An interdepartmental program

Biological Physics

Courses of Study:
Major (BS)

Objectives

The undergraduate major in biological physics is designed to provide the quantitative skills and background in chemistry and biology for students interested in the study of the physics of biological systems, especially on the molecular scale. This program provides a strong foundation in the physical sciences that underpin much of the modern revolution in biology. It should be of particular interest to students wishing to pursue careers in fundamental or applied research in biophysics, quantitative biology, and biotechnology.

For a related graduate program, please see the Biophysics and Structural Biology Program elsewhere in this *Bulletin*.

How to Become an Major

The major requires a large number of science courses, some of which are prerequisites for more advanced courses. Therefore, it is important to start taking these courses in the first year. Students are advised to meet with the biological physics chair as soon as possible to plan their schedule. It is most advantageous to take physics and math in the first year, but starting with chemistry and math in the first year is also adequate.

The Seminar in Biological Physics (BIPH 11a,b) is recommended for first-year students, but can be taken in the second year. Students interested in the honors program, involving a senior research thesis, should begin to seek a faculty mentor by the end of their second year, with the prospect of starting research as early as possible.

Committee

Robert Meyer, Chair
(Physics, Volen National Center for Complex Systems)

Bulbul Chakraborty
(Physics)

Zvonimir Dogic
(Physics)

Seth Fraden
(Physics, Volen National Center for Complex Systems)

Jeff Gelles
(Biochemistry)

Anne Gershenson
(Chemistry)

Michael Hagan
(Physics)

Dorothee Kern
(Biochemistry, Volen National Center for Complex Systems)

Jané Kondev
(Physics)

Gregory Petsko
(Biochemistry and Chemistry, and Director, Rosenstiel Center)

Dagmar Ringe
(Biochemistry and Chemistry, and Rosenstiel Center)

Azadeh Samadani
(Physics)

Requirements for the Major

Degree of Bachelor of Science
To satisfy the requirements for the major in biological physics leading to the degree of Bachelor of Science, students must successfully complete the foundation of this program, which is a set of required courses in the physical and life sciences. The core courses, divided by fields, are:

Physics: PHYS 15a,b; PHYS 19a,b; PHYS 20a,b; PHYS 30b; PHYS 39; PHYS 40

Mathematics: MATH 10a,b

Chemistry: CHEM 11a,b and CHEM 18a,b or equivalents

Biology: BIOL 18a,b and BIOL 22a,b

Biological Physics: BIPH 11a,b

The Seminar in Biological Physics (BIPH 11a,b) should be taken in the first or second year. Students who enter the program after their first year may find it convenient to replace BIPH 11a,b with PHYS 105A, Biological Physics, which covers the same material at a higher level of both mathematics and physics.

Students with high enough Advanced Placement Examination scores may place out of some of the elementary courses. See the Advanced Placement Credit chart on page 23 for details concerning the equivalent Brandeis courses for sufficient scores in the tests in Mathematics (AB or BC), Physics (C), and Chemistry. Concentration credit is given for all these tests except for Physics C: Electrical. Students who take Advanced Placement credit for Physics 15b will be required to take Physics 30a, the intermediate-level course in this subject.

Beyond the core, curriculum students are expected to explore areas of further inquiry by taking at least two elective courses. Possible topics and related courses are listed below. Other courses can be taken as electives with approval of the program advisor.

Molecular structure: The use of physical techniques including X-ray diffraction, electron microscopy, and nuclear magnetic resonance to elucidate the structure of bio-molecules. Electives: BIOL 102b, BCHM 171b*, BIOL 126b, BCHM 104b*.

Single molecule biophysics: The study of biological processes on the single molecule scale, such as enzyme function, ion transport through membranes, protein folding, molecular motors. Electives: BIOL 25a, BCHM 101a*.

Modeling of biological structure and function: The development and analysis of mathematical models for elucidating biological structure and function. Electives: CHEM 144a, PHYS 105a, NPHY 115a*, NBIO 136b.

Systems and networks: Study of topics including bioinformatics, neural networks, and networks of genes and proteins. Electives: BCHM 170b*, NBIO 140b.

*Required prerequisites for this course are not included in the core curriculum.

A student starting the biological physics major in the first year, with no Advanced Placement, should follow the recommended sequence:

Year 1: BIPH 11a,b; MATH 10a,b; PHYS 15a,b; PHYS 19a,b

Year 2: CHEM 11a,b; CHEM 18a,b; PHYS 20a,b

Year 3: BIOL 18a,b; BIOL 22 a,b; PHYS 40a

Year 4: PHYS 30b; PHYS 39a; two electives

A student with advanced preparation in math, physics, and chemistry who wants to emphasize biochemistry might take the following program:

Year 1: BIPH 11a,b; MATH 15a, MATH 20b; PHYS 19b, PHYS 20a,b

Year 2: BIOL 18a,b; BIOL 22a,b; CHEM 25a,b; CHEM 29a,b

Year 3: BCHM 100a; PHYS 40a; one elective

Year 4: PHYS 30a,b; PHYS 39a; one elective

Students with advanced preparation might choose additional courses in other areas rather than organic and biochemistry. A student who has started as a premed and switched to biological physics (not completing the premed program) might have the following program:

Year 1: CHEM 11a,b; CHEM 18a,b; MATH 10a,b

Year 2: BIOL 18a; BIOL 22a; BIPH 11a,b; PHYS 15a,b; PHYS 19a,b

Year 3: BIOL 18b; BIOL 22b; PHYS 20a,b; one elective

Year 4: PHYS 30b; PHYS 39a; PHYS 40a; one elective

In addition to the required courses, students are urged to learn the necessary topics in organic chemistry as preparation for biochemistry. This opens up additional options for undergraduate research and graduate programs in the life sciences. For medical school, a year of organic chemistry with laboratory, in addition to the required courses for biological physics, will complete the premed program requirements.

An important component of the program is the opportunity for students to participate in research. Opportunities exist for research in the laboratories of physics, chemistry, neuroscience, biochemistry, and biology faculty.

Honors Program
Graduation with honors requires completion of a senior research thesis. Students must enroll in BIPH 99d in their senior year to carry out a research project. Students wishing to join the honors program should apply to the honors advisor in the program in the spring of their junior year.

Special Notes Relating to Undergraduates

Students majoring in biological physics may not count required courses toward a minor in physics. By completing other required courses, they can complete a second major in physics. However, for the preparation for a career in biological physics, it might be more valuable to devote extra science courses to deeper preparation in chemistry and biochemistry.

Courses of Instruction

(1–99) Primarily for Undergraduate Students

BIPH 11a Seminar in Biological Physics
Corequisite: PHYS 15a. May yield half-course credit toward rate of work and graduation.
Introduction to recent experimental and theoretical advances in biological physics at the first-year physics level. Examples of topics include the physics of DNA and proteins, molecular motors, principles of laser tweezers, and atomic force microscopy. Can be taken before or after BIPH 11b. Usually offered every year.
Mr. Kondev

BIPH 11b Seminar in Biological Physics
Corequisite: PHYS 15b. May yield half-course credit toward rate of work and graduation.
Introduction to recent experimental and theoretical advances in biological physics at the first-year physics level. Examples of topics include the physics of DNA and proteins, molecular motors, principles of laser tweezers, and atomic force microscopy. Can be taken before or after BIPH 11a. Usually offered every year.
Mr. Kondev

BIPH 98a Reading in Biological Physics
Open to students wishing to study a subject not available in the curriculum.
Staff

BIPH 98b Reading in Biological Physics
Open to students wishing to study a subject not available in the curriculum.
Staff

BIPH 99d Senior Research
Research and preparation of a report under the direction of an instructor. Open to students doing research in an approved topic in biological physics.
Staff

Core Courses

BIOL 18a
General Biology Laboratory

BIOL 18b
General Biology Laboratory

BIOL 22a
Genetics and Molecular Biology

BIOL 22b
Cell Structure and Function

CHEM 11a
General Chemistry I

CHEM 11b
General Chemistry II

CHEM 18a
General Chemistry Laboratory I

CHEM 18b
General Chemistry Laboratory II

MATH 10a
Techniques of Calculus (a)

MATH 10b
Techniques of Calculus (b)

PHYS 15a
Advanced Introductory Physics I

PHYS 15b
Advanced Introductory Physics II

PHYS 19a
Physics Laboratory I

PHYS 19b
Physics Laboratory II

PHYS 20a
Modern Physics I

PHYS 20b
Modern Physics II

PHYS 30b
Quantum Theory

PHYS 39a
Advanced Physics Laboratory

PHYS 40a
Introduction to Thermodynamics and Statistical Mechanics

Elective Courses

The following courses are approved for the program. Not all are given in any one year. Please consult the Schedule of Classes each semester.

BCHM 101a
Advanced Biochemistry: Enzyme Mechanisms

BCHM 104b
Physical Chemistry of Macromolecules

BCHM 170b
Bioinformatics

BIOL 25a
Molecular Motors

BIOL 102b
Structural Molecular Biology

BIOL 126b
Protein Structure and Disease

CHEM 144a
Computational Chemistry

NBIO 136b
Computational Neuroscience

NBIO 140b
Principles of Neuroscience

NPHY 115a
Dynamical Systems, Chaos, and Fractals

PHYS 105a
Biological Physics

Department of

Biology

Courses of Study:
Major (BA/BS)
Combined BS/MS

Objectives

Undergraduate Major
The undergraduate program in biology, leading either to the BA or the BS degree, is designed to give students an understanding of fundamental and current biological knowledge in a variety of fields. The program offers a wide array of courses to undergraduates, ranging from introductory to advanced, specialized, graduate-level courses in many of these areas. The biology department has twenty-five full-time faculty members with teaching and research interests in the fields of genetics, molecular biology, development, cancer, immunology, neurobiology, motility, cell biology, structural biology, animal behavior, and ecology.

Since the interests and needs of our students vary, the major is designed to provide flexibility once the core courses have been completed. Students may elect undergraduate-level courses in a variety of areas of biology and biochemistry or may choose to obtain more-advanced, in-depth training in one particular area. Students are also encouraged to take advantage of opportunities to become integral members of research laboratories in the department and to attend departmental colloquia.

A major in biology provides excellent preparation for students intent on careers in biological research who want to go to graduate school; for those seeking careers in medicine, veterinary medicine, and dentistry; and for those interested in the allied health professions such as public health, genetic counseling, physical therapy, or physician assistant. For those seeking courses concerned with ecology or environmental science, the biology department offers study in those areas. See "Special Note B" below for additional programs in those areas.

Graduate Programs in the Biological Sciences
For MS and PhD degrees in the biological sciences, see the separate listings for molecular and cell biology, biophysics and structural biology, neuroscience, and genetic counseling programs in this *Bulletin*.

How to Become an Major

Students wishing to major in biology should enroll in general chemistry during their first year. Students may elect to take BIOL 15b, an introductory course in biology in the first year. Exceptionally well prepared students may enroll in Cell Structure and Function and/or Genetics in their first year. Most students begin the biology series in their sophomore year and take Genetics and Molecular Biology and Cell Structure and Function (BIOL 22a and b), plus labs. During their sophomore year, students should enroll in Organic Chemistry, with associated labs. While other course schedules are possible, the one described above allows students ample time to complete the remaining requirements (physics, and biology electives) for the biology degree during the junior and senior years and leaves students the option of enrolling in Senior Research during the senior year.

To learn more about the biology major, students should attend one of the special departmental programs held each fall or consult with the undergraduate advising head.

Faculty

Eve Marder, Chair (Volen National Center for Complex Systems)
Neurotransmitter modulation of neural circuits.

Susan Birren (National Center for Behavioral Genomics; Volen National Center for Complex Systems)
Developmental neurobiology.

Carolyn Cohen (Rosenstiel Center)
Structural molecular biology.

Paul Garrity (National Center for Behavioral Genomics; Volen National Center for Complex Systems)
Neural development and behavior.

Bruce Goode (Rosenstiel Center)
Biochemistry and genetics of yeast cytoskeleton.

Leslie Griffith (National Center for Behavioral Genomics; Volen National Center for Complex Systems)
Biochemistry of synaptic plasticity.

James Haber (Rosenstiel Center)
Genetics and molecular biology of yeast meiotic and mitotic recombination. Mating-type switching. Repair of broken chromosomes.

Jeffrey Hall (Volen National Center for Complex Systems)
Neurogenetics and molecular neurobiology of higher behaviors in *Drosophila*.

Kenneth Hayes (Director, Foster Animal Lab)
Comparative nutritional pathophysiology in man and animals. Lipoprotein metabolism and atherogenesis, cholelithiasis.

Elaine Hiller
Human genetics.

Melissa Kosinski-Collins
Protein biochemistry.

John Lisman (Volen National Center for Complex Systems; Chair, Neuroscience)
Mechanisms of phototransduction. Molecular mechanism of memory storage.

Susan Lovett (Rosenstiel Center)
Genetics and molecular biology of bacteria and yeast. DNA repair. Recombination and mutagenesis.

Michael Marr
Mechanisms controlling gene expression.

Paul Miller (Volen National Center for Complex Systems)
Computational and theoretical neuroscience.

James Morris
Evolution. Medicine. Epigenetics. History of science.

Sacha Nelson (National Center for Behavioral Genomics; Volen National Center for Complex Systems)
Synaptic integration in the visual cortex.

Daniela Nicastro (Rosenstiel Center)
Electron tomography of cellular and macromolecular structures.

Dan L. Perlman (Chair, Environmental Studies)
Ecology, conservation biology, animal behavior.

Joan Press, Undergraduate Advising Head (Rosenstiel Center)
Developmental immunology and immunogenetics.

Ruibao Ren (Rosenstiel Center)
Signal transduction.

Michael Rosbash (National Center for Behavioral Genomics)
RNA processing and molecular neurobiology.

Piali Sengupta (National Center for Behavioral Genomics; Volen National Center for Complex Systems)
Developmental neurobiology in *C. elegans*.

Neil Simister (Rosenstiel Center)
Molecular immunology. Antibody transport.

Judith Tsipis (Chair, Genetic Counseling)
Genetic counseling.

Gina Turrigiano (National Center for Behavioral Genomics; Volen National Center for Complex Systems)
Activity-dependent regulation of neuronal properties.

Lawrence Wangh
Mammalian embryogenesis. Gene expression in single cells. DNA amplification and *in vitro* DNA diagnostics.

Kalpana White, Senior Honors Coordinator (Volen National Center for Complex Systems)
Developmental neurogenetics.

Requirements for the Major

A. Required of all candidates: BIOL 22a, b; BIOL 18a,b lab; CHEM 11a,b or CHEM 15a,b; CHEM 18a,b or CHEM 19a,b lab; CHEM 25a,b; CHEM 29a,b lab; PHYS 10a,b or PHYS 11a,b; PHYS 18a,b or PHYS 19a,b lab; *and* Option I or II below.

Option I: The BA Degree in Biology
The BA is the standard biology option that provides students with a general background in biology. In addition to the courses required of all candidates (listed above), students must complete one course from the Quantitative Course List below. Also, students must complete a total of five elective courses, three of which must come from Category 1 and be taken at Brandeis. Two semesters of BIOL 99 (or BCHM 99 or NEUR 99) may count as one elective in Category 1. Additional courses may be taken as electives from either the Quantitative Course List or Category 2 (see below).

Option II: The BS Degree in Biology
The BS is the intensive biology option that provides students with a strong background in several areas of biology. In addition to the courses required of all candidates (listed as in A above), students must complete BCHM 100a plus two courses from the Quantitative Course List. In addition, students must complete five elective courses, at least three of which must come from Category 1 and be taken at Brandeis. Two semesters of BIOL 99 (or BCHM 99 or NEUR 99) may count as one elective for the BS in biology in Category 1. Additional courses may be taken as electives from either the Quantitative Course List (beyond the two used to fufill the BS quantitative requirement) or Category 2 (see below).

No course offered for major requirements in either Option I or II may be taken on a pass/fail basis. Satisfactory grades (C– or above) must be earned in all biology and biochemistry courses offered for the major and in all elective courses offered for the major in biology. No more than one D will be allowed in any other course offered toward the requirements in this department.

Quantitative Course List
CHEM 144a
MATH 10a, 10b, 15a, 20a, 21a, 21b
NPHY 115a
NPSY 137b
QBIO 110a
One of the following statistics courses: BIOL 51a, ECON 83a, HSSP 100b, MATH 36b, PSYC 51a.
NOTE: AP calculus will not satisfy the quantitative requirement.

Category 1 Electives
BIOL 15a (only if taken before BIOL 22a or b)
BIOL 17b
All other BIOL courses above the 22 level (excluding courses numbered 90–98)
BCHM 100a
All NBIO courses (excluding courses numbered 90-98)
Two semesters of BIOL 99a,b (or BCHM 99 or NEUR 99) may count as one elective

Category 2 Electives
ANTH 116a
BCHM courses above the 100 level
CHEM 141a, 142a, 143b, 146a, 147b
QBIO 120b
Any course from the Quantitative Course List above (a single course cannot be used to fulfill both the quantitative requirement and an elective).
Only one course may be taken from the grouping (BIOL 51a, PSYC 51a, ECON 83a, MATH 36b, or HSSP 100b), either as an elective or to fulfill the quantitative requirement.

B. Senior Research
Any senior, regardless of GPA, may enroll in laboratory research (BIOL 99a and b or 99e). Students petition the department during the beginning of their senior year for participation in Senior Research. Petitions and information about Senior Research are available in the biology department office. See BIOL 99d course description for details.

C. Senior Honors Program
Laboratory research is a major component of the senior honors program. Enrollment in BIOL 99 (Senior Research) is obligatory; students must fulfill the BIOL 99 requirements (see B above). At the conclusion of their second semester of BIOL 99 (Senior Research), candidates for senior honors will give an oral defense of their senior honors thesis to a designated faculty research committee. At the conclusion of their senior year, candidates for senior honors must either have a 3.30 grade point average in all courses offered for the biology major, or have a 3.00 GPA in courses offered for the biology major and have achieved an average of B+ or better in three biology electives, not including BIOL 99. Petitions and information about the senior honors program are available in the biology department office.

Combined BS/MS Program

Candidates for departmental honors may be admitted to a special four-year BS/MS program upon recommendation of the department and approval by the Graduate School. Application to the Graduate School must be made by May 1 preceding the senior year; applications should include a proposed course of study specifying how all degree requirements will be met, a transcript, a letter of recommendation from the research sponsor, and a brief description of the proposed research project. To qualify for the BS/MS degree in biology, students must complete a total of thirty-eight courses; these courses must include those needed to satisfy requirements A, option II, and B, as indicated above plus three additional electives in biology or biochemistry or as listed under requirement A, option II, above. Of the eight electives required for the BS/MS degree, at least six must be at the graduate level (and completed with a grade of B– or above) and they must include courses from at least three of the research areas of the biology department. Research areas include genetics, molecular biology, cell biology, structural biology, immunology, and neurobiology. In addition, a substantial research contribution is required, and students must submit a research thesis to the biology department graduate committee for review. A thesis submitted for the master's degree may also be submitted to the biology department for departmental honors.

Special Notes Relating to the Undergraduate Program

A. Premedical and Predental Students
BIOL 18a and 18b (labs) and BIOL 22a and 22 b will satisfy the general biology entrance requirements of most medical schools.

B. Biology majors wishing to study ecology, conservation, and marine studies may wish to look into the environmental studies program described in this *Bulletin*, as well as the following programs.

Semester in Environmental Science at the Marine Biological Laboratory in Woods Hole: Five courses are offered each fall as part of a residential program, including the analysis of terrestrial and aquatic ecosystems, microbial and animal ecology, global issues, and ecological modeling. Every student must do an independent research project during the semester. Up to four semester course credits may be earned toward the Brandeis degree and three semester course credits may be counted toward the biology BA or BS elective requirement.

Marine Studies Consortium: The MSC, with which Brandeis is affiliated, offers a wide variety of courses on the marine environment. These courses are listed among the biology and environmental studies course offerings in this *Bulletin*.

Denmark's International Studies Program: DIS offers a range of programs in marine biology and ecology, environmental biology, medical practice and policy, and molecular biology and genetics. Organization for Tropical Studies: OTS offers semester-long interdisciplinary programs covering tropical biology, Latin American culture, and Spanish; summer courses include field tropical ecology and field ethnobiology. Courses are offered in both Costa Rica and South Africa.

School for Field Studies: SFS offers programs at a number of different sites around the world, including East Africa, Costa Rica, Baja Mexico, Australia, and the West Indies.

School for International Training: SIT offers programs around the world in ecology, conservation, and sustainable development. Students should see Mr. D. L. Perlman for further information on these programs, including information on transferability of course credits as biology electives.

C. Biology majors who wish to enroll in PHYS 11a and b (Basic Physics), rather than PHYS 10a and b (Physics for the Life Sciences), must complete *both* MATH 10a and b as prerequisites.

D. AP exam credit: Students receiving AP credit as per university guidelines may use these to satisfy the general chemistry (CHEM 11) or physics (PHYS 10, 11) requirements. However, neither AP Math AB scores of 4, 5 nor AP Math BC scores 3, 4, 5 may be used to satisfy the quantitative course requirement for the biology major.

Courses of Instruction

(1–99) Primarily for Undergraduate Students

BISC 2a Human Reproduction, Population Explosion, Global Consequences
[sn]
Does NOT meet requirements for the major in biology.
Appropriate for students interested in a broad range of fields including biology, environmental studies, and the social sciences. This course progresses from a molecular and cellular biology description of basic facts in human genetics and reproduction, an evolutionary description of human origins in Africa and global migration, to a demographic and epidemiological view of human population growth, to a consideration of some of the very complex problems arising from the presence of more than six billion people on Earth today. Readings include scientific papers appropriate to students with high school backgrounds in biology and chemistry, essays in the social sciences, and a wide variety of other texts and media. Usually offered every second year.
Mr. Wangh

BISC 2b Genes, Culture, History: A Case Study
[sn]
Does NOT meet requirements for the major in biology.
An interdisciplinary course with contributions from professors in three departments. Findings from the Human Genome Project are correlated with cultural and historical information about specific human populations. Usually offered every third year.
Mr. Wangh

BISC 3a Paradigms of Biological Investigation
[sn]
Does NOT meet requirements for the major in biology. May not be taken by students who have completed BIOL 22a or BIOL 22b.
Examines the concepts and principles of scientific research with examples from its Greek beginnings to modern times. Topics from evolutionary biology, biophysics, molecular biology, and physics are used to describe the nature of scientific advances. Concepts related to experimental design and critical thinking are considered. Usually offered every year.
Mr. Farber

BISC 3b Humans and the Environment
[sn]
Does NOT meet requirements for the major in biology.
Explores a range of interactions between organisms and their environments. Focuses on human interactions with and impacts on the natural world. Usually offered every third year.
Mr. D.L. Perlman

BISC 4a Heredity
[sn]
Does NOT meet requirements for the major in biology. May not be taken by students who have completed BIOL 22a.
An exploration of what genes are and their functions. Examines how genes are inherited, how they work, and how changes in certain genes cause inherited diseases. Also investigates recent biological developments such as the Human Genome Project, genomics, gene therapy, stem cells, and the new medical and ethical challenges these developments pose in the twenty-first century. Usually offered every third year.
Ms. Sengupta

BISC 5a Pathogens and Human Disease
[sn]
Prerequisite: High school chemistry and biology are essential. Does NOT meet requirements for the major in biology. May not be taken by students who have completed BIOL 22a, 22b, 125a, or 175b.
This lecture course discusses the life cycle, pathogenesis, transmission, and epidemiology of certain organisms (bacteria, viruses, fungi, etc.) that cause important human diseases. Other topics will include emerging diseases, host defense mechanisms, vaccines, public health concerns. Usually offered every year.
Ms. Press

BISC 5b Diseases of the Mind
[sn]
Prerequisite: High school chemistry. Does not meet the requirements for the major in biology. May not be taken by students who have completed BIOL 22b.
An exploration of biology of several protein folding diseases including Alzheimer's, Parkinson's Huntington's, ALS, and mad cow disease and their affect on normal brain function. Examines the medical and ethical challenges of therapies, drug design, and clinical trials on patients afflicted with these disorders. Usually offered every second year.
Ms. Kosinski-Collins

BISC 6b Environmental Health
[sn]
Does NOT meet requirements for the major in biology.
The impact on human health of environmental contamination with toxic, carcinogenic, or pathogenic agents. Tools of toxicology, epidemiology, and risk assessment are applied to specific environmental issues such as air and water quality, petroleum, metal, and other chemical contaminations. Usually offered every second year.
Staff

BISC 7a The Biology and Culture of Deafness
Does not satisfy the School of Science requirement. Does not meet requirements for the major in biology.
An exploration of the biology, sociology, and language of the deaf. Looks at normal mechanisms of hearing and different causes of deafness. Medical models of deafness are compared with social/cultural concepts of deafness. The course will also introduce students to the language of the deaf community, American Sign Language (ASL). Usually offered every second year.
Mr. Morris

BISC 7b Exercise Physiology
[sn]
Does NOT meet requirements for the major in biology.
An introductory course in exercise physiology, with the focus on the muscular, neuromuscular, cardiovascular, and metabolic responses and the physiological adaptations that occur during exercise. Concepts related to physical fitness, body composition/weight control, and training principles are discussed. Usually offered every year.
Mr. Burr

BIOL 12a General Biology Lab I
Prerequisite: Must be taken concurrently with BIOL 14a. Does yield half-course credit toward rate of work and graduation. Two semester-hour credits. Laboratory fee: $15 per semester. Does NOT meet requirements for the major in biology, biochemistry, or neuroscience, but does satisfy the general biology entrance requirement of most medical schools.
Provides firsthand experience with a wide array of organisms and illustrates basic approaches to problem solving in biology. Usually offered every summer.
Staff

BIOL 12b General Biology Lab II
Prerequisites: Must be taken concurrently with BIOL 14b. Does yield half-course credit toward rate of work and graduation. Two semester hour credits. Laboratory fee: $15 per semester. Does NOT meet requirements for the major in biology, biochemistry, or neuroscience, but does satisfy the general biology entrance requirement of most medical schools.
See BIOL 12a for course description. Usually offered every summer.
Staff

BIOL 14a General Biology I
[sn]
Does NOT meet requirements for the major in biology.
An introduction to the biology of organisms and populations. Topics include evolution of life, biological diversity, and the physiology of plants and animals. Usually offered every summer.
Staff

BIOL 14b General Biology II
[sn]
Prerequisites: BIOL 14a, an introductory biology course, or high school AP biology. Does NOT meet requirements for the major in biology.
An introduction to the principles of modern cellular and molecular biology. Also includes selected topics in genetics, biochemistry, and developmental biology. Usually offered every summer.
Staff

BIOL 15b Biology: Human Implications
[sn]
This course may not be taken for credit by students who have completed BIOL 22a or BIOL 22b. Core course for the HSSP program.
The last half-century brought an unprecedented expansion of our knowledge of the living world. The effects of these discoveries on our lives and the effects of our lives on the rest of the living world are increasing. Recent developments in biology affect our health-care choices, our consumer choices, and even our choices as parents. This course is intended as an introduction to contemporary biology. It stresses the fundamentals of cell biology and genetics and explores the diversity of life, including microorganisms and plants. It emphasizes evolution, physiology, and ecology. The course is intended to prepare students to understand the biology of everyday life and to provide a strong foundation for those who continue to study the life sciences. Usually offered every year.
Mr. Simister

BIOL 17b Conservation Biology
[sn wi]
First- and second-year students should contact the instructor before enrolling in this writing-intensive course.
Considers the current worldwide loss of biological diversity, causes of this loss, and methods for protecting and conserving biodiversity. Explores biological and social aspects of the problems and their solutions. Usually offered every year.
Mr. D.L. Perlman

BIOL 18a General Biology Laboratory
[sn wi]
Prerequisites: CHEM 18a or 19a, and BIOL 18b, or permission of the instructor. BIOL 22a must be taken before or concurrently with this course. Does yield full-course credit toward rate of work and graduation. Laboratory fee: $20 per semester. This lab is time-intensive and students will be expected to come in to lab between regular scheduled lab sessions.
Provides firsthand experience with a wide array of organisms and illustrates basic approaches to problem solving in genetics and molecular biology. Usually offered every year.
Ms. Kosinski-Collins

BIOL 18b General Biology Laboratory
Prerequisites: CHEM 18a or 19a. BIOL 22b must be taken before or concurrently with this course. Does yield half-course credit toward rate of work and graduation. Laboratory fee: $20 per semester.
Provides firsthand experience with a wide array of organisms and illustrates basic approaches to problem solving in cell biology. Usually offered every year.
Ms. Kosinski-Collins

BIOL 22a Genetics and Molecular Biology
[qr1 sn]
Prerequisite: CHEM 10a or 11a or 15a.
An introduction to our current understanding of hereditary mechanisms and the cellular and molecular basis of gene transmission and expression. Usually offered every year.
Mr. Garrity

BIOL 22b Cell Structure and Function
[sn]
Prerequisite: CHEM 10a or 11a or 15a.
An introduction to the architecture and function of cells, organelles, and their macromolecular components. Topics include fundamental processes that are common to all cells and the functions of specialized cells. Usually offered every year.
Mr. Simister

BIOL 23a Ecology
[sn]
Prerequisite: BIOL 22a or 15b, or a score of 5 on the AP Biology Exam, or permission of the instructor.
Studies organisms and the environments in which they live. Focuses on the physical factors and intra- and inter-species interactions that explain the distribution and abundance of individual species, from an evolutionary perspective. Usually offered every year.
Mr. Olson

BIOL 25a Molecular Motors
[sn]
Prerequisite: BIOL 22b.
A discussion of movement at the cellular level. Analyzes how molecular motors generate motion and how their activity is controlled. Topics include intracellular transport, muscle contraction, rotary motion, enzymes moving along DNA, and cell division. Usually offered every second year.
Staff

BIOL 28a Marine Biology
[sn]
Prerequisites: BIOL 22a and BIOL 22b. Offered under the auspices of the Marine Science Consortium and open to Brandeis students by petition.
Survey of the basic biology, behavior, and life history of marine biota. Review of physical habitats from polar to tropical waters. Focus is on the evolution of adaptive responses to the physical and biological factors in marine communities. Weekly laboratory consists of field trips to different habitats and examination of specimens from several marine phyla. Usually offered every third year (at Brandeis).
Mr. D.L. Perlman (Brandeis coordinator)

BIOL 30b Biology of Whales
[sn]
Prerequisites: BIOL 22a and BIOL 22b, plus two upper-level biology electives. This limited enrollment course is offered under the auspices of the Marine Science Consortium and is open to Brandeis students by petition.
Examines the biology and conservation of whales, dolphins, and porpoises. Topics include physiology, morphology, population biology, life history, molecular genetics, distributional ecology, and social behavior. Usually offered every year (at Brandeis).
Mr. D.L. Perlman (Brandeis coordinator)

BIOL 31b Biology of Fishes
[sn]
Prerequisites: BIOL 22a and BIOL 22b, plus two upper-level biology electives. This limited-enrollment course is offered under the auspices of the Marine Science Consortium and is open to Brandeis students by petition.
Evolution, systematics, anatomy, physiology, and behavior of freshwater, marine, and anadromous fishes from temperate and tropical environments. Fish interactions in communities: predator/prey, host/symbiont relationships, and fish as herbivores. The ecology of fish populations. Usually offered every year (at the New England Aquarium).
Mr. D.L. Perlman (Brandeis coordinator)

BIOL 32a Field Biology
[sn]
Introduces students to the biodiversity of southern New England, emphasizing plants and insects. Course work primarily takes place on field trips to various terrestrial and aquatic habitats. Field trip scheduling will be discussed during the first meeting. Usually offered every year.
Mr. D.L. Perlman

BIOL 42a Physiology
[sn]
Prerequisite: BIOL 22b.
Introduces basic physiological principles with an overview of neural and hormonal control mechanisms. Topics include physiology of cardiovascular and respiratory systems, electrolyte regulation, digestion and absorption, and reproduction, with an overview of immunology. Usually offered every year.
Mr. Hayes

BIOL 43b Human Anatomy
[sn]
Prerequisite: BIOL 22b.
This course is designed to provide a sound basis for an understanding of human (mammalian) anatomy. The gross and microscopic morphology of each organ system is considered in depth. Correlations between structure and function are emphasized. Lectures, laboratory dissections, and clinical cases are used to illustrate the structures and functions of the human body. Usually offered every year.
Mr. Morris

BIOL 50b Animal Behavior
[sn]
Prerequisite: BIOL 23a or BIOL 60b.
Examines a wide range of animal behavior, including mating and reproductive tactics, territoriality, and social behaviors. The course employs an ecological framework to understand the evolution of behavior. Usually offered every second year.
Mr. D.L. Perlman

BIOL 51a Biostatistics
[sn]
Prerequisite: MATH 10a.
A basic introduction to methods of statistics and mathematical analysis applied to problems in the life sciences. Topics include statistical analysis of experimental data, mathematical description of chemical reactions, and mathematical models in neuroscience, population biology, and epidemiology. Usually offered every year.
Ms. Johnson-Leung

BIOL 55b Diet and Health
[sn]
Prerequisite: BIOL 22b must be successfully completed prior to taking BIOL 55b.
Reviews the current evidence concerning dietary impact on the chronic diseases of humans. Topics include genetics and nutrition, cardiovascular disease, obesity, diabetes, osteoporosis, and cancer. Students also examine the involvement of specific nutrients, e.g., fat and cholesterol, vitamins, minerals, fiber, and alcohol in these disease processes. Usually offered every second year.
Mr. Hayes

BIOL 60b Evolution
[qr sn oc]
Prerequisite: BIOL 22a (formerly BIBC 22a).
"Nothing in biology makes sense except in the light of evolution," Dobzhansky said famously. Evolution is a unifying theory of biology because it explains almost everything about the living world—the diversity of life, similarities among organisms, and the characteristics of all living things. This course examines processes and patterns of evolution, including the origin and fate of variation, natural and sexual selection, inbreeding and genetic drift, the evolution of sociality, the species concept and the origin of new species, biodiversity, and phylogenetics, as well as the history of life on Earth, including the fossil record and human evolution. Usually offered every year.
Mr. Morris

BIOL 98a Readings in Biology
Prerequisites: BIOL 22a and BIOL 22b. Does NOT meet the requirement in biology. May not be taken for credit by students who have satisfactorily completed BIOL 98b.
Open to exceptionally well qualified students. This is a tutorial course with readings in a specified biological field. The student will be given a reading list, including current literature and reviews of the topic to be discussed. Course requirements include weekly discussions and the writing of several papers. Usually offered every year.
Staff

BIOL 98b Readings in Biology
Prerequisites: BIOL 22a and BIOL 22b. Does NOT meet the major requirement in biology. May not be taken for credit by students who have satisfactorily completed BIOL 98a.
See BIOL 98a for course description.
Usually offered every year.
Staff

BIOL 99a Senior Research
The first of a two semester courses involving the student in an independent research project conducted under the supervision of a staff member and serving as an intensive introduction to specific methods of biological research. In cases where students are able to do unusually long, intensive work in the laboratory, they may request a third course credit during the petition process; if this request is approved by the senior honors coordinator, students should register for BIOL 99a (fall) followed by BIOL 99e (spring). The combined enrollments for Senior Research may not exceed three semester-course credits. To fulfill the BIOL 99 requirements, students must (1) submit to their research sponsor, at the conclusion of their first BIOL 99 semester, a paper that reviews the literature pertinent to their field of research, and (2) submit to their research sponsor, at the conclusion of their second BIOL 99 semester, a senior thesis that includes an abstract, an introduction, a review of materials and methods, results, discussion, and references. Usually offered every year.
Staff

BIOL 99b Senior Research
A continuation of BIOL 99a. See BIOL 99a for course description.
Staff

BIOL 99e Senior Research
See BIOL 99a for course description.
Usually offered every semester.
Staff

(100–199) For Both Undergraduate and Graduate Students

BIOL 101a Molecular Biotechnology
[sn]
Prerequisite: BIOL 22a.
A study of the molecular basis of DNA replication, RNA transcription, RNA processing and editing, protein synthesis, and structure function relationships with emphasis on DNA and protein manipulation and molecular biology techniques. Usually offered every year.
Ms. Kosinski-Collins

BIOL 102b Structural Molecular Biology
[sn]
Prerequisites: BIOL 22a and 22b, or permission of the instructor.
Cells are filled with machines that carry materials about the cell, that chemically transform molecules, that transduce energy, and much more. Our understanding of how these machines work depends on understanding their structures. This introduction to the structural basis of molecular biology examines the designs of proteins and nucleic acids, their assembly into macromolecular complexes, and the means whereby we visualize these structures. Considers the physical and chemical basis for specificity in molecular recognition. Usually offered every second year.
Staff

BIOL 103b Mechanisms of Cell Functions
[sn]
Prerequisite: BIOL 22b or permission of the instructor.
An advanced course focusing on a mechanistic understanding of cell biological processes and the methods by which these processes are elucidated. Papers are chosen to illustrate a variety of experimental approaches including biochemistry, genetics, and microscopy. Topics include cell cycle, signal transduction, cytoskeleton and cell movement, membrane traffic, and intercellular transport. Usually offered every year.
Mr. Goode and Ms. Nicastro

BIOL 105b Molecular Biology
[sn]
Prerequisites: BIOL 22a and 22b.
Examination of molecular processes in replication and expression of genetic information and techniques by which this understanding has been achieved. Topics include recombinant DNA and other molecular biological techniques, structure and organization of DNA in chromosomes, DNA replication, transcription and regulation of gene expression, RNA structure and processing, mRNA stability, and other mechanisms of post-translational control. Usually offered every year.
Ms. Lovett and Mr. Rosbash

BIOL 111a Developmental Biology
[sn]
Prerequisite: BIOL 22b.
How do complex organisms build themselves starting from single cells? Examines how processes such as fertilization, embryogenesis, cell differentiation, and tissue-specific gene expression occur; what is known about the key molecules and genes that orchestrate these processes; and how genetic changes affecting these processes underlie the evolution of body form. Usually offered every second year.
Ms. Birren

BIOL 122a Molecular Genetics
[sn]
Prerequisite: BIOL 22a.
A lecture- and literature-based course emphasizing strategies of genetic analysis in understanding complex processes such as the control of DNA replication or the regulation of the cell cycle and cell differentiation. A second emphasis is on the mechanisms that preserve genetic stability and ensure accurate transmission of genetic information from generation to generation in both somatic and germ cells. Classical genetic methods and molecular genetic and genomic approaches are examined. Research papers of current and historical interest are discussed. Usually offered every second year.
Mr. Haber

BIOL 125a Immunology
[sn]
Prerequisites: BIOL 22a and 22b.
Topics include properties, functions of cells involved in innate and adaptive immunity; genes, structure, function of immunoglobins and T cell receptors; cell interactions; lymphocyte differentiation; genetic regulation; MHC restriction; cell interactions and signaling; tolerance and autoimmunity; vaccines; viral immunity; AIDS. Usually offered every year.
Ms. Press

BIOL 126b Protein Structure and Disease
[sn]
Prerequisites: BIOL 22a and 22b, or the equivalent, or permission of the instructor.
Reviews the basic principles of protein structure, so that the functional aspects of different protein designs may be understood. Examines various protein mutations related to certain molecular diseases and the architecture of some key viruses and their infectivity. Consideration of drug design is an integral part of the course. Student presentations are essential to the course. Usually offered every second year.
Ms. Cohen

BIOL 128a Human Genetics
[sn]
Prerequisites: BIOL 22a and 22b.
Survey of topics, including: mutation and polymorphism; molecular methodology; single-gene inheritance and complexities thereof; multifactorial conditions, risk assessment and Bayesian analysis; cytogenetics; hemoglobinopathies; population genetics; gene mapping; cancer genetics; ethical considerations in genetics; immunogenetics; pharmacogenetics; genetics of development; biochemistry of selected genetic diseases; gene therapy, genomics, proteomics, and bioinformatics. Usually offered every year.
Ms. Hiller

BIOL 132a General Microbiology
[sn]
Prerequisites: BIOL 22a and 22b, CHEM 25a and 25b.
A survey of the physiology of bacteria and other microorganisms. Concentrates on those aspects of cell structure and function that are important for diverse microbial lifestyles. In addition, pays special attention to the biology of disease-causing organisms and microbiological problems facing medicine today. Usually offered every second year.
Ms. Press

BIOL 134b Tropical Ecology
[sn oc]
Prerequisite: BIOL 23a or permission of the instructor.
Offers an in-depth look at tropical ecology focusing on the question: why are tropical regions ecologically so different from temperate and polar regions? Usually offered every second year.
Mr. D.L. Perlman

NBIO 136b Computational Neuroscience
[sn]
Prerequisite: MATH 10a or PHYS 10a or approved equivalents.
An introduction to concepts and methods in computer modeling of neural systems. Topics include the basic biophysics of ion conduction, single and multicompartment neuron models, information representation and processing in the visual system, and models of synaptic plasticity, working memory, and decision making. Usually offered every second year.
Mr. Miller

NBIO 139b The Neurobiology of Brain Disorders
[sn]
Prerequisite: NBIO 140b.
Explores the basic mechanisms underlying some of the major mental illnesses that have provided insight into normal brain functioning. Primary sources are used to compare ideas about the bases and treatments of these diseases. Special one-time offering, spring 2008.
Ms. Grashow

NBIO 140b Principles of Neuroscience
[sn]
Prerequisite: BIOL 22b or permission of the instructor.
Examines the basic principles of neuroscience. Topics include resting potentials, action potentials, synaptic transmission, sensory systems, motor systems, learning, neural circuits underlying behavior, neurological diseases, and mental illness. Usually offered every year.
Mr. Lisman

BIOL 141b Molecular Pathophysiology
[sn]
Prerequisite: BIOL 42a, BCHM 100a, or NBIO 140b, or permission of the instructor.
An in-depth investigation of the molecular mechanisms by which the body's organ systems maintain health/homeostasis and succumb to genetic diseases (e.g., cystic fibrosis, Parkinson's disease, ALS), with additional emphasis on understanding how the body adapts to physical exertion and exercise. Usually offered every second year.
Staff

NBIO 143b Developmental Neurobiology
[sn]
Prerequisite: BIOL 22b or permission of the instructor.
Discusses the mechanisms used in the development of the nervous system. Topics include determination of neuronal cell fates, neuronal differentiation and pattern formation, neuron survival and growth, and mechanisms responsible for generation of connectivity in the nervous system. Usually offered every second year.
Ms. Sengupta

NBIO 145b Systems Neuroscience
[sn]
Prerequisite: NBIO 140b.
A fundamental question in neuroscience is how our brains extract and compute features and functions—such as direction of motion from visual stimuli—and how experience allows the microcircuits within our brains to become better tuned to such features. Understanding these processes requires insight into the cellular and network mechanisms that give rise to them. We will begin by examining the classical literature, and then we will move on to recent advances in understanding the cellular and network properties of brain microcircuits. The course emphasizes reading from original papers and extensive class discussion. Usually offered every year.
Ms. Turrigiano

NBIO 146a The Neurobiology of Human Disease
[sn]
Prerequisite: NBIO 140b.
A lecture- and literature-based overview of the neurobiological underpinnings of neurological and psychiatric disorders including autism, mental retardation, schizophrenia, bipolar disorder, Alzheimer's disease, Parkinson's disease, and other neurodevelopmental and neurodegenerative disorders. Usually offered every second year.
Mr. Nelson

NBIO 147a Neurogenetics
[sn]
Prerequisites: BIOL 18a and 22a.
Development and function of the nervous system and responses of excitable cells studied in neurological and behavioral mutants. Characterization and manipulation of genes, defined by these mutations and using molecular biological tools. Organisms: microbes, roundworms, fruit flies, mammals. Neurobiological areas: embryonic neural development, nerve cell differentiation and pattern formation, membrane excitability, responses to visual and chemical stimuli, biological rhythms, and reproductive behavior. Usually offered every third year.
Staff

NBIO 148b Cellular Neuroscience
[sn]
Prerequisite: NBIO 140b or permission of the instructor. May be taken concurrently with NBIO 140b.
Focuses on cellular and molecular mechanisms of excitability and synaptic plasticity. Students examine classic experiments on action potentials and synaptic transmission and the original research literature dealing with the cellular mechanisms of developmental and learning-related plasticity. Usually offered every year.
Mr. Nelson

BIOL 149b Molecular Pharmacology
[sn]
Prerequisites: BIOL 22b and CHEM 25a and b. NBIO 140b strongly recommended.
Covers the essentials of pharmacology and the study of the actions of chemical agents (drugs, toxins, neurotransmitters, and hormones) that interact with living systems. Emphasizes molecular mechanisms of neuropharmacology. Topics include pharmacokinetics, hormone action, autonomic pharmacology, and the psychopharmacology of drugs of abuse and mental disorders. Usually offered every third year.
Ms. Griffith

NBIO 150a Autism and Human Developmental Disorders
[sn]
Prerequisite: BIOL 22b.
Autism and other developmental disorders are characterized by abnormal brain development resulting in cognitive and behavioral deficits. Takes an integrative approach to investigate the biological, behavioral, medical, and social aspects of human developmental disorders. Usually offered every second year.
Ms. Birren

BIOL 155a Project Laboratory in Genetics and Genomics
[sn]
Prerequisites: BIOL 18a,b and 22a,b.
This small, laboratory-based course provides a unique opportunity for students to pursue an independent research project. Each year focuses on a specific topic, such as bacterial genetics, epigenetic mechanisms of gene regulation, or microbial diversity, and students will design and carry out original experiments. Students will learn basic molecular biology techniques, genetic and genomic analysis, and experimental design. Usually offered every year.
Ms. Lovett and Mr. Morris

BIOL 160b Human Reproductive and Developmental Biology
[sn]
Prerequisites: BIOL 22a and 22b.
Course deals with hormonal, cellular, and molecular aspects of gametogenesis, fertilization, pregnancy, and birth. Pathological and abnormal variations that occur and the available medical technologies for intervention, correction, and facilitation of these processes are discussed. Usually offered every year.
Ms. Jackson

BIOL 172b Growth Control and Cancer
[sn]
Prerequisites: BIOL 22a and 22b.
Covers the fundamental rules of behavior of cells in multicellular organisms. Examines cellular and molecular mechanisms that govern cell growth, and differentiation and survival in normal cells, as well as how this regulation is disrupted in cancer. Usually offered every second year.
Mr. Ren

BIOL 174b Stem Cells
[sn]
Prerequisites: BIOL 22a and 22b.
Stem cells are cells that can both undergo self-renewal and give rise to all cells or special cell types of the body. They have the potential for the restoration of lost organ function that cannot be achieved through traditional drug therapies. Covers stem cell biology, cell differentiation and transdifferentiation, cell lineage commitment, gene expression regulation, signal transduction, cell identity memory, and cell therapies. Provides a unique way to gain insights into developmental biology, molecular and cell biology, cancer biology, biology of aging, and regenerative medicine, as well as bioethics and health and public policies. Usually offered every second year.
Mr. Ren

BIOL 175b Advanced Immunology: Topics in Infectious Disease
[sn]
Prerequisites: BIOL 125a and permission of the instructor.
An advanced lecture- and literature-based course that focuses on a select group of microorganisms (bacteria, viruses, etc.) considered important in human disease. Topics include mechanisms/determinants of pathogenicity, immune evasion, host immune responses, vaccines, public health issues, and bioterrorism agents. Usually offered every second year.
Ms. Press

Cross-Listed Courses

ANTH 116a
Human Osteology

COSI 230a
Topics in Computational Biology

QBIO 110a
Numerical Modeling of Biological Systems

QBIO 120b
Quantitative Biology Instrumentation Laboratory

Bioorganic Chemistry

See Biochemistry

A graduate program

Biophysics and Structural Biology

Courses of Study:
Master of Science
Doctor of Philosophy

Objectives

Graduate Program in Biophysics and Structural Biology
The interdepartmental Graduate Program in Biophysics and Structural Biology, leading to the degree of Doctor of Philosophy, is designed to develop the student's capacity for independent research. The program is focused on the application of the physical sciences to important problems in molecular and cellular biology. It offers opportunities for study and research in a variety of fields, including protein crystallography and magnetic resonance spectroscopy, molecular microscopy, biophysical chemistry, neuroscience, sensory transduction, and chemo-mechanical energy transduction. Applicants are expected to have strong backgrounds in the physical sciences with undergraduate majors in any related field, such as biology, biochemistry, chemistry, engineering, mathematics, or physics. The course requirements for the PhD are formulated individually for each student to complement the student's previous academic work with the goal of providing a broad background in the physics and chemistry of biological processes.

Research for the PhD dissertation is carried out under the personal supervision of a faculty advisor; advisors can be from any department within the School of Science. Prospective applicants should obtain the complete list of faculty research interests and recent publications from the program or view this information at: www.bio.brandeis.edu/biophysics.

How to Be Admitted to the Graduate Program

The general requirements for admission to the Graduate School are given in an earlier section of this *Bulletin*. Applications should include, in addition to letters of reference, a personal statement describing the reasons for the applicant's interest in the field and previous research experience, if any. Applicants are required to take the Graduate Record Examination and are encouraged to visit Brandeis for interviews, if possible.

Faculty Advisory Committee

Dorothee Kern, Chair
(Biochemistry)

Jeff Agar
(Chemistry)

Jeff Gelles
(Biochemistry)

Jané Kondev
(Physics)

Christopher Miller
(Biochemistry)

Requirements for the Degree of Master of Science

Program of Study
This graduate program does not normally admit students to pursue the MS degree. In special cases, however, the MS degree may be awarded upon completion of an approved program of study consisting of at least six graduate-level courses in biology, physics, biochemistry, quantitative biology, or chemistry with a grade of B– or better. Generally, the courses include BIOP 200b, BIOP 300a, and BIOP 300b.

Residence Requirement
The minimum residence requirement is one year.

Language Requirement
There is no language requirement.

Thesis
To qualify for the MS, a student must submit a thesis reporting a substantial piece of original research carried out under the supervision of a research advisor or advisors.

Requirements for the Degree of Doctor of Philosophy

Program of Study
The PhD Program in Biophysics and Structural Biology is designed to accommodate students with previous academic majors in a wide range of fields, including biology, physical chemistry, engineering, and physics. Consequently, the course requirements for the PhD are tailored to the needs of the particular student. In consultation with each entering student, the program chair formulates a program of study for the student based on the student's previous academic accomplishments and scientific interests. Successful completion of the courses listed in the program of study fulfills the course requirements for the PhD. The required program of study consists of seven one-semester courses, of which six are completed in the student's first year. The first-year courses include BIOP 200b and two courses of laboratory rotations (BIOP 300a,b). In addition to the seven courses, the noncredit course CONT 300b (Ethical Practice in Health-Related Sciences) is required of all first-year students. All students beyond the first year must register for BIOP 401d. Students in their third and higher years of study will have yearly progress meetings with a faculty committee of three for the purpose of maintaining a satisfactory trajectory toward completion of the thesis defense.

Teaching Requirement
As part of their PhD training, students are required to assist with the teaching of two one-semester courses.

Residence Requirement
The minimum residence requirement is three years.

Language Requirement
There is no language requirement.

Financial Support
Students may receive financial support (tuition and stipend) throughout their participation in the PhD program. This support is provided by a combination of university funds, training grants, and faculty research grants.

Qualifying Examinations
To qualify for the PhD degree, each student must write and defend in oral examinations two propositions related to research in biophysics or structural biology. The subject of the second proposition must be outside the immediate area of the student's dissertation research.

Dissertation and Defense
The dissertation must report the results of an original scientific investigation into an approved subject and must demonstrate the competence of the PhD candidate in independent research. The dissertation research must be presented and defended in a final oral examination.

Requirements for the Degree of Doctor of Philosophy in Biophysics and Structural Biology with Specialization in Quantitative Biology

Program of Study
Students wishing to obtain this specialization must first gain approval of the graduate program chair or quantitative biology liaison. This should be done as early as possible, ideally during the first year of graduate studies. In order to receive the PhD in Biophysics and Structural Biology with additional specialization in quantitative biology, candidates must complete 1.) the requirements for the PhD described above and 2.) the course requirements for the quantitative biology specialization that are described in the quantitative biology section of this *Bulletin*.

Any alteration to the quantitative biology course requirements must be approved by the graduate program chair and by the quantitative biology program faculty advisory committee.

Courses of Instruction

(200 and above) Primarily for Graduate Students

BIOP 200b Reading in Macromolecular Structure-Function Analysis
Required for first-year biochemistry and biophysics and structural biology graduate students.
Introduces students to chemical and physical approaches to biological problems through critical evaluation of the original literature. Students analyze scientific papers on a wide range of topics in the fields of biochemistry and biophysics. Discussion focuses on understanding of the scientific motivation for and experimental design of the studies. Particular emphasis is placed on making an independent determination of whether the author's conclusions are well justified by the experimental results. In consultation with the instructor, each student also develops a research proposition based on independent reading and prepares a research plan in the form of a mock-grant proposal. Usually offered every year.
Mr. Gelles

BIOP 300a Introduction to Research in Biophysics
Students must consult with the program chair prior to enrolling in these courses.
Students carry out four nine-week projects in the research laboratories of biological and physical science faculty members.
Staff

BIOP 300b Introduction to Research in Biophysics
A continuation of BIOP 300a.
Staff

BIOP 401d Biophysical Research Problems
Independent research for the MS or PhD degrees. All graduate students beyond the first year must register for this course. Usually offered every semester.
Staff

Cross-Listed Courses

BCHM 101a
Advanced Biochemistry: Enzyme Mechanisms

BCHM 102a
Quantitative Approaches to Biochemical Systems

BCHM 103b
Advanced Biochemistry: Information Transfer Mechanisms

BCHM 104b
Physical Chemistry of Macromolecules

PHYS 105a
Biological Physics

QBIO 110a
Numerical Modeling of Biological Systems

QBIO 120b
Quantitative Biology Instrumentation Laboratory

Courses of Related Interest

BCHM 170b
Bioinformatics

BCHM 171b
Protein X-ray Crystallography

BCHM 219b
Enzyme Mechanisms

BCHM 220a
Proteases

BCHM 223a
Enzymology of Biofuels, Bioplastics, and Bioremediation

BCHM 224a
Single-Molecule Biochemistry and Biophysics

BIOL 102b
Structural Molecular Biology

BIOL 103b
Mechanisms of Cell Functions

BIOL 224b
The RNA World

CHEM 129b
Special Topics in Inorganic Chemistry: Introduction to X-ray Structure Determination

CHEM 132b
Advanced Organic Chemistry: Spectroscopy

CHEM 143b
Kinetics, Dynamics, and Transport

CHEM 144a
Computational Chemistry

CHEM 246b
Advanced NMR Spectroscopy

NBIO 140b
Principles of Neuroscience

NBIO 145b
Systems Neuroscience

PHYS 104a
Soft Condensed Matter

PHYS 110a
Mathematical Physics

PHYS 163a
Statistical Physics and Thermodynamics

PHYS 169b
Advanced Laboratory

Required First-Year Graduate Health-Related Science Programs Course

CONT 300b Ethical Practice in Health-Related Sciences
Required of all first-year graduate students in health-related science programs. Not for credit.
Ethics is an essential aspect of scientific research. This course, taught by university faculty from several graduate disciplines, covers major ethical issues germane to the broader scientific enterprise, including areas or applications from a number of fields of study. Lectures and relevant case studies are complemented by public lectures during the course. Usually offered every year.
Mr. Morris