

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.

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	Introduction to Cellular and Molecular Biology and Introduction to Cellular and Molecular Biology Laboratory	4
or BIOS 043	Phage Hunting Laboratory	
BIOS 044 & BIOS 045	Introduction to Integrative and Comparative Biology and Introduction to Integrative and Comparative Biology Laboratory	4
BIOS 115 & BIOS 116	Genetics and Genetics Laboratory	4
or BIOS 118	Phage Genetics Laboratory	

Biology electives ¹ 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

1

Biology electives must include one course from List A (see below) and one course from List B (see below). List C (see below) course electives can count as either List A or List B Biology electives.

These will be chosen in consultation with the major advisor. No more than 3 credits can be used from the following courses: BIOS 161, BIOS 261, BIOS 262, BIOS 391, BIOS 393, College scholar project.

Credits from BIOS 130 cannot be used to fulfill the biology elective requirement.

Biology Electives List A

Choose one of the following:

BIOS 234	Comparative Vertebrate Anatomy	4
BIOS 241		4
BIOS 276	Central Nervous System and Behavior	3
BIOS 313		4
BIOS 314		4
BIOS 315	Neuropharmacology	3
BIOS 317	Evolution	3
BIOS 326	Coevolution	3
BIOS 329		3
BIOS 332	Behavioral Neuroanatomy	3
BIOS 334	Species and Speciation	3
BIOS 335	Animal Behavior	3
BIOS 337	Behavioral Ecology	3
BIOS 369		3-4
BIOS 374		3
BIOS 382	Endocrinology of Behavior	3
BIOS 385	Synapses, Plasticity and Learning	3
EES 152	Ecology	4

No more than one of the following:

EES 250	Terrestrial Ecosystems	4
EES 358	Microbial Ecology	3,4
EES 386	Wetland Ecology	3,4

Biology Electives List B

Choose one of the following:

BIOS 237	Introductory Molecular Modeling and Simulation	3
BIOS 324	Microbiology	3
BIOS 327	Development and Disease	3
BIOS 328	Immunology	3
BIOS 330	Molecular Evolution	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 353	Virology	3
BIOS 367	Cell Biology	3
BIOS 371	Elements of Biochemistry I	3
BIOS 372	Elements of Biochemistry II	3
BIOS 380		3-4
BIOS 381	Physical Biochemistry	3
BIOS 384	Eukaryotic Signal Transduction	3

Biology Electives List C

These courses can count as either List A or List B Biology Electives:

BIOS 235	Human Physiology	3
BIOS 323	Evolution of Development	

BIOS 338	Neurodegenerative Diseases in Model Organisms	3
BIOS 343	Personal Genomics	3
BIOS 365	Neurobiology of Sensory Systems	3
BIOS 366	Diseases of the Nervous System	3
BIOS 376	Developmental Biology	3
BIOS 386	Genes and the Brain	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	Introduction to Cellular and Molecular Biology and Introduction to Cellular and Molecular Biology Laboratory	4
or BIOS 043	Phage Hunting Laboratory	
BIOS 044 & BIOS 045	Introduction to Integrative and Comparative Biology and Introduction to Integrative and Comparative Biology Laboratory	4
BIOS 115 & BIOS 116	Genetics and Genetics Laboratory	4
or BIOS 118	Phage Genetics Laboratory	
BIOS 317	Evolution	3
Biology electives ¹		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	General Physics I	4
or PHY 011	Introductory Physics I	
PHY 012	Introductory Physics Laboratory I	1
PHY 013	General Physics II	3
or PHY 021	Introductory Physics II	
PHY 022	Introductory Physics Laboratory II	1

Total Credits **98-99**

1

Biology electives must include two courses from List A (see below) and two courses from List B (see below) and at least four credits of laboratory experience (e.g., two 2 credit laboratory courses). List C (see below) course electives can count as either List A or List B Biology electives. 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 241		4
BIOS 276	Central Nervous System and Behavior	3
BIOS 313		4
BIOS 314		4
BIOS 315	Neuropharmacology	3
BIOS 323	Evolution of Development	3
BIOS 326	Coevolution	3
BIOS 329		3
BIOS 332	Behavioral Neuroanatomy	3
BIOS 334	Species and Speciation	3
BIOS 335	Animal Behavior	3
BIOS 337	Behavioral Ecology	3
BIOS 348	Marine Biology	3
BIOS 369		3-4
BIOS 374		3
BIOS 382	Endocrinology of Behavior	3
BIOS 385	Synapses, Plasticity and Learning	3
EES 152	Ecology	4
No more than one of the following:		
EES 250	Terrestrial Ecosystems	4
EES 358	Microbial Ecology	3,4
EES 386	Wetland Ecology	3,4

Biology Electives List B

Choose two of the following:

BIOS 237	Introductory Molecular Modeling and Simulation	3
BIOS 324	Microbiology	3
BIOS 327	Development and Disease	3
BIOS 328	Immunology	3
BIOS 330	Molecular Evolution	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 380		3-4
BIOS 381	Physical Biochemistry	3
BIOS 384	Eukaryotic Signal Transduction	3

Biology Electives List C

These courses can count as either List A or List B Biology Electives:

BIOS 235	Human Physiology	3
BIOS 323	Evolution of Development	
BIOS 338	Neurodegenerative Diseases in Model Organisms	3
BIOS 365	Neurobiology of Sensory Systems	3
BIOS 366	Diseases of the Nervous System	3

BIOS 376	Developmental Biology	3
BIOS 386	Genes and the Brain	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		
CHM 110 & CHM 111		4
BIOS 044 & BIOS 045		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

Fourth Year		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	Introduction to Cellular and Molecular Biology and Introduction to Cellular and Molecular Biology Laboratory	4
BIOS 044	Introduction to Integrative and Comparative Biology	3
BIOS 115 & BIOS 116	Genetics and Genetics Laboratory	4
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	Introduction to Cellular and Molecular Biology and Introduction to Cellular and Molecular Biology Laboratory	4
or BIOS 043	Phage Hunting Laboratory	
BIOS 044 & BIOS 045	Introduction to Integrative and Comparative Biology and Introduction to Integrative and Comparative Biology Laboratory	4
BIOS 115 & BIOS 116	Genetics and Genetics Laboratory	4
or BIOS 118	Phage Genetics Laboratory	
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 ¹		
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 56-57¹

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	Introduction to Cellular and Molecular Biology and Introduction to Cellular and Molecular Biology Laboratory	4
or BIOS 043	Phage Hunting Laboratory	
BIOS 044 & BIOS 045	Introduction to Integrative and Comparative Biology and Introduction to Integrative and Comparative Biology Laboratory	4
BIOS 115 & BIOS 116	Genetics and Genetics Laboratory	4
or BIOS 118	Phage Genetics Laboratory	
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	

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 ¹	
BIOS 377	Biochemistry Laboratory	
BIOS 277 or BIOS 278 or BIOS 279 (must be different than course chosen for Required Major Courses)		

Advanced BIOS Course Requirement

Select two of the following:		6
BIOS 315	Neuropharmacology	
BIOS 323	Evolution of Development	
BIOS 338	Neurodegenerative Diseases in Model Organisms	
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	

Math and Science Requirements for the B.S.

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

Major Electives

Select two of the following:		6
Any 300-level BIOS course not fulfilling another BNS requirement above. ²		
PSYC 117	Cognitive Psychology	
PSYC 153	Personality	
PSYC 176	Cognitive Neuroscience	

Total Credits **77-81**

1

If this course is elected, Cell Biology BIOS 367 must be taken as an elective.

2

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

Biology

BIOS 041 & BIOS 042	Introduction to Cellular and Molecular Biology and Introduction to Cellular and Molecular Biology Laboratory	4
or BIOS 043	Phage Hunting Laboratory	
BIOS 044 & BIOS 045	Introduction to Integrative and Comparative Biology and Introduction to Integrative and Comparative Biology Laboratory	4
BIOS 115 & BIOS 116	Genetics and Genetics Laboratory	4
or BIOS 118	Phage Genetics Laboratory	
Select one of the following:		3
BIOS 324	Microbiology	
BIOS 328	Immunology	
Select one of the following:		2-3
BIOS 325	Microbiology 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

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

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 4Organic Chemistry I
and Organic Chemistry Laboratory ICHM 112
& CHM 113 4Organic Chemistry II
and Organic Chemistry Laboratory II**Physics**

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 4

Biostatistics

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 4Organic Chemistry I
and Organic Chemistry Laboratory ICHM 112
& CHM 113 4Organic Chemistry II
and Organic Chemistry Laboratory II**Physics**

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

Molecular BiologyBIOS 041
& BIOS 042 4Introduction to Cellular and Molecular
Biology
and Introduction to Cellular and
Molecular Biology Laboratory

or BIOS 043 Phage Hunting Laboratory

BIOS 044
& BIOS 045 4Introduction to Integrative and
Comparative Biology
and Introduction to Integrative and
Comparative Biology LaboratoryBIOS 115
& BIOS 116 4Genetics
and Genetics Laboratory

or BIOS 118 Phage Genetics Laboratory

Select one of the following: 3

BIOS 324 Microbiology

BIOS 328 Immunology

Select one of the following: 2-3

BIOS 325 Microbiology Laboratory

BIOS 368 Cell Biology Laboratory

BIOS 377 Biochemistry Laboratory

BIOS 345
& BIOS 346 5Molecular Genetics
and Molecular Genetics Laboratory

BIOS 367 3

Cell Biology

BIOS 371 3

Elements of Biochemistry I

BIOS 372 3

Elements of Biochemistry II

BIOS 381 3

Physical Biochemistry

BIOS Approved Molecular Biology Electives 12

Total Credits 82-85**RECOMMENDED SEQUENCE FOR THE B.S. IN MOLECULAR BIOLOGY**

First Year CR 4

BIOS 041
& BIOS 042 4

MATH 021 4

MATH 022 4

CHM 030 4

CHM 031 4

20

Second Year CR 4

BIOS 115
& BIOS 116 4CHM 110
& CHM 111 4CHM 112
& CHM 113 4PHY 010
& PHY 012 5PHY 013
& PHY 022 4**21**

Third Year CR 4

BIOS 044
& BIOS 045 4

BIOS 324 or 328 3

BIOS 325, 368, or 377 2

BIOS 345
& BIOS 346 5BIOS 371
& BIOS 372 6**20**

Fourth Year	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	Introduction to Cellular and Molecular Biology and Introduction to Cellular and Molecular Biology Laboratory	4
BIOS 115 & BIOS 116	Genetics and 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
Collateral coursework		
MATH 051 or MATH 021	Survey of Calculus I 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/artsandsciences/>).

GRADUATE STUDY IN THE BIOLOGICAL SCIENCES

A research oriented program leading to a Doctor of Philosophy in Biology is offered, with concentrations in: biochemistry (https://www.lehigh.edu/~inbios/Grad/Grad_DDP.html#biochem), evolution and behavior (https://www.lehigh.edu/~inbios/Grad/Grad_DDP.html#evolution), neuroscience (https://www.lehigh.edu/~inbios/Grad/Grad_DDP.html#neuro) and cell and molecular biology (https://www.lehigh.edu/~inbios/Grad/Grad_DDP.html#cell). 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.

Concentration: Biochemistry

In the Biochemistry concentration, research areas include DNA/RNA structure and function, regulation of protein synthesis, and signal transduction. Students admitted to graduate study in the biochemistry concentration will typically have an undergraduate degree in Chemistry or Biochemistry. Students with an undergraduate degree in a related discipline are 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 are expected to take courses to fulfill those requirements as part of their graduate study.

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 24 course credits, 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 will be completed during the fourth semester in the program. The proposal-based qualifying exam will require students to generate a specific hypothesis that extends from current findings within the literature, and to design an appropriate experimental approach to test their hypothesis. The exam will consist of two parts: a written proposal and an oral examination. The goal of the exam is to test the student's depth and breadth of knowledge in their chosen field. If a student fails their first attempt at the written proposal or the oral examination, they will be provided one opportunity to re-do each component of the qualifying exam. Admission to candidacy is granted after successful completion of the qualifying exam.

Next, a thesis 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. In summary, the successful completion of coursework, the qualifying exam, and the defense of a Dissertation Proposal/General Examination are requirements for Admission to Candidacy, the second stage of the graduate experience.

Course 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 the Program Core listed below. 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.

Program Core

BIOS 401	Professional Skills for Biological Sciences Graduate Students	3
BIOS 402	Ethics and Rigor in Research	1
BIOS 406	Biological Sciences Seminar (2 semesters (1 credit each semester))	2
BIOS 408	Responsible Conduct of Science	0

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.

Core Competency Courses

Required if background is insufficient. Need will be determined by the Graduate Committee based on the student's academic history.

BIOS 473	Principles of Biochemistry I	3
BIOS 372	Elements of Biochemistry II	3

Concentration Electives

Concentration electives, choose 3-4 courses, (1-12 credits). Note: If both BIOS 473 and BIOS 372 were taken, choose only 2 courses.

BIOS 471	Eukaryotic Signal Transduction	3
BIOS 472	Lipids and Membranes	3
BIOS 474	Computational, Molecular Modeling and Simulation	3

Free Electives

400 or 300-level courses outside of concentration or department. Choose 1-3 courses together with the Graduate Committee or Research Advisor. (3-9 credits)

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.

Core Competency Course

Required if background is insufficient. Need will be determined by the Graduate Committee based on the student's academic history.

BIOS 404	Behavioral Neuroscience	3
----------	-------------------------	---

Concentration Electives

Choose 3-4 courses (9-12 credits)

BIOS 415	Synapses, Plasticity and Learning
BIOS 424	Advanced Neurobiology of Sensory Systems
BIOS 438	Neurodegenerative Diseases in Model Organisms
BIOS 453	General Neuroanatomy
BIOS 457	Advanced Behavioral Neuroendocrinology
BIOS 486	Genes and the Brain

Free Electives

400 or 300-level courses outside of concentration or department. Choose 1-3 courses together with the Graduate Committee or Research Advisor. (3-9 credits)

BEHAVIOR AND EVOLUTION CONCENTRATION

The graduate program in evolution and behavior is designed to train students in advanced organismal biology with emphasis 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.

BEHAVIOR AND EVOLUTION CONCENTRATION

Core Competency Course

Required if background is insufficient. Need will be determined by the Graduate Committee based on the student's academic history.

BIOS 317	Evolution
----------	-----------

Concentration Electives

Choose 3-4 courses (9-12 credits)

BIOS 423	Evolution of Development
BIOS 426	Coevolution
BIOS 428	Molecular Evolution
BIOS 434	Speciation
BIOS 439	Advanced Behavioral Ecology
BIOS 448	Marine Biology
BIOS 449	Molecular Ecology

Free Electives

400 or 300-level courses outside of concentration or department. Choose 1-3 courses together with the Graduate Committee or Research Advisor. (3-9 credits)

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.

Core Competency Course

Required if background is insufficient. Need will be determined by the Graduate Committee based on the student's academic history.

BIOS 345	Molecular Genetics	3
----------	--------------------	---

Concentration Electives

Choose 3-4 courses (9-12 credits)

BIOS 411	Advanced Cell Biology
BIOS 421	Molecular Cell Biology I
BIOS 422	Molecular Cell Biology II
BIOS 442	Cellular Basis of Human Disease
BIOS 443	Personal Genomics
BIOS 466	Structure and Function of RNAs and Ribonucleoprotein Complexes

Free Electives

400 or 300-level courses outside of concentration or department. Choose 1-3 courses together with the Graduate Committee or Research Advisor. (3-9 credits)

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 3 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 032 (EES 032) Oceanography 3 Credits

An introduction to the structure, composition, and processes of the earth from a marine perspective. Topics include earth structure, plate tectonics, continental margins, coastal processes, seawater chemistry, ocean circulation, wave dynamics, primary productivity, plankton and plants, marine organisms and communities. May be combined with EES 022 or EES 004 for 4 credits.

Attribute/Distribution: NS

BIOS 041 Introduction to Cellular and Molecular Biology 0,3 Credits

Basic building blocks and higher order 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, basic Mendelian genetics, 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 Introduction to Cellular and Molecular Biology Laboratory 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); 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 044 Introduction to Integrative and Comparative Biology 0,3 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 041 and (BIOS 042 or BIOS 043).

Prerequisites: BIOS 041 and (BIOS 042 or BIOS 043)

Attribute/Distribution: NS

BIOS 045 Introduction to Integrative and Comparative Biology Laboratory 1 Credit

Experiments and discussions related to the topics covered in BIOS 044; emphasis on experimental design and scientific communication.

Prerequisites: BIOS 044

Can be taken Concurrently: BIOS 044

Corequisites: BIOS 044

Attribute/Distribution: NS

BIOS 115 Genetics 0,3 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 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 recombinering 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 130 (MATH 130) Biostatistics 0,4 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 0-3 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 044 and BIOS 045

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 044

Attribute/Distribution: NS

BIOS 237 (BIOC 237) Introductory Molecular Modeling and Simulation 3 Credits

Key concepts, methods, and tools used in molecular modeling and simulation. A hybrid lecture/hands-on practice course using the lectures and tools in CHARMM-GUI (<http://www.charmm-gui.org/> lecture). Topics include (but not limited to) UNIX operating system, text editors, Python programming, scientific programming using Python, PDB (Protein Data Bank), molecular mechanics, minimization, molecular dynamics, Monte Carlo simulation. The understanding of these concepts and algorithms as well as their applications to well-defined practical examples involving currently important biological problems will be emphasized.

Prerequisites: CHM 030 or CHM 040

Attribute/Distribution: NS

BIOS 238 Epigenetics, Health, and Environment 3 Credits

Foundational concepts in environmental epigenetics. Course will be centered around presentations and discussions of studies that address current issues, such as the mechanisms behind heritable health effects of acute malnourishment in human populations across multiple generations, or the potential for extremely fast evolutionary adaptation in species threatened by environmental change. This course may be listed as a Writing Intensive course.

Prerequisites: BIOS 044

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 274 (HMS 274) Neuroethics 3 Credits

The intersection of neuroscience and ethics. History of biomedical science and current topics in neuroethics explored through weekly case studies and relevant readings in neurobiology. Examples include: definitions of mental illness, definitions of consciousness and brain death, addiction neuroscience, brain-machine interfaces, wearable technology, social determinants of health and equity within science and medicine. Reading and critical analysis of scientific articles, integration of biological concepts with moral reasoning, effective written communication and participation in peer review, oral presentations and group discussions.

Prerequisites: BIOS 044

Attribute/Distribution: NS

BIOS 276 Central Nervous System and Behavior 0,3 Credits

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

Prerequisites: BIOS 044

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 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 0,3 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 044

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: 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

Can be taken Concurrently: 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 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 044

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 044

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 339 Computational, Molecular Modeling and Simulation 3 Credits

This course is designed to introduce the most basic and key concepts, methods, and tools used in molecular modeling and simulation. This class is a hybrid of lecture and hands-on practice styles, using the lectures and tools in CHARMM-GUI (<http://www.charmm-gui.org/> lecture). Some topics include the UNIX operating system, text editors, Python programming and Monte Carlo simulation. The understanding of these concepts and algorithms, as well as their applications to well-defined practical examples involving currently important biological problems will be emphasized.

Attribute/Distribution: NS

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 343 Personal Genomics 3 Credits

Contemporary methods and technologies for investigating human genetic variation and its use for inferring ancestry and risk for disease, along with discussions of relevant policy and ethics. Readings will include primary scientific literature in population and statistical genetics, government publications, and news reports. Final projects will involve development of outreach and education resources in this topic for non-experts.

Prerequisites: (BIOS 115 and BIOS 130) or BIOS 317

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 348 Marine Biology 3 Credits

Ecology and adaptations of marine species, populations and ecosystems. Studying life in the ocean requires a perspective that spans spatial and temporal scales from the planetary to the microscopic, from the geologic to the physiological, and from the surface to the deepest seafloor. Through this course, students develop a fundamental understanding of how the physical environment of planet earth shapes and is shaped by marine organisms.

Prerequisites: BIOS 041 and BIOS 042

Attribute/Distribution: NS

BIOS 349 Molecular Ecology 3 Credits

Molecular ecology is a field of research that seeks to answer questions in ecology, evolution, behavior and conservation; through the use of molecular tools. Biological scales range from organisms, to populations and species. This is a discussion-based course. Students read, present and analyze classic and modern scientific literature. Students also formulate a research proposal addressing outstanding questions in the field.

Prerequisites: BIOS 044

Attribute/Distribution: NS

BIOS 353 Virology 3 Credits

An introduction to viruses and their interactions with host organisms. Topics include viral pathogenesis, from entry through release, viral immune evasion mechanisms, and viral evolution. Vaccines, antiviral strategies, as well as therapeutic uses of viruses for gene therapy will be emphasized.

Prerequisites: BIOS 115

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 371 (CHM 371) Elements of Biochemistry I 0,3 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 473 or ((BIOS 371 or CHM 371) and BIOS 041)

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 376

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 0,3 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 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 044

Attribute/Distribution: NS

BIOS 383 Biological Sciences Colloquia 0,1 Credits

Analysis of weekly colloquia in the biological sciences.

Repeat Status: Course may be repeated.

Prerequisites: BIOS 044

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 402 Ethics and Rigor in Research 1 Credit

This course covers material critical to the responsible conduct of science, in addition to data reproducibility, rigor, research ethics, and misconduct.

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 0,1 Credits

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 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 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 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 or 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 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 435 Epigenetics 3 Credits

Foundational concepts in environmental epigenetics. Course will be centered around presentations and discussions of studies that address current issues, such as the mechanisms behind heritable health effects of acute malnourishment in human populations across multiple generations, or the potential for extremely fast evolutionary adaptation in species threatened by environmental change.

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 443 Personal Genomics 3 Credits

Contemporary methods and technologies for investigating human genetic variation and its use for inferring ancestry and risk for disease, along with discussions of relevant policy and ethics. Readings will include primary scientific literature in population and statistical genetics, government publications, and news reports. Final projects will involve development of outreach and education resources in this topic for non-experts.

BIOS 448 Marine Biology 3 Credits

Ecology and adaptations of marine species, populations, and ecosystems. With an average depth of more than two miles, the ocean makes up more than 95% of the habitable space on our planet. Ocean ecosystems are essential life support systems for the entire earth. Studying life in the ocean requires a perspective that spans spatial and temporal scales from the planetary to the microscopic, from the geologic to the physiological, and from the surface to the deepest seafloor. Through this course,.

BIOS 449 Molecular Ecology 3 Credits

Molecular ecology is a field of research that seeks to answer questions in ecology, evolution, behavior and conservation; through the use of molecular tools. Biological scales range from organisms, to populations and species. This is a discussion-based course. Students read, present and analyze classic and modern scientific literature. Students also formulate a research proposal addressing outstanding questions in the field.

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 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

The study of lipids and lipid membranes similar to those found in mammalian cells including methods of synthesis, surface activity, bilayer and micellar structures, lipid mixing, fluidity, permeability and membrane stability. Special emphasis will be given to the current evidence for and against the lipid raft hypothesis.

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 474 Computational, Molecular Modeling and Simulation 3 Credits

This course is designed to introduce the basic and advanced concepts, methods, and tools used in molecular modeling and simulation. This class is a hybrid of lecture and hands-on practice styles, using the lectures and tools in CHARMM-GUI (<http://www.charmm-gui.org/lecture>). Topics include (but are not limited to) the UNIX operating system, text editors, Python programming, scientific programming using Python, PDB (Protein Data Bank) format, molecular mechanics, minimization, molecular dynamics, Monte Carlo simulation. The understanding of these concepts and algorithms, as well.

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 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