable, maximum 12 units.

L41 Biol 590D Research
Credit to be arranged.
Credit variable, maximum 12 units.

L41 Biol 5911 Seminar in Biology & Biomedical Sciences
These seminars cover the recent literature in various areas not included in other courses, or in more depth than other courses. Prerequisite: permission of instructor. Credit to be arranged.
Credit variable, maximum 12 units.

L41 Biol 5920 Foundations in Cancer Biology
This basic cancer biology class is designed to provide a didactic foundation into cancer biology principles. These will include tumor suppressors & oncogenes, DNA damage pathways, protein modifications, tumor progression, metastasis, tumor microenvironment and numerous other topics relevant to cancer biology.
Credit 3 units.

L41 Biol 5922 Entering Mentoring
This course is a series of facilitated discussions aimed at developing and improving mentoring skills for those involved in supervising undergraduate research experiences. It is designed for postdocs and graduate students who are or will be ´bench mentors´ for undergraduates doing Bio 500 and/or Summer Research. Participants will receive "Entering Mentoring" materials, including articles and worksheets to facilitate mentoring interactions with their mentee, plus several resource books relevant to mentoring. They will develop a mentoring philosophy statement, work on specific assignments designed to improve their relationship with their mentee and share their present and past experiences as mentors and mentees. Bench mentors will be eligible for a travel award to help defray expenses for attending a meeting with their mentee, if that student wins one of the HHMI SURF travel awards (4-5 awarded annually) or is otherwise being supported to present at a scientific meeting. Prerequisite: open to graduate students and postdocs, with priority for those who plan to mentor undergraduates in summer research experiences. Graduate students and postdocs do NOT need to be mentoring a student at the time of the course; it is open to all with an interest in mentoring now or in the future. Note: The sessions will be held either at the beginning of the day or the end of the day at the Danforth campus. Once registration closes, an email will be sent to those registered to poll for the best days & times.
Credit 1 unit.

L41 Biol 5929 Experimental Cancer Biology
This basic cancer biology class is meant to coincide with the Foundation course. Topics will be discussed in parallel with Foundation course topics but from the perspective of the laboratory experimentalist. Experimental details will provide the basis for understanding how to ask and answer important questions in the cancer biology laboratory.
Credit 3 units.

L41 Biol 5930 Advanced Topics in Neuroscience
This course will expose upper level students and postdocs to advanced topics and methods in Neuroscience. The course will rapidly fill gaps in student knowledge in areas that may be relevant to new directions in thesis work or interest areas. Each section of the course will be offered asynchronously, sometimes in coordination with existing journal clubs and other seminars. Each section will meet for 2-hours per week for 3-

weeks. Sections may start with a didactic component or review paper, but will quickly delve into discussion of primary papers curated by faculty and covering a focused topic. It is expected that papers will cover historical and current contexts. Some sections will be techniques-focused; others conceptually focused. Each section will be led by a faculty member drawn from the Neuroscience program in an area of their expertise. Objectives include deepening critical thinking, statistical knowledge, experiemental design, and technical prowess.
Credit 0.5 units.

L41 Biol 5940 Foundations in Cancer Biology and Experimental Cancer Biology
This advanced course will teach the clinical perspective of cancer biology using topics from oncology, radiation biology, radiology, pathology, immunology and surgery. Students will learn to write a grant proposal that includes a clinical trial element while also shadowing physicians in a real cancer clinical setting.
Credit 3 units.

L41 Biol 598 Topics in Evolution, Ecology and Population Biology
This course will meet weekly to discuss ongoing research and future directions of the Evolution, Ecology, and Population Biology (EEPB) graduate program. A different EEPB faculty member will present each week. This course introduces new EEPB students to the diversity of research questions and approaches undertaken by laboratories in the EEPB program; it will also introduce new students to faculty and vice versa. The course will educate the students about the breadth of research in evolution, ecology, and behavior. It will also provide knowledge that students can use when choosing lab rotations and interdisciplinary exposure to enhance creativity in research.
Credit 1 unit.

L41 Biol 5989 Advanced Topics in Neuroscience
This course will expose upper-level and postdoctoral students to advanced topics and methods in neuroscience. The course will rapidly fill gaps in student knowledge in areas that may be relevant to new directions in thesis work or interest areas. Each section of the course will be offered asynchronously, sometimes in coordination with existing journal clubs and other seminars. Each section will meet for two hours per week for three weeks. Sections may start with a didactic component or a review paper, but they will quickly delve into the discussion of primary papers curated by faculty and covering a focused topic. It is expected that papers will cover both historical and current contexts. Some sections will focus on technique; others will be conceptually focused. Each section will be led by a faculty member drawn from the Neuroscience program in an area of their expertise. Objectives include deepening critical thinking, statistical knowledge, experimental design, and technical prowess.
Credit 0.5 units.

L41 Biol 5991 Decision Neuroscience
This is an advanced, reading-intensive graduate course. We will meet once a week for 3 hrs and focus primarily on discussing the literature on decision making from various perspecitves. Decision making is a cantral object of study in multiple diciplines including neuroscience, cognitive psychology, and economics. Within systems neuroscience, research in the past 20 years has developed in two main areas - namely perceptual decisions and economic (value-based) decisions. Each week we will discuss a specific topic and/or research question. Discussion topics will originate from perceptual decisions or economic decisions, and often be relevant to both. Readings will include experimental papers and computational/theoretical papers. Every week, students are expected to read the assigned papers and to write a short comment before class. In class, we will discuss the papers and the weekly topic in a journal-club format. Participation of PhD students from different programs is encouraged, pending permission from the instructor. The goal of the class is to bring graduate students from different disciplines up-to-date on the current debate(s) in decision neuroscience, and to inspire and support their future research.
Credit 3 units.

L41 Biol 5999 Independent Work
This course is designed for individual students wishing to explore indepth specialized areas of literature or technology with one or more faculty members. Credit will vary with the amount of work and discussion, but cannot be more than 3 credits.
Credit variable, maximum 3 units.