

## Biological Sciences

The biological sciences include the study of living systems at levels ranging from the structure and function of molecules to the behavior and evolution of communities of organisms. The department offers four different routes to mastering skills and knowledge in this broad area. The B.A. and B.S. programs in biology provide a broad introduction to biology with opportunities for students to create a program of study suited to their specific interests. Programs of study focused on particular aspects of biology are the B.A. and B.S. degree in the areas of behavioral neuroscience and molecular biology. For programs in biochemistry and bioengineering, see those separate sections in the catalog.

The Department of Biological Sciences strongly supports the positions of both the American Association for the Advancement of Science and the National Academy of Sciences that intelligent design is not scientific and should not be presented as science in science classes.

The requirements for the B.A. and B.S. in biology, behavioral neuroscience, and molecular biology are listed below. Research interests of the faculty and instrumentation are described in the section on graduate education.

**Professors.** Michael J. Behe, PHD (University of Pennsylvania); R. Michael Burger, PHD (University Texas, Austin); Lynne U. Cassimeris, PHD (University of North Carolina); David L. Cundall, PHD (University of Arkansas); Matthias M. Falk, PHD (Ruprecht Karl University of Heidelberg); Wonpil Im, PHD (Cornell University); Mary Kathryn Iovine, PHD (Washington University); Murray Itzkowitz, PHD (University of Maryland); Linda J. Lowe-Krentz, PHD (Northwestern University); Jill E. Schneider, PHD (Wesleyan University); Neal G. Simon, PHD (Rutgers University); Robert V. Skibbens, PHD (University of North Carolina Chapel Hill); Jennifer Swann, PHD (Northwestern University); Vassie C. Ware, PHD (Yale University)

**Associate Professors.** Julie Haas, PHD (Boston University); Michael R. Kuchka, PHD (Carnegie Mellon University)

**Assistant Professors.** Daniel Babcock, PHD (University Texas Houston); Gregory I. Lang, PHD (Harvard University); Michael J. Layden, PHD (University of Oregon); Julie M. Miwa, PHD (Rockefeller University); Amber M. Rice, PHD (University of North Carolina); David C. Zappulla, PHD (Stony Brook University)

**Professors Of Practice.** Ann E. Fink, PHD (University of Southern California); Santiago Herrera, PHD (Massachusetts Institute of Technology); Katie M. Hoffman, PHD (University of Montana)

**Emeriti.** Steven Krawiec, PHD (Yale University); John G. Nyby, PHD (University Texas, Austin); Hayden N. Pritchard, PHD (Lehigh University); Jeffrey A. Sands, PHD (The Pennsylvania State University)

### B.A. WITH MAJOR IN BIOLOGY

#### College and university requirements for all majors

ENGL 001	Critical Reading and Composition	3
ENGL 002	Research and Argument	3
First Year Seminar		3
Social Sciences		8
Humanities		8

#### Biology

BIOS 041 & BIOS 042	Biology Core I: Cellular and Molecular and Biology Core I: Cellular and Molecular Lab	4
BIOS 115 & BIOS 116	Biology Core II: Genetics and Biology Core II: Genetics Laboratory	4
BIOS 121 & BIOS 122	Biology Core III: Integrative & Comparative Biology and Biology Core III: Integrative and Comparative Lab	4

Biology electives <sup>1</sup> 18

#### Mathematics

Select one of the following: 4

MATH 051	Survey of Calculus I	
MATH 021	Calculus I	
Select one of the following:		3-4
MATH 052	Survey of Calculus II	
MATH 012	Basic Statistics	
BIOS 130	Biostatistics	

#### Collateral Sciences

Select one of the following:		4
CHM 030 & CHM 031	Introduction to Chemical Principles and Chemical Equilibria in Aqueous Systems	
CHM 040 & CHM 041	Honors General Chemistry I and Honors General Chemistry II	
CHM 110 & CHM 111	Organic Chemistry I and Organic Chemistry Laboratory I	4
CHM 112 & CHM 113	Organic Chemistry II and Organic Chemistry Laboratory II	4

Total Credits 74-75

<sup>1</sup> Biology electives must include one course from list A (see below) and one course from list B (see below). These will be chosen in consultation with the major advisor. No more than 3 credits from the following courses: BIOS 161, BIOS 261, BIOS 262, BIOS 391, BIOS 393, College scholar project, not BIOS 130.

#### Biology Electives List A

Choose one of the following:

BIOS 234	Comparative Vertebrate Anatomy	4
BIOS 235	Human Physiology	4
BIOS 241	Vertebrate Natural History	4
BIOS 276	Central Nervous System and Behavior	3
BIOS 313	Vertebrate Histology	4
BIOS 314	Vertebrate Development	4
BIOS 315	Neuropharmacology	3
BIOS 317	Evolution	3
BIOS 323	Evolution of Development	3
BIOS 326	Coevolution	3
BIOS 329	Herpetology	3
BIOS 334	Species and Speciation	3
BIOS 335	Animal Behavior	3
BIOS 337	Behavioral Ecology	3
BIOS 365	Neurobiology of Sensory Systems	3
BIOS 366	Diseases of the Nervous System	3
BIOS 369	Comparative Physiology of Vertebrate Systems	3-4
BIOS 374	Sex Determination and Differentiation	3
BIOS 382	Endocrinology of Behavior	3
BIOS 385	Synapses, Plasticity and Learning	3
BIOS 386	Genes and the Brain	3

#### Biology Electives List B

Choose one of the following:

BIOS 323	Evolution of Development	3
BIOS 324	Microbiology	3
BIOS 327	Development and Disease	3
BIOS 328	Immunology	3
BIOS 340	Molecular Basis of Disease	3
BIOS 342	Cellular Basis of Human Disease	3
BIOS 345	Molecular Genetics	3
BIOS 347	Advanced Topics in Genetics	3
BIOS 367	Cell Biology	3
BIOS 371	Elements of Biochemistry I	3

BIOS 372	Elements of Biochemistry II	3
BIOS 376	Developmental Biology	3
BIOS 381	Physical Biochemistry	3
BIOS 384	Eukaryotic Signal Transduction	3

**THE B.S. IN BIOLOGY**

The Bachelor of Science in biology offers broad scientific preparation in biology to facilitate advanced work in the life sciences. Progression through the program is best served through early commitment.

**Requirements for the B.S. in Biology****College and university requirements for all majors**

ENGL 001	Critical Reading and Composition	3
ENGL 002	Research and Argument	3
First Year Seminar		3
Social Sciences		8
Humanities		8

**Biology**

BIOS 041 & BIOS 042	Biology Core I: Cellular and Molecular and Biology Core I: Cellular and Molecular Lab	4
BIOS 115 & BIOS 116	Biology Core II: Genetics and Biology Core II: Genetics Laboratory	4
BIOS 121 & BIOS 122	Biology Core III: Integrative & Comparative Biology and Biology Core III: Integrative and Comparative Lab	4
BIOS 317	Evolution	3
Biology electives <sup>1</sup>		22

**Mathematics**

Select one of the following:		7-8
MATH 021 & MATH 022	Calculus I and Calculus II	
MATH 051 & MATH 052	Survey of Calculus I and Survey of Calculus II	
BIOS 130	Biostatistics	4

**Collateral Sciences**

Select one of the following:		8
CHM 030 & CHM 031	Introduction to Chemical Principles and Chemical Equilibria in Aqueous Systems	
CHM 040 & CHM 041	Honors General Chemistry I and Honors General Chemistry II	
CHM 110 & CHM 111	Organic Chemistry I and Organic Chemistry Laboratory I	4
CHM 112 & CHM 113	Organic Chemistry II and Organic Chemistry Laboratory II	4
PHY 010 or PHY 011	General Physics I or Introductory Physics I	4
PHY 012	Introductory Physics Laboratory I	1
PHY 013 or PHY 021	General Physics II or Introductory Physics II	3
PHY 022	Introductory Physics Laboratory II	1

Total Credits 98-99

<sup>1</sup> Biology electives must include two courses from list A (see below), two courses from list B (see below) and at least four credits of laboratory experience (e.g., two 2 credit laboratory courses). These will be chosen in consultation with the major advisor.

**Biology Electives List A**

Choose two of the following:

BIOS 234	Comparative Vertebrate Anatomy	4
BIOS 235	Human Physiology	4
BIOS 241	Vertebrate Natural History	4

BIOS 276	Central Nervous System and Behavior	3
BIOS 313	Vertebrate Histology	4
BIOS 314	Vertebrate Development	4
BIOS 315	Neuropharmacology	3
BIOS 323	Evolution of Development	3
BIOS 326	Coevolution	3
BIOS 329	Herpetology	3
BIOS 334	Species and Speciation	3
BIOS 335	Animal Behavior	3
BIOS 337	Behavioral Ecology	3
BIOS 365	Neurobiology of Sensory Systems	3
BIOS 366	Diseases of the Nervous System	3
BIOS 369	Comparative Physiology of Vertebrate Systems	3-4
BIOS 374	Sex Determination and Differentiation	3
BIOS 382	Endocrinology of Behavior	3
BIOS 385	Synapses, Plasticity and Learning	3
BIOS 386	Genes and the Brain	3

**Biology Electives List B**

Choose two of the following:

BIOS 323	Evolution of Development	3
BIOS 324	Microbiology	3
BIOS 327	Development and Disease	3
BIOS 328	Immunology	3
BIOS 340	Molecular Basis of Disease	3
BIOS 342	Cellular Basis of Human Disease	3
BIOS 345	Molecular Genetics	3
BIOS 347	Advanced Topics in Genetics	3
BIOS 367	Cell Biology	3
BIOS 371	Elements of Biochemistry I	3
BIOS 372	Elements of Biochemistry II	3
BIOS 376	Developmental Biology	3
BIOS 381	Physical Biochemistry	3
BIOS 384	Eukaryotic Signal Transduction	3

**RECOMMENDED B.S. BIOLOGY SEQUENCE**

First Year	CR
BIOS 041 & BIOS 042	4
MATH 051	4
MATH 052	3
CHM 030	4
CHM 031	4
	19
Second Year	CR
BIOS 115 & BIOS 116	4
AND/OR	
BIOS 121 & BIOS 122	4
CHM 110 & CHM 111	4
CHM 112 & CHM 113	4
BIOS 130	4
	20
Third Year	CR
BIOS 115 & BIOS 116 AND/OR BIOS 121 & BIOS 122	

PHY 010 & PHY 012	5
PHY 013 & PHY 022	4
Approved biology electives including two from list A and two from list B	9-12
	18-21
<b>Fourth Year</b>	CR
BIOS 317	3
Biology electives including at least 4 credits of laboratory	10-14
	13-17

Total Credits: 70-77

#### MINOR IN BIOLOGY

A minor in biology may be achieved by completing the following requirements (17-18 credits):

BIOS 041 & BIOS 042	Biology Core I: Cellular and Molecular and Biology Core I: Cellular and Molecular Lab	4
BIOS 115 & BIOS 116	Biology Core II: Genetics and Biology Core II: Genetics Laboratory	4
BIOS 121	Biology Core III: Integrative & Comparative Biology	3
CHM 110	Organic Chemistry I	3
Biology electives at the 200 or 300 level		3-4
Total Credits		17-18

#### B.A. WITH MAJOR IN BEHAVIORAL NEUROSCIENCE

The B.A. in Behavioral Neuroscience is a natural science major for B.A. distribution purposes.

##### Required Major Courses

BIOS 041 & BIOS 042	Biology Core I: Cellular and Molecular and Biology Core I: Cellular and Molecular Lab	4
BIOS 115 & BIOS 116	Biology Core II: Genetics and Biology Core II: Genetics Laboratory	4
BIOS 121 & BIOS 122	Biology Core III: Integrative & Comparative Biology and Biology Core III: Integrative and Comparative Lab	4
BIOS 130	Biostatistics	4
BIOS 276	Central Nervous System and Behavior	3
Select one of the following:		2
BIOS 277	Experimental Neuroscience Laboratory	
BIOS 278	Neurophysiology Laboratory	
BIOS 279	Experimental Molecular Neuroscience Laboratory	
BIOS 382	Endocrinology of Behavior	3
Select one of the following:		3
BIOS 315	Neuropharmacology	
BIOS 323	Evolution of Development	
BIOS 365	Neurobiology of Sensory Systems	
BIOS 366	Diseases of the Nervous System	
BIOS 384	Eukaryotic Signal Transduction	
BIOS 385	Synapses, Plasticity and Learning	
BIOS 386	Genes and the Brain	
BIOS 395	Miscellaneous	

#### Major Electives

Select two of the following: 6  
Any 300-level BIOS course not fulfilling another BNS requirement above <sup>1</sup>

PSYC 117	Cognitive Psychology	
PSYC 153	Personality	
PSYC 176	Cognitive Neuroscience	

#### Math and Science Requirements for the B.A.

Select one of the following: 7-8

MATH 021 & MATH 022	Calculus I and Calculus II	
MATH 051 & MATH 052	Survey of Calculus I and Survey of Calculus II	

Select one of the following: 4

CHM 030 & CHM 031	Introduction to Chemical Principles and Chemical Equilibria in Aqueous Systems	
CHM 040 & CHM 041	Honors General Chemistry I and Honors General Chemistry II	
CHM 110 & CHM 111	Organic Chemistry I and Organic Chemistry Laboratory I	4
CHM 112 & CHM 113	Organic Chemistry II and Organic Chemistry Laboratory II	4
PSYC 001	Introduction to Psychology	4

Total Credits 56-57

<sup>1</sup> Except BIOS 320, BIOS 347, BIOS 383, BIOS 387, BIOS 388, BIOS 391, or BIOS 393.

#### Other Options

The B.A. in Behavioral Neuroscience can be structured for a wide variety of possibilities (see listing of recommended elective courses). By using free electives to take additional science, the B.A. also can serve as a pre-professional degree for many graduate and professional schools. Students interested in a particular career based program should consult their advisor or the program director, Professor Michael Kuchka.

#### B.S. IN BEHAVIORAL NEUROSCIENCE

An early commitment to the B.S. is desirable to meet all the requirements of this program.

##### Required Major Courses

BIOS 041 & BIOS 042	Biology Core I: Cellular and Molecular and Biology Core I: Cellular and Molecular Lab	4
BIOS 115 & BIOS 116	Biology Core II: Genetics and Biology Core II: Genetics Laboratory	4
BIOS 121 & BIOS 122	Biology Core III: Integrative & Comparative Biology and Biology Core III: Integrative and Comparative Lab	4
BIOS 130	Biostatistics	4
BIOS 276	Central Nervous System and Behavior	3

Select one of the following:

BIOS 277	Experimental Neuroscience Laboratory	
BIOS 278	Neurophysiology Laboratory	
BIOS 279	Experimental Molecular Neuroscience Laboratory	

BIOS 382 Endocrinology of Behavior 3

#### Additional Biological Sciences Requirements for the B.S.

BIOS 371	Elements of Biochemistry I	3
BIOS 372	Elements of Biochemistry II	3

Select one of the following: 2-4

BIOS 234	Comparative Vertebrate Anatomy	
BIOS 368	Cell Biology Laboratory <sup>1</sup>	

BIOS 377	Biochemistry Laboratory	
BIOS 277 or BIOS 278 or BIOS 279 (must be different than course chosen for Required Major Courses)		
<b>Advanced BIOS Course Requirement</b>		
Select two of the following:		3-4
BIOS 315	Neuropharmacology	
BIOS 323	Evolution of Development	
BIOS 365	Neurobiology of Sensory Systems	
BIOS 366	Diseases of the Nervous System	
BIOS 384	Eukaryotic Signal Transduction	
BIOS 385	Synapses, Plasticity and Learning	
BIOS 386	Genes and the Brain	
<b>Math and Science Requirements for the B.S.</b>		
Select one of the following:		7-8
MATH 021 & MATH 022	Calculus I and Calculus II	
MATH 051 & MATH 052	Survey of Calculus I and Survey of Calculus II	
Select one of the following:		8
CHM 030 & CHM 031	Introduction to Chemical Principles and Chemical Equilibria in Aqueous Systems	
CHM 040 & CHM 041	Honors General Chemistry I and Honors General Chemistry II	
CHM 110 & CHM 111	Organic Chemistry I and Organic Chemistry Laboratory I	4
CHM 112 & CHM 113	Organic Chemistry II and Organic Chemistry Laboratory II	4
Select one of the following:		5
PHY 010 & PHY 012	General Physics I and Introductory Physics Laboratory I	
PHY 011 & PHY 012	Introductory Physics I and Introductory Physics Laboratory I	
Select one of the following:		4-5
PHY 013 & PHY 022	General Physics II and Introductory Physics Laboratory II	
PHY 021 & PHY 022	Introductory Physics II and Introductory Physics Laboratory II	
PSYC 001	Introduction to Psychology	4
<b>Major Electives</b>		
Select two of the following:		6
Any 300-level BIOS course not fulfilling another BNS requirement above. <sup>2</sup>		
PSYC 117	Cognitive Psychology	
PSYC 153	Personality	
PSYC 176	Cognitive Neuroscience	
Total Credits		75-80

<sup>1</sup> If this course is elected, Cell Biology BIOS 367 must be taken as an elective.

<sup>2</sup> Except BIOS 320, BIOS 347, BIOS 383, BIOS 387, BIOS 388, BIOS 391, or BIOS 383.

#### B.A. WITH MAJOR IN MOLECULAR BIOLOGY

##### Requirements for the B.A. in Molecular Biology

##### College and university requirements for all majors

ENGL 001	Critical Reading and Composition	3
ENGL 002	Research and Argument	3
First Year Seminar		3
Social Sciences		8
Humanities		8
<b>Biology</b>		
BIOS 041 & BIOS 042	Biology Core I: Cellular and Molecular and Biology Core I: Cellular and Molecular Lab	4

BIOS 115 & BIOS 116	Biology Core II: Genetics and Biology Core II: Genetics Laboratory	4
BIOS 121 & BIOS 122	Biology Core III: Integrative & Comparative Biology and Biology Core III: Integrative and Comparative Lab	4
Select one of the following:		3
BIOS 324	Microbiology	
BIOS 328	Immunology	
Select one of the following:		2-3
BIOS 325	Bacteriology Laboratory	
BIOS 368	Cell Biology Laboratory	
BIOS 377	Biochemistry Laboratory	
BIOS 371	Elements of Biochemistry I	3
BIOS 345 & BIOS 346	Molecular Genetics and Molecular Genetics Laboratory	5
BIOS 367	Cell Biology	3
BIOS approved electives		6
<b>Mathematics</b>		
Select one of the following:		7-8
MATH 021 & MATH 022	Calculus I and Calculus II	
MATH 051 & MATH 052	Survey of Calculus I and Survey of Calculus II	
<b>Chemistry</b>		
Select one of the following:		4
CHM 030	Introduction to Chemical Principles	
CHM 040	Honors General Chemistry I	
Select one of the following:		4
CHM 031	Chemical Equilibria in Aqueous Systems	
CHM 041	Honors General Chemistry II	
CHM 110 & CHM 111	Organic Chemistry I and Organic Chemistry Laboratory I	4
CHM 112 & CHM 113	Organic Chemistry II and Organic Chemistry Laboratory II	4
<b>Physics</b>		
Select one of the following:		5
PHY 010 & PHY 012	General Physics I and Introductory Physics Laboratory I	
PHY 011 & PHY 012	Introductory Physics I and Introductory Physics Laboratory I	
Select one of the following:		4-5
PHY 013 & PHY 022	General Physics II and Introductory Physics Laboratory II	
PHY 021 & PHY 022	Introductory Physics II and Introductory Physics Laboratory II	
Total Credits		91-94

#### THE B.S. IN MOLECULAR BIOLOGY

##### Requirements for the B.S. in Molecular Biology

##### Mathematics

Select one of the following:		7-8
MATH 021 & MATH 022	Calculus I and Calculus II	
MATH 051 & MATH 052	Survey of Calculus I and Survey of Calculus II	
BIOS 130	Biostatistics	4

##### Chemistry

Select one of the following:		4
CHM 030	Introduction to Chemical Principles	
CHM 040	Honors General Chemistry I	
Select one of the following:		4

CHM 031	Chemical Equilibria in Aqueous Systems	
CHM 041	Honors General Chemistry II	
CHM 110 & CHM 111	Organic Chemistry I and Organic Chemistry Laboratory I	4
CHM 112 & CHM 113	Organic Chemistry II and Organic Chemistry Laboratory II	4
<b>Physics</b>		
Select one of the following:		5
PHY 010 & PHY 012	General Physics I and Introductory Physics Laboratory I	
PHY 011 & PHY 012	Introductory Physics I and Introductory Physics Laboratory I	
Select one of the following:		4-5
PHY 013 & PHY 022	General Physics II and Introductory Physics Laboratory II	
PHY 021 & PHY 022	Introductory Physics II and Introductory Physics Laboratory II	
<b>Molecular Biology</b>		
BIOS 041 & BIOS 042	Biology Core I: Cellular and Molecular and Biology Core I: Cellular and Molecular Lab	4
BIOS 115 & BIOS 116	Biology Core II: Genetics and Biology Core II: Genetics Laboratory	4
BIOS 121 & BIOS 122	Biology Core III: Integrative & Comparative Biology and Biology Core III: Integrative and Comparative Lab	4
Select one of the following:		3
BIOS 324	Microbiology	
BIOS 328	Immunology	
Select one of the following:		2-3
BIOS 325	Bacteriology Laboratory	
BIOS 368	Cell Biology Laboratory	
BIOS 377	Biochemistry Laboratory	
BIOS 345 & BIOS 346	Molecular Genetics and Molecular Genetics Laboratory	5
BIOS 367	Cell Biology	3
BIOS 371	Elements of Biochemistry I	3
BIOS 372	Elements of Biochemistry II	3
BIOS 381	Physical Biochemistry	3
BIOS Approved Molecular Biology Electives		12
Total Credits		82-85

**RECOMMENDED SEQUENCE FOR THE B.S. IN MOLECULAR BIOLOGY**

<b>First Year</b>		CR
BIOS 041 & BIOS 042		4
MATH 021		4
MATH 022		4
CHM 030		4
CHM 031		4
		20
<b>Second Year</b>		CR
BIOS 115 & BIOS 116		4
CHM 110 & CHM 111		4
CHM 112 & CHM 113		4

PHY 010 & PHY 012		5
PHY 013 & PHY 022		4
		21
<b>Third Year</b>		CR
BIOS 121 & BIOS 122		4
BIOS 324 or 328		3
BIOS 325, 368, or 377		2
BIOS 345 & BIOS 346		5
BIOS 371 & BIOS 372		6
		20
<b>Fourth Year</b>		CR
BIOS 367		3
BIOS 381		3
BIOS Approved Molecular Biology Electives		12
		18

Total Credits: 79

**MOLECULAR BIOLOGY MINOR****Minor Program**

BIOS 041 & BIOS 042	Biology Core I: Cellular and Molecular and Biology Core I: Cellular and Molecular Lab	4
BIOS 115 & BIOS 116	Biology Core II: Genetics and Biology Core II: Genetics Laboratory	4
BIOS 345 & BIOS 346	Molecular Genetics and Molecular Genetics Laboratory	5
BIOS coursework at the 200 or 300 level (minimum 4 additional credits).		4
<b>Collateral coursework</b>		
MATH 051 or MATH 021	Survey of Calculus I or Calculus I	4
CHM 030	Introduction to Chemical Principles	4
CHM 110	Organic Chemistry I	3
Total Credits		28

**DEPARTMENTAL HONORS**

A student may apply for admission to the departmental honors program through a potential thesis advisor. Requirements for Departmental Honors include a major GPA of 3.25 and at least 2 semesters of 300-level research for a minimum of 6 cr. The student must write a research proposal for their project and a thesis at the conclusion of their research. This work must be presented in a symposium at the end of the project. Students must meet regularly with their advisor and research group to discuss their research progress and also must complete the year-long, 2-course sequence for BIOS honors students (BIOS 387 and BIOS 388).

**SPECIAL HEALTH PROFESSIONS PROGRAMS**

Students may apply for admission to an accelerated B.A.-Doctor of Medicine program and a B.A.-Doctor of Medical Dentistry program. A seven-year B.A.M.D. program is offered in conjunction with Drexel University College of Medicine, and a seven year B.A.D.M.D. program is offered in conjunction with the University of Pennsylvania School of Dental Medicine. Students in these programs receive a B.A. from Lehigh and a graduate degree from the designated professional school within a seven-year period. For details concerning admission to these programs, see Health Professions (<http://catalog.lehigh.edu/coursesprogramsandcurricula/artsandsocieties>).

**GRADUATE STUDY IN THE BIOLOGICAL SCIENCES**

Rigorous, research-oriented graduate programs leading to a Doctor of Philosophy are offered in three divisions of the Department of Biological Sciences: biochemistry, integrative biology and neuroscience, and cell and molecular biology. To complete the program students must successfully complete core courses, pass a qualifying exam, prepare, submit, and successfully defend a written research proposal, complete the research described in the proposal, and submit a written dissertation and defend the completed research to the department.

Once students enter the department, their progress is monitored by the graduate committee until they are admitted to candidacy. Members of the committee meet with the student each semester to assess the student's progress towards the degree and to assist students in choosing the appropriate courses to provide a solid scientific foundation and an up-to-date understanding of the discipline. This will be assessed by the qualifying exam.

The qualifying exam generally should be taken after the third semester and no later than the fourth semester of course work. It will be prepared, administered and graded by the faculty associated with the specific graduate program in which the student is enrolled. It consists of a two-day written exam and an oral examination. The exam can be repeated once. Admission to candidacy is granted after successful completion of the qualifying exam and the thesis proposal. The proposal is a written description of an original research project developed under the guidance of a faculty member chosen by the student to be his/her advisor. The proposal will be presented orally to the thesis committee, typically after the fifth semester. Following the presentation of the proposal, an oral examination will take place in which the thesis committee will question the student about general science related to the project. This will constitute the general examination.

Core requirements for each division are listed below. The graduate school requires students to register for at least 72-post baccalaureate credits to earn the Ph.D. In addition, all students must take BIOS 408 (0 credits) Responsible Conduct of Science within their first year of graduate study. All students must also attend departmental seminars and enroll in BIOS 406 (1 credit) Biological Sciences Seminar at least twice in the first four semesters. A minimum of 24 course credits may be chosen from upper level courses in biochemistry, molecular biology, cell biology, behavioral biology and evolutionary biology, and neuroscience. At least 12 of these credits must be at the 400 level.

**Biochemistry**

In the biochemistry program, research areas include DNA structure and function, regulation of protein synthesis, and signal transduction. Students admitted to graduate study in biochemistry will typically have an undergraduate degree in chemistry or biochemistry. Students with an undergraduate degree in a related discipline will be expected to have the following undergraduate preparation for graduate study beyond introductory chemistry and a year of organic chemistry: at least one semester of analytical chemistry and one semester of physical chemistry thermodynamics and kinetics, with appropriate math. Students without that background will be expected to take courses to fulfill those requirements as part of their graduate study.

**Required courses**

BIOS 371	Elements of Biochemistry I	3
BIOS 372	Elements of Biochemistry II	3
BIOS 406	Biological Sciences Seminar (2 semesters, 1 credit each)	1
One of the following:		
BIOS 421	Molecular Cell Biology I	3
BIOS 422	Molecular Cell Biology II	3
BIOS 471	Eukaryotic Signal Transduction (OR)	3
One of the following:		
BIOS 345	Molecular Genetics	3
BIOS 411	Advanced Cell Biology	3
One of the following:		

CHM 423

Chemical Biology

3

400-level bioinformatics course (through CSE or BIOS)

Elective courses

- Additional courses to reach 24 course credits (12 at the 400-level). May be chosen from the upper level courses in Biochemistry, Molecular Biology, and Bio-Organic Chemistry.

**Integrative Biology and Neuroscience**

The graduate program in integrative biology and neuroscience is designed to train students in advanced organismal biology with the emphasis on behavioral ecology, evolution, functional morphology, endocrinology, and neurobiology of animals. The mission of the program is to create students who are broadly trained and uniquely capable of asking questions and solving problems at the interface of these traditionally defined fields. Students admitted to the program should have a basic knowledge of evolution, anatomy, physiology, behavioral neuroscience, and/or behavioral ecology. Students will begin by taking core courses providing a broad foundation in integrative biology at the graduate level and work toward a Ph.D. with a concentration in either behavioral neuroscience or behavioral and evolutionary biology. Regardless of concentration, all students in the program develop an appreciation for the fact that all aspects of biology, whether cellular, physiological, anatomical, behavioral, evolutionary, or social, are inextricably linked and cannot be fully understood as separate, parallel systems of knowledge. The integrative program consists of two tracks: (I) Animal Behavior and Evolution, and (II) Neuroscience.

**GRADUATE STUDY IN BIOLOGY**

A rigorous, research-oriented graduate program leading to a Doctor of Philosophy in Biology with concentrations in biochemistry; molecular and cell biology; neuroscience; and evolution and behavior is offered in the Department of Biological Sciences. To complete the program students must successfully complete core courses, pass a qualifying exam, prepare, submit, and successfully defend a written research proposal, complete the research described in the proposal, and submit a written dissertation and defend the completed research to the department.

Once students enter the department, their progress is monitored by the graduate committee until they are admitted to candidacy. Members of the committee meet with the student each semester to assess the student's progress towards the degree and to assist students in choosing the appropriate courses to provide a solid scientific foundation and an up-to-date understanding of the discipline. This will be assessed by the qualifying exam.

The qualifying exam generally should be taken after the third semester and no later than the fourth semester of course work. It will be prepared, administered and graded by the faculty associated with the specific concentration in which the student is enrolled. It consists of a two-day written exam and an oral examination. The exam can be repeated once. Admission to candidacy is granted after successful completion of the qualifying exam and the thesis proposal. The proposal is a written description of an original research project developed under the guidance of a faculty member chosen by the student to be his/her advisor. The proposal will be presented orally to the thesis committee, typically after the fifth semester. Following the presentation of the proposal, an oral examination will take place in which the thesis committee will question the student about general science related to the project. This will constitute the general examination.

Core requirements for each concentration are listed below. The graduate school requires students to register for at least 72-post baccalaureate credits to earn the Ph.D. In addition, all students must take BIOS 408 (0 credits) Responsible Conduct of Science within their first year of graduate study. All students must also attend departmental seminars and enroll in BIOS 406 (1 credit) Biological Sciences Seminar at least twice in the first four semesters. A minimum of 24 course credits may be chosen from upper level courses in biochemistry, molecular biology, cell biology, behavioral biology and evolutionary biology, and neuroscience. At least 12 of these credits must be at the 400 level.

**Biochemistry concentration**

In the biochemistry program, research areas include DNA structure and function, regulation of protein synthesis, and signal transduction. Students admitted to graduate study in biochemistry will typically have an undergraduate degree in chemistry or biochemistry. Students with an undergraduate degree in a related discipline will be expected to have the following undergraduate preparation for graduate study beyond introductory chemistry and a year of organic chemistry: at least one semester of analytical chemistry and one semester of physical chemistry thermodynamics and kinetics, with appropriate math. Students without that background will be expected to take courses to fulfill those requirements as part of their graduate study.

**Required courses**

BIOS 371	Elements of Biochemistry I	3
BIOS 372	Elements of Biochemistry II	3
CHM 423	Chemical Biology	3
BIOS 345	Molecular Genetics	3
<b>Seminar course</b>		
BIOS 406	Biological Sciences Seminar	1
or CHM 400	First Year Graduate Student Seminar	

**neuroscience concentration**

The graduate program in neuroscience is designed to train students in advanced topics in neuroscience with emphases on the behavioral, synaptic, cellular, endocrinology, and physiological aspects of neurobiology. The mission of the program is to create students who are broadly trained and uniquely capable of asking questions and solving problems at the interface of these traditionally defined fields. Students admitted to the program should have a basic knowledge of anatomy, physiology, behavioral and cellular neuroscience. Students will begin by taking core courses providing a broad, integrative foundation in neuroscience at the graduate level and work toward a Ph.D. with a concentration in neuroscience. Regardless of concentration, all students develop an appreciation for the fact that all aspects of biology, whether cellular, physiological, anatomical, behavioral, evolutionary, or social, are inextricably linked and cannot be fully understood as separate, parallel systems of knowledge.

**NEUROSCIENCE CONCENTRATION**

Depending on the student's background, additional courses may be required.

**Required Courses**

Take one (1) of the following:

BIOS 453	General Neuroanatomy
BIOS 457	Advanced Behavioral Neuroendocrinology

Take one (1) of the following:

BIOS 415	Synapses, Plasticity and Learning
BIOS 424	Advanced Neurobiology of Sensory Systems

Take one (1) of the following:

BIOS 471	Eukaryotic Signal Transduction
BIOS 486	Genes and the Brain

Take one (1) course from EITHER the 400-level Cell and Molecular offerings (see Catalog entry) OR the 400-level Animal Behavior and Evolution offerings (see above)

**ANIMAL BEHAVIOR AND EVOLUTION CONCENTRATION**

The graduate program in evolution and behavior is designed to train students in advanced organismal biology with emphases on behavioral ecology, evolution, and/or functional morphology. The mission of the program is to create students who are broadly trained and uniquely capable of asking questions and solving problems at the interface of these traditionally defined fields. Students admitted to the program should have a basic knowledge of evolution, anatomy, physiology and/or behavioral ecology. Students will begin by taking core courses providing a broad, integrative foundation in evolution and behavior at the graduate level and work toward a Ph.D. with a concentration in evolution and behavior. Regardless of concentration, all students develop an appreciation for the fact that all aspects

of biology, whether cellular, physiological, anatomical, behavioral, evolutionary, or social, are inextricably linked and cannot be fully understood as separate, parallel systems of knowledge.

**ANIMAL BEHAVIOR AND EVOLUTION CONCENTRATION****Required Courses**

Take three (3) of the following:

BIOS 423	Evolution of Development
BIOS 426	Coevolution
BIOS 428	Molecular Evolution
BIOS 434	Speciation
BIOS 439	Advanced Behavioral Ecology

Take one (1) course from EITHER the 400-level Cell and Molecular offerings (see Catalog entry) OR the 400-level Neuroscience offerings (see below)

**Additional Requirements**

BIOS 401	Professional Skills for Biological Sciences Graduate Students (strongly recommended to be taken in first two years)
BIOS 406	Biological Sciences Seminar (2 semesters)
BIOS 408	Responsible Conduct of Science

**CELL AND MOLECULAR BIOLOGY CONCENTRATION**

In the cell and molecular biology program, research areas include microbial evolution and genetics, plant and animal molecular genetics, eukaryotic cell biology, and regulation of gene expression.

BIOS 345	Molecular Genetics	3
BIOS 371	Elements of Biochemistry I	3
BIOS 372	Elements of Biochemistry II	3
BIOS 411	Advanced Cell Biology	3
BIOS 421	Molecular Cell Biology I	3
BIOS 422	Molecular Cell Biology II	3

Additional requirements

BIOS 406	Biological Sciences Seminar	1
Upper level electives in molecular biology, cell biology, and biochemistry.		6
<b>Total Credits</b>		<b>25</b>

Facilities available for research in the biological sciences include core facilities with equipment (for example, for DNA synthesis, confocal microscopy, digital imaging, chromatography, cell culture, centrifugation, controlled environments, gamma and scintillation counting, flow cytometry, and rodent surgery). Individual research laboratories and advanced teaching laboratories contain a variety of additional equipment. Ongoing interactions with a variety of private companies contribute additional opportunities for student experiences.

**Cell and Molecular Biology**

In the cell and molecular biology program, research areas include microbial evolution and genetics, plant and animal molecular genetics, eukaryotic cell biology, and regulation of gene expression.

BIOS 345	Molecular Genetics	3
BIOS 371	Elements of Biochemistry I	3
BIOS 372	Elements of Biochemistry II	3
BIOS 411	Advanced Cell Biology	3
BIOS 421	Molecular Cell Biology I	3
BIOS 422	Molecular Cell Biology II	3

**Additional Requirements**

BIOS 406	Biological Sciences Seminar (2 semesters)	1
Upper level electives in molecular biology, cell biology, and biochemistry		6
<b>Total Credits</b>		<b>25</b>

Facilities available for research in the biological sciences include core facilities with equipment (for example, for DNA synthesis,

confocal microscopy, digital imaging, chromatography, cell culture, centrifugation, controlled environments, gamma and scintillation counting, flow cytometry, and rodent surgery). Individual research laboratories and advanced teaching laboratories contain a variety of additional equipment. Ongoing interactions with a variety of private companies contribute additional opportunities for student experiences.

#### Courses

##### **BIOS 010 Bioscience in the 21st Century 4 Credits**

A multidisciplinary survey of advances in bioscience. Exploration of themebased topics (e.g., infectious diseases, cancer, genomebase medicine, engineered biomedical systems) coupled with social/ethical considerations. Three lectures per week. Participation in online multidisciplinary discussion, writing assignments, field trips, and/or other activities.

**Attribute/Distribution:** NS

##### **BIOS 041 Biology Core I: Cellular and Molecular 3 Credits**

Basic building blocks and higherorder structures required for cellular processes. Topics include the character of membranes, the molecular/cellular basis of energy production, cell cycle progression, DNA replication, gene expression, signal transduction, and cell division.

**Prerequisites:** CHM 075 or CHM 025 or CHM 030 or CHM 040

**Can be taken Concurrently:** CHM 075, CHM 025, CHM 030, CHM 040

**Attribute/Distribution:** NS

##### **BIOS 042 Biology Core I: Cellular and Molecular Lab 1 Credit**

Techniques and experiments related to the principal topics covered in BIOS 041; emphasis on experimental design and scientific communication.

**Prerequisites:** BIOS 041

**Can be taken Concurrently:** BIOS 041

**Attribute/Distribution:** NS

##### **BIOS 043 Phage Hunting Laboratory 2 Credits**

The first laboratory research course in a two-semester series (as part of the Howard Hughes Medical Institute's SEA-PHAGES Program) that focuses on the isolation (from local soil), as well as the physical and genomic characterization of novel bacteriophages that infect mycobacteria. Course will substitute for BIOS 42. Application and acceptance into Lehigh's SEA program required (see [www.lehigh.edu/~insea](http://www.lehigh.edu/~insea)); freshman status in the spring semester or permission of the instructor. Co-requisite: BIOS 41 or instructor permission.

**Prerequisites:** BIOS 041

**Can be taken Concurrently:** BIOS 041

**Attribute/Distribution:** NS

##### **BIOS 115 Biology Core II: Genetics 3 Credits**

The structure, function, and continuity of hereditary information. Classical genetic analysis. Molecular biology of genes and genomes. Population genetics and evolution. Genetics of complex traits.

**Prerequisites:** BIOS 041

**Attribute/Distribution:** NS

##### **BIOS 116 Biology Core II: Genetics Laboratory 1 Credit**

Introduction to model organisms; techniques used in molecular genetics; experimental design and scientific communication.

**Prerequisites:** BIOS 115

**Can be taken Concurrently:** BIOS 115

**Attribute/Distribution:** NS

##### **BIOS 118 Phage Genetics Laboratory 2 Credits**

Part of a 2-semester series focusing on genetic analysis of novel bacteriophage genomes to determine gene function using recombineering strategies. Phage genome annotation using bioinformatics for previously sequenced phage genomes. Additional genetics, molecular biology, and/or biochemical research on previously isolated bacteriophages may also be included.

**Prerequisites:** BIOS 115

**Can be taken Concurrently:** BIOS 115

**Corequisites:** BIOS 115

**Attribute/Distribution:** NS

##### **BIOS 121 Biology Core III: Integrative & Comparative Biology 3 Credits**

Experimental and historical approaches to the analysis of structural and functional properties in organisms. Use of scientific method to study species diversity. Introduction to the analysis of organismal attributes that explain behavioral repertoire and ecological relationships. **Prerequisites:** BIOS 41 and 42.

**Prerequisites:** BIOS 041 and BIOS 042

**Attribute/Distribution:** NS

##### **BIOS 122 Biology Core III: Integrative and Comparative Lab 1 Credit**

Experiments and discussions related to the topics covered in BIOS 121; emphasis on experimental design and scientific communication.

**Prerequisites:** BIOS 121

**Can be taken Concurrently:** BIOS 121

**Attribute/Distribution:** NS

##### **BIOS 130 (MATH 130) Biostatistics 4 Credits**

Elements of statistics and probability theory with emphasis on biological applications. Statistical analysis of experimental and observational data.

**Prerequisites:** BIOS 041 and MATH 052 or MATH 022

**Attribute/Distribution:** ND

##### **BIOS 161 Supervised Research 1-3 Credits**

Apprenticeship in ongoing faculty research program. Literature review, experimental design, data collection and analysis, and professional writing under faculty sponsor supervision. Only 3 credits can be counted toward any life science major. Consent of instructor required.

**Repeat Status:** Course may be repeated.

**Prerequisites:** BIOS 041

**Attribute/Distribution:** NS

##### **BIOS 202 Biomedical Externship 1-3 Credits**

Analysis of individualized experiences at external biomedical clinical or research sites. Limited enrollment. May not be taken for pass/fail grading. May not be used to satisfy any life science major or minor requirement. Consent of department chair required.

**Attribute/Distribution:** NS

##### **BIOS 234 Comparative Vertebrate Anatomy 4 Credits**

A course in vertebrate zoology with emphasis on the study of homologous body structures in the various vertebrate classes and their relationship to the functional demands of habit and environment in each class. Detailed dissections of representative vertebrates are made in the laboratory. Two lectures and two laboratory periods.

**Prerequisites:** BIOS 121 or BIOS 122

**Attribute/Distribution:** NS

##### **BIOS 235 Human Physiology 3 Credits**

The goal of this course is to provide students with a thorough understanding of the major systems of the human body. Students will examine many of the major body systems including Nervous, Muscular, Cardiac, Respiratory, and Digestive systems. These systems will be analyzed by their components at both the cellular and molecular level. Students will also examine how each system functions as a whole and how it interacts with other systems at the organismal level.

**Prerequisites:** BIOS 115

**Attribute/Distribution:** NS

##### **BIOS 241 Vertebrate Natural History 4 Credits**

An introduction to the ecology, behavior, distribution and evolution of vertebrates, with emphasis on the North American fauna. Two lectures, one tutorial and one laboratory and field trip. This course may be used to fulfill junior writing requirements with the permission of the instructor.

**Prerequisites:** BIOS 115 or BIOS 116 or BIOS 121 or BIOS 122

**Attribute/Distribution:** NS

##### **BIOS 251 Writing and Biological Sciences 3 Credits**

A course designed to acquaint students with some of the intellectual foundations of science, with attention to the distinctiveness of the biological sciences. Format includes readings, intensive writing, extemporaneous speaking, and discussion. May not be used to fulfill Biology B.A. elective requirements.

**Attribute/Distribution:** NS



**BIOS 261 Special Topics in Biological Sciences 1-3 Credits**

Research, conferences and reports on selected topics not covered in the general undergraduate offerings. Consent of instructor required.

**Repeat Status:** Course may be repeated.

**Attribute/Distribution:** NS

**BIOS 262 Research Proposal 3 Credits**

Literature and methods of research in area of department faculty expertise. Requires development of detailed proposal for research to be performed in senior year. Must have major in any biological sciences degree program, junior standing, GPA of 3.0 in major, and consent of department.

**Attribute/Distribution:** NS

**BIOS 276 Central Nervous System and Behavior 3 Credits**

Neuroanatomy and neurophysiology of animal and human behavior. Feeding, thirst, sleep, emotions, learning, and psychopathology.

**Prerequisites:** BIOS 121 and BIOS 122

**Attribute/Distribution:** NS

**BIOS 277 Experimental Neuroscience Laboratory 2 Credits**

Structure and function of the mammalian brain with special attention to cellular morphology and organization. Widely used histological and behavioral techniques to determine how the shape and function of the nervous system regulates behavior. Experimental design, hypothesis testing, statistical analysis, reading and writing of scientific papers, basic histology and imaging.

**Prerequisites:** BIOS 276

**Can be taken Concurrently:** BIOS 276

**Attribute/Distribution:** NS

**BIOS 278 Neurophysiology Laboratory 2 Credits**

The functional electrical underpinnings of the nervous system explored through direct recordings and thorough data analyses. Experimental design, hypothesis testing, numerical analysis, reading and writing of primary science.

**Prerequisites:** BIOS 276

**Can be taken Concurrently:** BIOS 276

**Attribute/Distribution:** NS

**BIOS 279 Experimental Molecular Neuroscience Laboratory 2 Credits**

Inquiry-based lab course emphasizing molecular and cellular neuroscience approaches to understanding the nervous system. Opportunity for making real research discoveries on the genetic and cellular underpinnings of brain function. Molecular genetic, bioinformatic, and neurochemical techniques. Can be taken more than once with instructor approval.

**Repeat Status:** Course may be repeated.

**Prerequisites:** BIOS 276

**Can be taken Concurrently:** BIOS 276

**Attribute/Distribution:** NS

**BIOS 300 Apprentice Teaching 1-4 Credits**

**Repeat Status:** Course may be repeated.

**BIOS 313 Vertebrate Histology 4 Credits**

Microstructural and ultrastructural properties of vertebrate cells and tissues. Techniques of tissue preparation. Two lectures and two labs.

**Prerequisites:** BIOS 115 and BIOS 116 and BIOS 121 and BIOS 122

**Attribute/Distribution:** ND, NS

**BIOS 314 Vertebrate Development 4 Credits**

Germ cell formation, fertilization, early development, and the origin of the principal organ systems. Location, structure, and regulation of information from molecular to organismal levels of organization.

**Prerequisites:** BIOS 115 and BIOS 116 and (BIOS 120 or (BIOS 121 and BIOS 122), )

**Attribute/Distribution:** NS

**BIOS 315 Neuropharmacology 3 Credits**

Mechanisms of drug action in the central nervous system. Pharmacokinetics/pharmacodynamics. Depressant, stimulants, analgesics, and psychedelics. Treatments for neuropsychiatric disorders. Drug abuse.

**Prerequisites:** BIOS 276

**Attribute/Distribution:** NS

**BIOS 317 Evolution 3 Credits**

Mechanisms of evolution, emphasizing genetic structure and variation of populations, and isolation. Origin of species and higher taxa. Rates of evolution, extinction.

**Prerequisites:** BIOS 121 and BIOS 122

**Attribute/Distribution:** NS

**BIOS 318 Advanced Phage Research Laboratory 1-3 Credits**

Apprentice-based laboratory research in phage biology in collaboration with faculty who direct Lehigh's SEA Phages Program (sponsored by the Howard Hughes Medical Institute). Research will focus on discoveries uncovered in SEA Phage courses and may include genetic, molecular, and biochemical analyses of novel bacteriophage genes, genomes, and novel gene functions. Additional research may include phage genome annotation using computational biology tools.

**Repeat Status:** Course may be repeated.

**Prerequisites:** BIOS 115 and BIOS 118

**Attribute/Distribution:** NS

**BIOS 320 (ENTP 320) The Business of Life Science 3 Credits**

An examination of business process in startup, early stage and developing bioscience companies. Technology assessment, business plan and proposal preparation, financial strategies, resource management, intellectual property, and legal as well as regulatory issues. Cannot be used to fulfill major or minor requirements in Biological Sciences.

**Prerequisites:** BIOS 121

**Attribute/Distribution:** NS

**BIOS 323 Evolution of Development 3 Credits**

This course examines how changes in the blueprint that describes the development of a multicellular animal from a single fertilized egg lead to the evolution of new species or new forms within a species.

**Prerequisites:** BIOS 317 or BIOS 376 or BIOS 327

**Can be taken Concurrently:** BIOS 317, BIOS 376, BIOS 327

**BIOS 324 Microbiology 3 Credits**

An examination of microbial life, including archaea, bacteria, fungi, protists and viruses. Emphasis on microbial molecular genetics and its relationship to the origin of life, human health/medicine, and the environment.

**Prerequisites:** CHM 110 and BIOS 115

**Attribute/Distribution:** NS

**BIOS 325 Microbiology Laboratory 2 Credits**

Laboratory studies of microorganisms, focusing on bacteria and fungi. Techniques for isolating, culturing, and identifying microorganisms. Experiments in microbial molecular genetics, phylogenetics, and evolution using traditional and modern techniques, as well as other topics covered in BIOS 324.

**Prerequisites:** BIOS 324

**Attribute/Distribution:** NS

**BIOS 326 Coevolution 3 Credits**

Discussion-based seminar course covering readings from the primary literature. Course will examine evolutionary consequences of species interactions, interactions between the sexes, and genetic interactions. Topics will include predator-prey interactions, host-parasite interactions, sexual conflict, genomic conflict, mutualism, and more. Consequences of coevolution for biodiversity and human health will also be examined.

**Prerequisites:** BIOS 317

**Attribute/Distribution:** NS

**BIOS 327 Development and Disease 3 Credits**

Development of organs from precursor cells; diseases that impact organ function. Focus on understanding how mutations or other causes influence organ development and function. Combination lecture and primary literature.

**Prerequisites:** BIOS 376

**Attribute/Distribution:** NS

**BIOS 328 Immunology 3 Credits**

Distinction of "self" and "nonself" through humoral and cellular mechanisms. Antigens; biochemical structures, cellular mechanisms, genetic control and processing, phylogenetic distribution, diseased states.

**Prerequisites:** BIOS 115

**Attribute/Distribution:** NS

**BIOS 329 Herpetology 3 Credits**

Biology of amphibians and reptiles. Two lectures, one laboratory or field trip per week.

**Prerequisites:** BIOS 115 and BIOS 116 and (BIOS 120 or (BIOS 121 and BIOS 122), )

**Attribute/Distribution:** ND

**BIOS 330 Molecular Evolution 3 Credits**

This course will focus on evolution at the level of individual genes, proteins, and genomes, alternating between lecture and discussion of papers from the recent primary literature. Topics include pathways for adaptive evolution, directionality in evolution, epistasis, evolvability, genome rearrangements and speciation, gene duplication, and evolutionary dynamics. We will draw on examples of molecular evolution in nature, laboratory model systems, and human pathogens.

**Prerequisites:** BIOS 317 or BIOS 345

**Can be taken Concurrently:** BIOS 317, BIOS 345

**Attribute/Distribution:** NS

**BIOS 332 Behavioral Neuroanatomy 3 Credits**

The study of neuroanatomy that underlies social and motivated behaviors and the techniques that support this study. Students learn by researching and reporting on original research, and ultimately designing and describing an original study on the topic.

**Prerequisites:** BIOS 276

**Attribute/Distribution:** NS

**BIOS 334 Species and Speciation 3 Credits**

Consideration of the origin of species. Discussion of a variety of "species" definitions and exploration of the evolutionary mechanisms by which new species arise. Alternation between lecture and discussion, drawing on the textbook and on current and classical literature.

**Prerequisites:** BIOS 317

**BIOS 335 (PSYC 335) Animal Behavior 3 Credits**

Discussion of the behavior of invertebrates and vertebrates and analysis of the physiological mechanisms responsible for behavioral stimuli, and adaptive value of specific behavior patterns.

**Prerequisites:** BIOS 121 and BIOS 122

**Attribute/Distribution:** NS

**BIOS 336 Animal Behavior Laboratory 2 Credits**

Experiments and field observations illustrating principles discussed in BIOS 335. Emphasis on observing animals, performing experiments, collecting and analyzing data, and individual research. Six hours of laboratory per week.

**Prerequisites:** BIOS 335 or BIOS 337

**Can be taken Concurrently:** BIOS 335, BIOS 337

**Attribute/Distribution:** NS

**BIOS 337 Behavioral Ecology 3 Credits**

Social systems of vertebrate and invertebrate groups. Emphasis on ecological and evolutionary factors that influence social behavior.

**Prerequisites:** BIOS 121 and BIOS 122

**Attribute/Distribution:** NS

**BIOS 338 Neurodegenerative Diseases in Model Organisms 3 Credits**

Discussion-based seminar course on the use of model systems to investigate neurodegenerative diseases. The primary focus will be on invertebrate model systems, including *Drosophila*. Critical reading of primary scientific literature and student discussion is required.

**Prerequisites:** BIOS 115

**BIOS 340 Molecular Basis of Disease 3 Credits**

Lectures and student projects on molecular mechanisms of human disease. Physiology of disease, molecular mechanisms, therapeutic approaches, ongoing research. Topics include: neurodegenerative diseases, cancer, autoimmune diseases, infectious diseases.

**Prerequisites:** BIOS 115

**Attribute/Distribution:** NS

**BIOS 342 Cellular Basis of Human Disease 3 Credits**

Cell and molecular biological advanced topics relevant to human disease and/or health. Critical reading of the primary literature, discussion and student discussion required.

**Prerequisites:** BIOS 367 or BIOS 411

**Attribute/Distribution:** NS

**BIOS 345 Molecular Genetics 3 Credits**

The organization and replication of genetic material; mutagenesis; mechanisms of regulation; mechanisms of gene transmission involving prokaryotes and eukaryotes and their viruses; techniques for intervention into genetic organization and expression.

**Prerequisites:** BIOS 115

**Attribute/Distribution:** NS

**BIOS 346 Molecular Genetics Laboratory 2 Credits**

Laboratory experiments related to the topics covered in BIOS 345. Emphasis is on molecular characterization of DNA and the principles of gene isolation and transfer.

**Prerequisites:** BIOS 345

**Can be taken Concurrently:** BIOS 345

**Attribute/Distribution:** NS

**BIOS 347 Advanced Topics in Genetics 3 Credits**

Lectures and student projects on selected aspects of genetics such as the genetics and evolution of particular organisms, regulation of gene expression and transmission, human genetics, gene therapy, etc. Consent of department chair.

**Prerequisites:** BIOS 115 and BIOS 116

**Attribute/Distribution:** NS

**BIOS 365 Neurobiology of Sensory Systems 3 Credits**

The fundamental features of sensory systems in a diverse array of animals. Focus on how nervous systems detect, compute, and internally represent aspects of the environment from the single cell to whole system level. Special attention to the way sensory processing influences how we think about the biological basis of perception and possible mechanisms for consciousness. Instructor permission required.

**Prerequisites:** BIOS 276

**Attribute/Distribution:** NS

**BIOS 366 Diseases of the Nervous System 3 Credits**

Neurobiological basis of CNS disorders, including affective, neurological and psychotic conditions. Emphasis on primary literature covering causes, diagnostic and treatment issues.

**Prerequisites:** BIOS 276 or BIOS 382

**Attribute/Distribution:** NS

**BIOS 367 Cell Biology 3 Credits**

Molecular aspects of cell biology. Emphasis on membrane structure and function, organelle biogenesis, cell motility, the cytoskeleton, and extracellular matrix.

**Prerequisites:** BIOS 115

**Attribute/Distribution:** NS

**BIOS 368 Cell Biology Laboratory 2 Credits**

Basic methods used in cell biology laboratories around the world and the opportunity to carry out an independent research project. Techniques include histology and microscopy (both white and fluorescent light), tissue culture and sterile procedures, cellular fractionation, nuclear import assays, and immunological probing. Consent of department required.

**Prerequisites:** BIOS 367

**Can be taken Concurrently:** BIOS 367

**Attribute/Distribution:** NS

**BIOS 369 Comparative Physiology of Vertebrate Systems 3-4 Credits**

Functional analysis of energy balance in vertebrate animal models. Digestion, respiration, circulation, and excretion, across aquatic and terrestrial vertebrates. Homeostatic mechanisms of salt, water, and gas exchange. Ionotropic and metabotropic signal transduction. Hormonal and electrical cellular communication among muscles, glands, and neurons. Sensory systems, movement and reproduction. Physiological adaptations to extreme environments. When offered for 4 credits, the course includes one laboratory meeting per week.

**Prerequisites:** BIOS 121 and BIOS 122

**Attribute/Distribution:** NS

**BIOS 371 (CHM 371) Elements of Biochemistry I 3 Credits**

A general study of carbohydrates, proteins, lipids, nucleic acids and other biological substances and their importance in life processes. Protein and enzyme chemistry are emphasized. Must have completed one year of organic chemistry.

**Prerequisites:** CHM 112

**Attribute/Distribution:** NS

**BIOS 372 (CHM 372) Elements of Biochemistry II 3 Credits**

Dynamic aspects of biochemistry; enzyme reactions including energetics, kinetics and mechanisms; metabolism of carbohydrates, lipids, proteins and nucleic acids; photosynthesis, electron transport mechanisms, coupled reactions, phosphorylations, and the synthesis of biological macromolecules.

**Prerequisites:** (BIOS 371 or CHM 371) and (BIOS 041)

**Attribute/Distribution:** NS

**BIOS 374 Sex Determination and Differentiation 3 Credits**

An examination of the primary scientific literature on how sex is conferred to a zygote. Hormonal and non-hormonal mechanisms of sexual differentiation. Neural correlates of sex, gender, and sexual orientation.

**Prerequisites:** BIOS 367 or BIOS 371 or BIOS 382

**Attribute/Distribution:** NS

**BIOS 375 Methods in Developmental Biology Lab 2 Credits**

Detection of gene expression and protein expression in vivo or in vitro. Mutants and/or transgenics examined. Students address research questions of instructor.

**Prerequisites:** BIOS 115 and BIOS 116

**Attribute/Distribution:** NS

**BIOS 376 Developmental Biology 3 Credits**

Differentiation of multicellular organisms from a single cell. Axis determination; gradients; induction and pattern formation viewed through modern analysis of regulated gene expression. Lecture topics on organ formation paired with discussions on birth defects and human diseases.

**Prerequisites:** BIOS 115 and BIOS 116

**Attribute/Distribution:** NS

**BIOS 377 (CHM 377) Biochemistry Laboratory 3 Credits**

Laboratory studies of the properties of chemicals of biological origin and the influence of chemical and physical factors on these properties. Laboratory techniques used for the isolation and identification of biochemicals.

**Prerequisites:** (BIOS 371 or CHM 371) and (BIOS 041)

**Can be taken Concurrently:** BIOS 371, CHM 371

**Attribute/Distribution:** ND

**BIOS 378 Biochemical Preparations 1-3 Credits**

A laboratory course involving the preparation or isolation, purification and identification of chemicals of biological origin.

**Prerequisites:** (BIOS 377 or CHM 377) and (BIOS 372 or CHM 372)

**Attribute/Distribution:** ND

**BIOS 380 (BIOE 380) Molecular and Cellular Biophysics 3-4 Credits**

Physical principles of biomolecular and cellular organization. Biomolecular interaction and recognition, molecular motors, physical organization and functioning of cellular membranes, electrical signaling in live cells. Modern techniques in biophysics: X-ray analysis, molecular spectroscopy, molecular modeling, fluorescence imaging, electrophysiology, electron microscopy.

**Prerequisites:** (BIOS 115) and (PHY 013 or PHY 021)

**BIOS 381 Physical Biochemistry 3 Credits**

Topics include: thermodynamics of biological systems; Forces acting on and between biological molecules; Principles of macromolecular structure; Physical methods used to characterize biomolecules; and other topics to be determined.

**Prerequisites:** (BIOS 371 or CHM 371) and (BIOS 041)

**Attribute/Distribution:** NS

**BIOS 382 (PSYC 382) Endocrinology of Behavior 3 Credits**

Hormonal effects upon animal and human behavior. Emphasis on neuroendocrinology of steroid hormone involvement in reproductive behaviors.

**Prerequisites:** BIOS 121

**Attribute/Distribution:** NS

**BIOS 383 Biological Sciences Colloquia 1 Credit**

Analysis of weekly colloquia in the biological sciences.

**Repeat Status:** Course may be repeated.

**Prerequisites:** BIOS 121

**Attribute/Distribution:** NS

**BIOS 384 Eukaryotic Signal Transduction 3 Credits**

Signal transduction between cells of multicellular eukaryotic organisms examined in the context of specialized functions that include: nutrition, hormones and neurotransmitters, vision, muscle contraction, adhesion, and the immune system. The evolution of cancer based on mutations in these signaling systems.

**Prerequisites:** BIOS 367 or BIOS 372 or CHM 372 or BIOS 382 or BIOS 365

**BIOS 385 Synapses, Plasticity and Learning 3 Credits**

Communication between neurons. Physiology of synaptic transmission; varying forms of neuronal plasticity; acquisition, encoding, and retrieval of memory.

**Prerequisites:** BIOS 276

**Attribute/Distribution:** NS

**BIOS 386 Genes and the Brain 3 Credits**

Modern molecular genetics techniques applied to complex brain processes. Emphasis on DNA and RNA manipulation strategies to elucidate mechanisms of complex behaviors. Animal models of learning, behavioral plasticity, and neuropsychiatric diseases.

**Prerequisites:** BIOS 276

**Attribute/Distribution:** NS

**BIOS 387 Biological Sciences Honors Seminar 1 Credit**

Development, presentation and implementation of research proposals, and discussions of research. Required for senior biology, molecular biology, biochemistry, and behavioral neuroscience majors pursuing departmental honors. Departmental permission required.

**Attribute/Distribution:** ND

**BIOS 388 Biological Sciences Honors Seminar 1 Credit**

Continuation and extension of BIOS 387. Departmental permission required.

**Attribute/Distribution:** ND

**BIOS 389 Honors Project 1-6 Credits**

**Repeat Status:** Course may be repeated.

**BIOS 391 Undergraduate Research 1-3 Credits**

Laboratory research under tutorial with a faculty member. Must have junior standing. Consent of instructor required.

**Repeat Status:** Course may be repeated.

**Attribute/Distribution:** ND

**BIOS 393 Thesis 3 Credits**

Literature review and design of project in selected area, execution of the project, final report and presentation. Consent of department required. Intended for senior majors in BIOS only. Consent of instructor required.

**Repeat Status:** Course may be repeated.

**Attribute/Distribution:** ND

**BIOS 401 Professional Skills for Biological Sciences Graduate Students 3 Credits**

Students learn expectations and fundamental skills related to success in the biological sciences. The course is designed to help students make the most out of their graduate education. Students learn the principles underlying fundable, publishable research, and how these general principles can be applied to their specific research area. They learn to write and review manuscripts and grant proposals by serving on a mock editorial board and scientific review panel. They gain experience in giving oral presentations. Readings are from texts on scientific writing and research styles, and from original journal articles and grant proposals written by the faculty. Required of all Integrative Biology graduate students.

**BIOS 404 (PSYC 404) Behavioral Neuroscience 3 Credits**

Theoretical and empirical issues in biopsychology. Must have graduate standing.

**BIOS 405 Special Topics in Molecular Biology 1-3 Credits**

Research, conferences, and reports on selected topics not covered in the general graduate offerings.

**Repeat Status:** Course may be repeated.

**BIOS 406 Biological Sciences Seminar 1 Credit**

An advanced seminar in current developments including departmental research. Required for candidates for graduate degrees in molecular biology.

**Repeat Status:** Course may be repeated.

**BIOS 407 Research in Biological Science 1-9 Credits**

Laboratory investigations in one of the department's research areas.

**BIOS 408 Responsible Conduct of Science 0 Credits**

Responsible practice in research. Training in general laboratory methods; human subjects concerns; radiation safety; chemical hazards; aseptic technique; physical, mechanical, biological, and fire hazards; animal welfare. Occupational and workplace considerations. Recombinant DNA guidelines; patent and proprietary rights; controversies over applications of science. Appropriate aspects required of investigators in all departmental research projects.

**BIOS 409 Evolutionary and Functional Morphology 3 Credits**

Readings in the current literature, demonstrations and laboratory exercises exploring the applications of comparative methods to the analysis of evolutionary patterns at a range of morphological levels (molecular and macroscopic). Students will also learn experimental approaches to testing relationships between form and function in vertebrates. Emphasis will be on the musculoskeletal and nervous systems.

**BIOS 410 Special Topics in Behavioral and Evolutionary Bioscience 1-3 Credits**

Readings and discussions on selected topics not covered in the general graduate offerings.

**BIOS 411 Advanced Cell Biology 3 Credits**

Cell structure and biochemistry, as related to specialized cell functions.

**BIOS 412 Metabolic Influences on Behavior 3 Credits**

Sensory systems that detect metabolic energy availability and affect the behavior of humans and other animals: food intake and body weight regulation, sexual and parental behavior, aggression, learning, and body temperature regulation.

**BIOS 414 Sexual Differentiation 3 Credits**

Genetic and hormonal events mediating the development and expression of sexual dimorphisms in physiology and behavior. Current theoretical models; emphasis on biochemical, neuroanatomical and molecular biological considerations.

**BIOS 415 Synapses, Plasticity and Learning 3 Credits**

Communication between neurons. Physiology of synaptic transmission; varying forms of neuronal plasticity; acquisition, encoding and retrieval of memory.

**BIOS 420 Pheromonal Communication 3 Credits**

Mechanisms of pheromone synthesis, biochemistry, sensory transduction, neuroanatomy/neuroendocrinology, and adaptive significance.

**BIOS 421 Molecular Cell Biology I 3 Credits**

Molecular aspects of cell structure, cell motility, intracellular transport; and biomembrane dynamics.

**Prerequisites:** BIOS 411

**BIOS 422 Molecular Cell Biology II 3 Credits**

Molecular aspects of gene expression, including genome structure and replication, RNA synthesis/processing, and protein synthesis.

**Prerequisites:** BIOS 345

**BIOS 423 Evolution of Development 3 Credits**

This course examines how changes in the blueprint that describes the development of a multicellular animal from a single fertilized egg lead to the evolution of new species or new forms within a species.

**Prerequisites:** BIOS 317 or BIOS 376 or BIOS 327

**Can be taken Concurrently:** BIOS 317, BIOS 376, BIOS 327

**BIOS 424 Advanced Neurobiology of Sensory Systems 3 Credits**

This course is designed to provide an overview of core principles of neuroscience through exploration of sensory systems. The course will provide an intensive review of fundamental neural signaling followed by a broad introduction to the major sensory pathways. Focus will be on major organizing principles of neural systems, and information processing. Student discussions and presentations will incorporate current literature and concepts.

**BIOS 426 Coevolution 3 Credits**

Discussion-based seminar course covering readings from the primary literature. Course will examine evolutionary consequences of species interactions, interactions between the sexes, and genetic interactions. Topics will include predator-prey interactions, host-parasite interactions, sexual conflict, genomic conflict, mutualism, and more. Consequences of coevolution for biodiversity and human health will also be examined.

**BIOS 427 Techniques in Cell and Molecular Biology 1-3 Credits**

Laboratory experiences in three or more cell and molecular biological techniques: gel electrophoresis of nucleic acids/proteins; polymerase chain reaction; DNA/RNA sequencing; molecular hybridization techniques; fluorescence microscopy; confocal microscopy; flow cytometry; electron microscopy tissue preparation; immunological detection methods; molecular cloning techniques; oocyte microinjection techniques; tissue culture methods; and autoradiography.

**BIOS 428 Molecular Evolution 3 Credits**

Evolution at the level of individual genes, proteins, and genomes. Lectures and discussion of papers from the recent primary literature. Topics include pathways for adaptive evolution, directionality in evolution, epistasis, evolvability, genome rearrangements and speciation, gene duplication, and evolutionary dynamics. Examples of molecular evolution in nature, laboratory model systems, and human pathogens.

**Prerequisites:** BIOS 317 or BIOS 345

**Can be taken Concurrently:** BIOS 317, BIOS 345

**BIOS 429 Advances in Herpetology 3 Credits**

Lectures and readings from the primary literature on current research in amphibian and reptilian biology. Two lectures, one discussion session and one laboratory or field trip. Not open to students who have received credit for BIOS 329.

**BIOS 431 Advanced Topics in Cell Biology 3 Credits**

Current research problems in cell biology.

**Repeat Status:** Course may be repeated.

**Prerequisites:** BIOS 367 or BIOS 367 or BIOS 411

**BIOS 432 Advanced Topics in Molecular Genetics 3 Credits**

Current research in molecular genetics.

**Repeat Status:** Course may be repeated.

**BIOS 433 Advanced Topics in Developmental Biology 3 Credits**

Current research problems in developmental biology.

**Repeat Status:** Course may be repeated.

**Prerequisites:** BIOS 345 or BIOS 345

**BIOS 434 Speciation 3 Credits**

Discussion-based seminar course covering readings from classical and current literature, including both theoretical and empirical contributions. Topics will be included species concepts, reproductive isolation, mechanisms and modes of speciation, and current approaches to studying speciation.

**BIOS 437 (CHM 437) Pathophysiological Chemistry 3 Credits**

Biochemical basis of human diseases involving abnormal metabolism of proteins, nucleic acids, carbohydrates, and lipids. Emphasis on the correlation of the clinical presentation of disease processes seen as physiological dysfunctions with clinical laboratory methods. Lectures, student presentations, and clinical case discussions. Consent of department required.

**BIOS 438 Neurodegenerative Diseases in Model Organisms 3 Credits**

Discussion-based seminar course on the use of model systems to investigate neurodegenerative diseases. The primary focus will be on invertebrate model systems, including *Drosophila*. Critical reading of primary scientific literature and student discussion is required.

**Prerequisites:** BIOS 115

**BIOS 439 Advanced Behavioral Ecology 3 Credits**

Critical evaluation of the theoretical foundation in sociobiology. Emphasis placed on kinship, altruism, mate choice, parental investment, parent-offspring conflict, etc. Lectures and seminars. Not open to students who have taken BIOS 337.

**Prerequisites:** BIOS 317 or BIOS 317

**BIOS 442 Cellular Basis of Human Disease 3 Credits**

Cell and molecular biological advanced topics relevant to human disease and/or health. Critical reading of the primary literature, discussion and student discussion required.

**Prerequisites:** BIOS 367 or BIOS 411

**BIOS 445 Systematics and Evolution 3 Credits**

Theoretical, philosophical and methodological foundations of the classification of eukaryotic organisms and the manner in which systematic theory and method relate to evolutionary theory. Two lectures and one lab/recitation/discussion session.

**BIOS 450 Developmental Neurobiology 3 Credits**

Fundamental mechanisms underlying neural development. Early events leading to the induction of the neuroectoderm and the reorganization of the vertebrate central nervous system during adulthood and aging. Major developmental events such as phenotype commitment, cell migration, differentiation and growth cone guidance. Emphasis on the interplay between concepts emerging from organismal and molecular levels of analyses.

**BIOS 453 General Neuroanatomy 3 Credits**

Graduate level study of the neuroanatomy and neurochemistry of systems that underlie behavior in vertebrates. Emphasis will be on the traditional and novel methodologies used to reveal neuroanatomical pathways as well as the function of these pathways. Consent of department required.

**BIOS 457 Advanced Behavioral Neuroendocrinology 3 Credits**

A seminar course that covers current primary literature on the hormone-nervous system interactions that underlie physiology and behavior. The course covers the neuroendocrinology of reproduction, sex behavior, parental behavior, social behavior, agonistic and territorial behavior, learning and memory, homeostasis (caloric, nutritional, water and salt balance, temperature regulation), circadian rhythms and seasonality in a variety of vertebrates.

**BIOS 464 Molecular Biology of Eukaryotic Organisms 3 Credits**

Comparative analysis of several eukaryotes as model systems in cell biology, developmental biology, genetics, and molecular biology.

**BIOS 466 Structure and Function of RNAs and Ribonucleoprotein Complexes 3 Credits**

Biochemistry and function of small nuclear RNPs, RNase P, ribosomes, self-splicing introns, signal recognition particle, RNA viruses. Functions of RNA in DNA replication, in regulation, as an enzyme, and as a repressor.

**BIOS 467 (CHM 467) Principles of Nucleic Acid Structure 3 Credits**

An examination of the principles underlying nucleic acid structure including stereochemistry, electrostatics, hydration, torsional constraints, sequence specific effects, and interaction with nuclear proteins. Special emphasis will be placed on DNA structure. Must have completed one year of biochemistry and one year of physical chemistry or consent of department required.

**BIOS 468 (CHM 468) Principles of Protein Structure 3 Credits**

An examination of the principles underlying protein structure including stereochemistry, preferred tertiary structures, protein homology, excluded volume effects, time dependent structural fluctuations, and prediction of protein structure from sequence information. Must have completed one year of biochemistry and one year of physical chemistry or consent of department required.

**BIOS 469 (CHM 469) Biochemical Problem Solving I 1 Credit**

Applications of material covered in BIOS 371 or CHM 371 including techniques used in research.

**BIOS 470 (CHM 470) Biochemical Problem Solving II 1 Credit**

Applications of concepts covered in BIOS 372 or CHM 372 including techniques used in research.

**BIOS 471 Eukaryotic Signal Transduction 3 Credits**

Signal transduction between and within cells of multicellular organisms examined in the context of specialized functions that include: nutrition, hormones and neurotransmitters, vision, muscle contraction, adhesion and the immune system. The evolution of cancer based on mutations in these signaling systems. Lecture, discussion, and student presentations.

**Prerequisites:** (BIOS 372 or CHM 372 or BIOS 411)

**BIOS 472 (CHM 472) Lipids and Membranes 3 Credits**

Structure, physical properties and functions of lipids and their biological aggregates. Techniques for studying lipid assemblies, enzymes which act on lipids, membrane proteins and lipoproteins will also be discussed.

**Prerequisites:** BIOS 372 or CHM 372

**BIOS 473 (CHM 473) Principles of Biochemistry I 3 Credits**

Study of proteins, carbohydrates, lipids, nucleic acids and other biological substances. Protein and enzyme chemistry are emphasized. Must have completed one year each of general chemistry and organic chemistry.

**BIOS 477 (CHM 477) Topics in Biochemistry 1-3 Credits**

Selected areas of biochemistry, such as mechanisms of enzyme action, new developments in the chemistry of lipids, nucleic acids, carbohydrates and proteins.

**Repeat Status:** Course may be repeated.

**BIOS 479 (CHM 479) Biochemical Techniques 3 Credits**

Laboratory studies of the techniques and principles involved in the isolation, identification, and biochemical transformation of carbohydrates, lipids, nucleic acids and proteins.

**Prerequisites:** (BIOS 371)

**Can be taken Concurrently:** BIOS 371

**BIOS 480 (CHM 480) Advanced Biochemical Preparations 1-3 Credits**

An advanced laboratory course in the preparation, isolation, purification, and identification of biochemically produced materials. Emphasis is placed on materials and procedures of current interest in biochemistry. Consent of department required.

**BIOS 483 Special Topics in Behavioral Neuroscience 3 Credits**

Examination of the biological substrates of behavior. Topics may include animal communication, sociobiology, behavioral endocrinology, or behavior genetics.

**Repeat Status:** Course may be repeated.

**BIOS 486 Genes and the Brain 3 Credits**

Modern molecular genetics techniques applied to complex brain processes. Emphasis on DNA and RNA manipulation strategies to elucidate mechanisms of complex behaviors. Animal models of learning, behavioral plasticity, and neuropsychiatric diseases.

**Attribute/Distribution:** NS

**BIOS 488 Seminar in Neuroscience, Behavior, and Evolution 1  
Credit**

Advanced seminar in current research developments.

**BIOS 490 Thesis 1-6 Credits**

**Repeat Status:** Course may be repeated.

**BIOS 499 Dissertation 1-15 Credits**