

## 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 to 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.

Because 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" later in this section for additional programs in those areas.

### 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) (on leave 2008–2009)

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) (on leave 2008–2009)

Genetics and molecular biology of yeast meiotic and mitotic recombination. Mating-type switching. Repair of broken chromosomes.

#### 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 (Rosenstiel Center)

Mechanisms controlling gene expression.

### 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 a 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 BIOL 22a (Genetics) in their first year.

Most students begin the biology series in their sophomore year and take BIOL 22a (Genetics and Molecular Biology) and BIOL 22b (Cell Structure and Function), plus labs. During their sophomore year, students can also enroll in CHEM 25a,b (Organic Chemistry), with associated labs.

Other course schedules are indeed possible, but students should note that some biology electives have a *prerequisite* of completion of CHEM 25a. Taking CHEM 25a,b in the sophomore year allows students to begin taking electives in their junior year, as well as to begin completing the remaining requirements for the BA or BS degree in biology. Students also have the option of enrolling in BIOL 99a,b (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.

#### 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.

#### Suzanne Paradis (National Center for Behavioral Genomics, Volen National Center for Complex Systems)

Molecular mechanisms of synapse development.

#### Dan L. Perlman (Chair, Environmental Studies)

Ecology, conservation biology, animal behavior.

**Joan Press, Undergraduate Advising Head and Senior Honors Coordinator (Rosenstiel Center)**

Developmental immunology and immunogenetics.

**Ruibao Ren (Rosenstiel Center) (on leave spring 2009)**

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)**

Behavioral and neuronal development 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 Wagh (on leave 2008–2009)**

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

**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 or PHYS 15a,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. 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 99a,b or NEUR 99a,b) may count as one elective in Category 1 *with permission of the biology department honors coordinator and the biology undergraduate advising head*.

Additional courses may be taken as electives from the Quantitative Course List, Category 1, 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 99a,b or NEUR 99a,b) may count as one elective for the BS in Biology in Category 1 *with permission of the biology department honors coordinator and the biology undergraduate advising head*.

Additional courses may be taken as electives from the Quantitative Course List (beyond the two used to fulfill the BS quantitative requirement), Category 1, 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, 22a, 22b

NPHY 115a

NPSY 137b

QBIO 110a

Any one of the following statistics courses: BIOL 51a, ECON 83a, HSSP 100b, MATH 36b, or PSY 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 numbered higher than 22 (excluding courses numbered 90–98)

BCHM 100a

All NBIO courses (excluding courses numbered 90–98)

Two semesters of BIOL 99 (or BCHM 99a,b or NEUR 99a,b) may count as one elective *with permission of the biology department honors coordinator and the biology undergraduate advising head*.

**Category 2 Electives**

ANTH 116a

BCHM courses numbered higher than 100

CHEM 33a, 141a, 142a, 143b, 146a, 147b

QBIO 120b

Any one course from the quantitative course list above (a single course cannot be used to fulfill both the quantitative requirement and an elective).

Note: Only one course may be taken from the statistics 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 BIOL 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 99 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 minimum 3.30 grade point average in all courses offered for the biology major, or have a minimum 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 higher) 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.** BIOL 18a and b (labs) and BIOL 22a and 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 two semester course credits may be counted toward the biology BA or BS elective requirement.

**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.

**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 the 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 of 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

#### BIOL 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, AND an evolutionary description of human origins in Africa and global migration, to a demographic and epidemiological view of human population growth, and 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 4b Food, Nutrition, and Health**

[ sn ]

*Does NOT meet requirements for the major in biology.*

Nutrition is the science of food and its role in health and disease. This course will introduce the biological background to provide students with tools to better understand everything from how we choose food to how our diet influences our long-term health. Usually offered every year.

Ms. Lai

**BISC 5a Pathogens and Human Disease**

[ sn ]

*Prerequisite: High school chemistry and biology. Does NOT meet requirements for the major in biology. May not be taken by students who have completed BIOL 125a, 132a, or 175b.*

This course discusses the life cycle, pathogenesis, transmission, and epidemiology of certain organisms (bacteria, viruses, fungi, etc.) that cause important human diseases. Other topics 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 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 effect 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 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. Yields full-course credit.*

*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 experimental design and problem solving in genetics and genomics. 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. Yields half-course credit.*

*Laboratory fee: \$20 per semester.*

Provides firsthand experience with modern molecular biology techniques and illustrates basic approaches to experimental design and problem solving in molecular and cellular 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 interspecies interactions that explain the distribution and abundance of individual species from an evolutionary perspective. Usually offered every year.

Staff

**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.*

Survey of the basic biology, behavior, and life history of marine biota. Review of physical habitats, from polar to tropical waters.

Weekly laboratory consists of field trips to different habitats and examination of specimens from several marine phyla. Focus is on the evolution of adaptive responses to the physical and biological factors in marine communities. Usually offered every third year.

Staff

**BIOL 30b Biology of Whales**

[ sn ]

*Prerequisites: BIOL 22a and BIOL 22b, plus two upper-level biology electives.*

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 third year.

Staff

**BIOL 31b Biology of Fishes**

[ sn ]

*Prerequisites: BIOL 22a and BIOL 22b, plus two upper-level biology electives.*

Topics include evolution, systematics, anatomy, physiology, and behavior of freshwater, marine, and anadromous fishes from temperate and tropical environments. Studies fish interactions in communities: predator/prey, host/symbiont relationships, and fish as herbivores. Also examines the ecology of fish populations. Usually offered every third year.

Staff

**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 ]

*Prerequisites: BIOL 22a and BIOL 22b. CHEM 25a and CHEM 25b are recommended.*

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.

Ms. Griffith

**BIOL 43b Comparative Vertebrate Anatomy**

[ sn ]

*Prerequisite: BIOL 22b.*

This course is designed to provide a solid basis for an understanding of vertebrate and in particular human 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 structure and function of the human body. Usually offered every year.

Mr. Morris

**BIOL 50b Animal Behavior**

[ sn ]

*Prerequisites: 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.

Staff

**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; for example, fat and cholesterol, vitamins, minerals, fiber, and alcohol in these disease processes. Usually offered every second year.

Mr. Hayes

**BIOL 60b Evolution**

[ oc qr sn ]

*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 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 93a Research Internship and Analysis**

Supervised biological research experience in a Brandeis University laboratory. In consultation with a Brandeis faculty member, the student will design and execute an individual research project, culminating in an oral and written presentation. Students seeking to do biology research in Brandeis laboratories outside the biology department must obtain sponsorship of a biology department faculty member as well as permission of the departmental curriculum committee chair (or UAH). This course is not intended to and will not provide credit for off-campus internships. Offered both semesters and requires permission of the instructor and fulfillment of BIOL 93 guidelines. Students wishing to do a summer internship for academic credit must: obtain permission from their biology department sponsor prior to commencing the internship; complete the summer internship (a minimum of 10 weeks full-time); and complete the appropriate academic work. Credit will be awarded via the student enrolling BIOL 93 in the subsequent fall term. Usually offered every semester.

Staff

**BIOL 98a Readings in Biology**

*Prerequisites: BIOL 22a and BIOL 22b. Does NOT meet requirements for the major 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 course 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

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**(100–199) For Both Undergraduate and Graduate Students**


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**BIOL 101a Molecular Biotechnology**

[ sn ]

*Prerequisite:* BIOL 22a.

A study of the molecular basis of DNA replication, RNA transcription focusing on molecular biology techniques such as PCR, DNA sequencing, genomics, cloning, microarrays, and siRNA and their relation to human disease research applications. Usually offered every year.

Ms. Kosinski-Collins

**BIOL 102b Structural Molecular Biology**

[ sn ]

*Prerequisites:* BIOL 22a and b, 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.

Ms. Nicastro

**BIOL 105b Molecular Biology**

[ sn ]

*Prerequisites:* BIOL 22a and b.

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.

Mr. Marr 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 b.

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 b, 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 b.

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 BIOL 22b.

A survey of the physiology and the properties of bacteria, viruses, and other microorganisms. Topics include microbial nutrition, metabolism, growth, and genetics; immunity and other means of microbial control; pathogenicity, epidemiology, concepts in infectious disease. Selected disease-causing organisms are discussed, including problems they pose for medical control and society. 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.

Staff

**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 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. Paradis and 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 BIOL 22a.*

Topics include 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: roundworms, fruit flies, fish, mammals. Neurobiological areas: embryonic neural development, nerve cell differentiation and pattern formation, membrane excitability, responses to sensory stimuli, biological rhythms, and reproductive behavior. Usually offered every third year.

Ms. Paradis and Ms. Sengupta

**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. Marder

**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 and b and BIOL 22a and b.*

This small, laboratory-based course provides a unique opportunity for students to pursue an independent research project. Each year we focus on a specific topic, such as bacterial genetics, epigenetic mechanisms of gene regulation, or microbial diversity, and 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 b.*

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 b.*

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 b.*

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****QBIO 110a**

Numerical Modeling of Biological Systems

**ANTH 116a**

Human Osteology

**QBIO 120b**

Quantitative Biology Instrumentation Laboratory

**COSI 230a**

Topics in Computational Biology

A graduate program

**Biophysics and Structural Biology**

Courses of Study:  
Master of Science  
Doctor of Philosophy

**Objectives**

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 adviser; advisers 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](http://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 Gelles**  
(Biochemistry)

**Michael Hagan**  
(Physics)

**Jané Kondev**  
(Physics)

**Christopher Miller (on leave 2008–2009)**  
(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 adviser or advisers.

## 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, biochemistry, 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.

## 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. Usually offered every year.  
Mr. Petsko

#### 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

### 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 the requirements for the PhD described above and 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.

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## Required First-Year Graduate Health-Related Science Programs Course

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### 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.  
Staff

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### Cross-Listed Courses

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#### 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

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### Courses of Related Interest

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#### 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

#### 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