Arabic Language and Literature

Faculty

See Near Eastern and Judaic Studies.

Courses of Instruction

(1–99) Primarily for Undergraduate Students

ARBC 10a Beginning Literary Arabic
A first course in literary Arabic, covering essentials of grammar, reading, pronunciation, translation, and composition. Six class-hours per week. Usually offered every year.
Staff

ARBC 20b Continuing Literary Arabic
Prerequisite: ARBC 10a or the equivalent.
Continuation of ARBC 10a. Four class-hours per week. Usually offered every year.
Staff

ARBC 30a Intermediate Literary Arabic
[fl]
Prerequisite: ARBC 20B or the equivalent.
Readings in related classical and modern texts. Study of advanced grammatical and syntactical forms. Drills in pronunciation and composition. Four class-hours per week. Usually offered every year.
Staff

ARBC 40b Advanced Intermediate Literary Arabic
[fl hum]
Prerequisite: ARBC 30a or the equivalent.
Continuation of ARBC 30a. Three class-hours per week. Usually offered every year.
Staff

(100–199) For Both Undergraduate and Graduate Students

ARBC 103a Advanced Literary Arabic
[hum]
Prerequisite: ARBC 40b or the equivalent. This course may not be repeated for credit by students who have taken NEJS 103a in previous years.
Designed to help the student attain an advanced reading proficiency. The syllabus includes selections from classical and modern texts representing a variety of styles and genres. Usually offered every year.
Staff

ARBC 103b Advanced Literary Arabic
[hum]
Prerequisite: ARBC 103a (formerly NEJS 103a) or the equivalent. This course may not be repeated for credit by students who have taken NEJS 103b in previous years.
Continuation of ARBC 103a. Usually offered every year.
Staff

Department of

Biochemistry

Courses of Study:
Major (BA/BS)
Combined BS/MS
Master of Science
Doctor of Philosophy

Objectives

Undergraduate Major
The biochemistry major is designed to equip students with a broad understanding of the chemical and molecular events involved in biological processes. The biochemistry major provides a foundation for careers in medicine, biotechnology, or research in all branches of the biological sciences.

The general aim of the major is to ensure that the students first learn the necessary chemical and physical chemical background and then the basic principles and observations of biochemistry and molecular biology. The department also offers a variety of introductory and advanced courses in more specialized subjects such as neurobiology, X-ray crystallography, and physical biochemistry. These courses sample the range of subjects that can be studied by biochemical methods and from a biochemical point of view.

Graduate Program in Biochemistry
The graduate program in biochemistry leading to the degree of Doctor of Philosophy is designed to provide students with a deep understanding of the chemical principles governing the workings of biological macromolecules. The bioorganic chemistry specialization of this program gives students the option of training in organic chemistry in addition to biochemistry. The emphasis in the graduate program is placed upon experimental research work to train students to carry out independent original research. Students are required, however, to complete formal course work in advanced biochemistry and physical biochemistry. Students in the bioorganic chemistry specialization supplement this core curriculum with courses in organic synthesis and other topics in organic chemistry. Additional courses and seminars are available in a wide range of subjects, including enzyme regulation and mechanism, neurobiology, immunology, structural biochemistry, membrane biology, and molecular genetics. Students are encouraged to choose advanced courses and seminars according to their particular interests. Doctoral research topics are chosen in areas under investigation by the faculty; these include problems in macromolecular structure and function, enzyme function and regulation, RNA

processing, gene regulation, membrane transport and receptor function, molecular pharmacology, mechanisms of cell motility, microbial metabolism, and the biochemistry of cellular electrical excitability. A theme running through this research is the relationship of biochemical functions to underlying molecular structures and mechanisms.

The graduate program in biochemistry leading to the degree of Master of Science is designed to give students a substantial understanding of the chemical and molecular events in biological processes and experience in research. The program is divided among formal course work, biochemical techniques, and a research project. Additional courses and seminars are available in a wide range of subjects.

How to Become a Major

Students who are interested in majoring in biochemistry should speak with the department advising head.

How to Be Admitted to the Graduate Program

The general requirements for admission to the Graduate School, given in an earlier section of the *Bulletin*, apply here. Applicants for admission to the biochemistry PhD program are also required to take the Graduate Record Examination. It is strongly suggested that the applicant take one of the advanced sections of this examination. The applicant's undergraduate curriculum should include fundamental courses in biology and chemistry.

Faculty

Gregory Petsko, Chair
X-ray crystallographic analysis of protein structure and enzyme mechanisms.

Jeff Gelles
Mechanisms of mechanoenzymes. Stochastic processes in single-enzyme molecules. Light microscopy as a tool to study enzyme mechanisms.

Nikolaus Grigorieff
High-resolution electron cryo-microscopy of membrane proteins and channels.

Lizbeth Hedstrom
Enzyme structure-function studies. Protein engineering. Design of enzyme inhibitors.

Dorothee Kern
Dynamics of enzymes. Magnetic resonance methods.

Daniel Krummel
RNA biochemistry, RNA-protein interactions. RNA processing.

Christopher Miller, Graduate Program Chair (on leave 2008–2009)
Structure and function of ion channel proteins. Membrane transport and mechanisms of electrical excitation.

Daniel Oprian, Undergraduate Advising Head
Structure-function studies of visual pigments and other cell surface receptors.

Dagmar Ringe
Structures of enzymes and enzyme-substrate complexes. X-ray crystallography.

Douglas Theobald
Structural bioinformatics analysis of telomeric complexes, integrating X-ray crystallographic structure determination, molecular evolution, and structure-function studies.

Requirements for the Major

Degree of Bachelor of Arts
One year of general chemistry with laboratory; one year of organic chemistry with laboratory; one year of physics taught using calculus (PHYS 15a,b) with laboratory; BIOL 22a (formerly BIBC 22a) with laboratory (Genetics and Molecular Biology); BIOL 22b with laboratory (Cell Structure and Function)—the above courses must be taken prior to the senior year; BCHM 100a (Introductory Biochemistry); one year of physical chemistry, CHEM 141a (Thermodynamics and Statistical Thermodynamics), and either BCHM 104b (Physical Chemistry of Macromolecules) or CHEM 143b (Kinetics, Dynamics, and Transport); and one elective consisting of a biochemistry-related 100-level course (excluding research courses) from any science department. The course used to fulfill the elective requirement must be approved in advance by the biochemistry undergraduate advising head.

Degree of Bachelor of Science
In addition to the degree requirements listed previously for the Bachelor of Arts degree, the Bachelor of Science degree requires one semester each of BCHM 101a and BCHM 103b (Advanced Biochemistry).

Required of all students: No course offered for major requirements may be taken pass/fail. Grades below C– in upper-level courses (any course numbered 100 or higher) cannot be used to fulfill the requirements for the major. Furthermore, no more than one D will be allowed in any other course required for the major.

Senior Honors Program
In addition to the degree requirements listed previously, departmental honors require completion of two semesters of BCHM 99 (Research for Undergraduates), submission of an acceptable research thesis, and a final GPA 3.00 or better in the sciences and mathematics. Honors candidates are also expected to give a short oral presentation of their thesis research to members of the department at the end of their senior year. BCHM 99 may not exceed three semester credits. Petition the department for participation in this program is made at the beginning of the senior year.

Combined BS/MS Program

In addition to all courses required for the BS degree, the BS/MS degree requires completion of one additional elective (excluding research courses) approved in advance by the biochemistry undergraduate advising head, three semesters of research (one or two semesters of BCHM 99 plus one or two semesters of BCHM 150), a full-time (i.e., no concurrent course work) summer research residency lasting at least ten weeks, submission of an acceptable thesis, a GPA of 3.00 or better in the sciences and mathematics, and grades of B– or better in all 100-level biochemistry and biology courses. This program requires completion of thirty-eight courses; no more than four semesters of research (BCHM 99 or BCHM 150) can count toward this total. Application to this program is made to the department and Graduate School no later than May 1 preceding the senior year, and all work, including the thesis, must be completed by the time the BS is awarded. To qualify for the BS/MS degree, the thesis must constitute a significant research contribution; if a thesis is found to be unacceptable under the BS/MS program, it will automatically be considered under the honors program.

In order to complete the honors program or the combined BS/MS program, it is advisable to gain exemption where possible from introductory courses in science and mathematics. This is especially important for the premedical students who must also fulfill the requirements imposed by medical schools.

Requirements for the Degree of Master of Science

Program of Study
Students must successfully complete an approved program of at least six courses. These courses are:

A.

BCHM 101a	Advanced Biochemistry: Enzyme Mechanisms
BCHM 102a	Quantitative Approaches to Biochemical Systems
BIOP 200b	Reading in Macromolecular Structure-Function Analysis

One advanced (100–200 level) course from the School of Science, approved in advance by the graduate program chair.

BCHM 300a,b	Biochemical Techniques (laboratory rotations)

Residence Requirement
The minimum residence requirement is one year.

Language Requirement
There is no language requirement.

Thesis
The student must complete an acceptable MS thesis describing original research.

Requirements for the Degree of Doctor of Philosophy in Biochemistry

Students must successfully complete:

A. The core curriculum consisting of:

BCHM 101a	Advanced Biochemistry: Enzyme Mechanisms
BCHM 102a	Quantitative Approaches to Biochemical Systems
BCHM 300a,b	Biochemical Techniques (laboratory rotations course)
BIOP 200b	Readings in Macromolecular Structure-Function Analysis
CONT 300b	Ethical Practices in Health-Related Sciences

B. Elective courses: four advanced (100- and 200-level) courses from the School of Science. Each course used to satisfy this requirement must be approved in advance by the graduate program chair. Ordinarily, at least one of these courses will be an advanced graduate seminar (200-level) offered by the biochemistry department.

C. Students in their second and higher years of study must register for BCHM 401d (Biochemical Research Problems)—a dissertation research course—during every semester in which they are enrolled.

D. 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.

Students ordinarily complete the core curriculum plus one elective in the first year and complete the remaining requirements in their subsequent years in the program.

Requirements for the Degree of Doctor of Philosophy in Biochemistry with Specialization in Bioorganic Chemistry

In order to receive a PhD in biochemistry with a specialization in bioorganic chemistry, students must complete the requirements defined for the biochemistry PhD degree, with the following restrictions:

A. As one of their four elective courses, students must complete one course in synthetic organic chemistry, chosen from the following:
CHEM 134b Advanced Organic Chemistry: Synthesis
CHEM 135a Advanced Organic Chemistry: Synthesis II

B. As one of their four elective courses, students must complete one other advanced chemistry course approved in advance by the graduate program chair.

Students wishing to obtain the specialization must first gain approval of the graduate program chair. This should be done as early as possible; ideally, during the first year of graduate studies.

Requirements for the Degree of Doctor of Philosophy in Biochemistry with Specialization in Quantitative Biology

In order to receive a PhD in biochemistry with a specialization in quantitative biology, students must complete the requirements defined for the biochemistry PhD degree, and in addition must satisfy 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 quantitative biology program faculty advisory committee. With the approval of the biochemistry graduate program chair, courses taken to satisfy the quantitative biology specialization requirements can be used to satisfy course requirements of the biochemistry PhD degree.

Students wishing to obtain the 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.

Teaching Requirement
As a 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 Requirements
There is no foreign 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 individual research grants.

Qualifying Examinations
A qualifying examination must be taken following the first year of course work. In this examination, the student will be asked to present and defend an original proposition put forth by the student. In addition, the student must successfully pass a comprehensive examination administered following the second year of course work.

Dissertation and Defense
The required dissertation must summarize the results of an original investigation of an approved subject and demonstrates the competence of the candidate in independent research. This dissertation will be presented in a departmental lecture and defended in a final oral examination.

Special Note Relating to Graduate Students
In addition to the formal courses listed in the following sections, all graduate students are expected to participate in the department's research clubs and colloquia. Colloquia are general meetings of the department in which department and guest speakers present their current investigations. Research clubs are organized by various research groups of the department.

Courses of Instruction

(1–99) Primarily for Undergraduate Students

BCSC 1a Designer Genes
[sn]
Does NOT satisfy the requirement for the major in biochemistry.
We are living during a far-reaching biological revolution. Information is stored in genes as DNA, the hereditary material of life, and this information is converted into proteins. This course investigates: identifying undesirable mutations; creating desirable mutations; cloning of cells, organs, and animals in agriculture and medicine. Usually offered every second year.
Staff

BCHM 98a Readings in Biochemistry
Prerequisites: BIOL 22a (formerly BIBC 22a), BCHM 100a, and one year of organic chemistry with laboratory. Does NOT satisfy the requirement for the major in biochemistry.
Directed scholarship on selected topics in biochemistry for outstanding juniors or seniors. Regularly scheduled discussion and written assignments leading to a substantive term paper. The tutorial is arranged only by mutual agreement between a faculty mentor and student. Usually offered every year.
Staff

BCHM 99a Research for Undergraduates
Prerequisites: BIOL 22a (formerly BIBC 22a), BCHM 100a, and one year of organic chemistry with laboratory. Requirement of BCHM 100a may be waived.
Undergraduate research. A maximum of three course credits may be taken as BCHM 99a and/or 99b. At the discretion of the department, one semester may be taken for double credit (99e). Offered every year.
Staff

BCHM 99b Research for Undergraduates
See BCHM 99a for special notes and course description.
Staff

BCHM 99e Research for Undergraduates
See BCHM 99a for special notes and course description.
Staff

(100–199) For Both Undergraduate and Graduate Students

BCHM 100a Introductory Biochemistry
[qr sn]
Prerequisite: One year of organic chemistry with laboratory.
Topics include chemistry, reaction, and metabolism of biologically important compounds; formation and utilization of "energy-rich" compounds; introduction to enzyme mechanisms; interrelation and comparison of basic biochemical and chemical processes; and metabolic regulation. Usually offered every year in multiple sections.
Mr. Oprian

BCHM 101a Advanced Biochemistry: Enzyme Mechanisms
[sn]
Prerequisites: One year of organic chemistry with laboratory and BCHM 100a or equivalents.
Describes the principles of biological catalysts and the chemical logic of metabolic pathways. Discusses representative enzymes from each reaction class, with an emphasis on understanding how mechanisms are derived from experimental evidence. Topics include serine proteases, phosphatases, isomerases, carboxylases, and dehydrogenases. Usually offered every year.
Ms. Hedstrom

BCHM 102a Quantitative Approaches to Biochemical Systems
[sn]
Prerequisite: BCHM 100a or equivalent.
Introduces quantitative approaches to analyzing macromolecular structure and function. Emphasizes the use of basic thermodynamics and single-molecule and ensemble kinetics to elucidate biochemical reaction mechanisms. Also discusses the physical bases of spectroscopic and diffraction methods commonly used in the study of proteins and nucleic acids. Usually offered every year.
Ms. Kern

BCHM 103b Advanced Biochemistry: Information Transfer Mechanisms
[sn]
Prerequisites: One year of organic chemistry with laboratory and BCHM 100a or equivalents.
Addresses fundamental issues of gene expression and signal transduction at a molecular level. Discusses parallels between nucleic acid and protein biosynthesis, modification, transport, and degradation, with an emphasis on understanding the mechanisms of specificity and regulation of these complex macromolecular processes. Usually offered every year.
Mr. Oprian

BCHM 104b Physical Chemistry of Macromolecules
[sn]
Prerequisites: CHEM 141a or equivalent and BCHM 100a or equivalent.
Illustrates the basic principles on which biological macromolecules are constructed and by which they function. Describes overall structures of proteins, nucleic acids, and membranes in terms of the underlying molecular forces: electrostatics, hydrophobic interactions, and H-bonding. The energetics of macromolecular folding and of the linkage between ligand binding and conformational changes will also be discussed. Usually offered every year.
Mr. Theobald

BCHM 150a Research for the BS/MS Candidates
[sn]
Prerequisites: BIOL 22a and BCHM 100a, one year of organic chemistry and laboratory, and BCHM 99.
The final semester(s) of laboratory research under the BS/MS program, to be pursued under the supervision of a faculty adviser. Usually offered every year.
Staff

BCHM 150b Research for the BS/MS Candidates
[sn]
See BCHM 150a for special notes and course description. Usually offered every year.
Staff

BCHM 150e Research for the BS/MS Candidates
See BCHM 150a for special notes and course description.
Staff

BCHM 153b Methods in High-Resolution Electron Cyro-Microscopy
[sn]
Transmission electron microscopy is introduced as a method in structural biology. Instrumentation, data collection, image processing, and interpretation of biological structures visualized by this method are discussed. Usually offered every second year.
Mr. Grigorieff

BCHM 170b Bioinformatics
[sn]
Prerequisites: Familiarity with computing is necessary and a basic biochemistry course is recommended. A joint offering between Brandeis University and Wellesley College.
Familiarizes students with the basic tools of bioinformatics and provides a practical guide to biological sequence analysis. Topics covered include an introduction to probability and statistics; sequence alignments; database searches; alignments and phylogenetic trees; sequence pattern discovery; structure determination by secondary structure prediction; and three-dimensional structure prediction by homology modeling. In all cases, the strengths and limitations of the methods will be discussed. Usually offered every third year.
Ms. Ringe

BCHM 171b Protein X-ray Crystallography
[sn]
A practical guide to the determination of three-dimensional structures of proteins and nucleic acids by X-ray diffraction. Students learn the theory behind diffraction from macromolecular crystals and carry out all the calculations necessary to solve a protein structure at high resolution. Usually offered every second year.
Mr. Miller and Mr. Oprian

(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

BCHM 219b Enzyme Mechanisms
Ms. Hedstrom

BCHM 220a Proteases
Ms. Hedstrom

BCHM 223a Enzymology of Biofuels, Bioplastics, and Bioremediation
Mr. Oprian

BCHM 224a Single-Molecule Biochemistry and Biophysics
Mr. Gelles

BCHM 225b Protein Dynamics
Prerequisite: BCHM 101a.
Introduces the fundamental concept of atomic fluctuations in proteins and their relation to protein function. Protein dynamics on different timescales is discussed, with emphasis on different experimental and computational approaches to this problem. Usually offered every third year.
Ms. Kern

BCHM 251b Structure and Function of Membrane Proteins
Considers the molecular properties of membrane transport proteins, including ion channels, aquaporins, solute pumps, and secondary active transporters. Readings focus on primary literature aimed at interpreting the mechanisms of transmembrane solute movements in terms of the structures of these integral membrane proteins. Specific subjects chosen vary depending upon the trajectory of recent advances in this fast-moving research area. Usually offered every third year.
Mr. Miller

BCHM 300a Biochemistry Techniques
Prerequisite: BCHM 101. May be taken concurrently.
Usually offered every year.
Staff

BCHM 300b Biochemistry Techniques
Prerequisite: BCHM 101. May be taken concurrently.
Usually offered every year.
Staff

BCHM 401d Biochemical Research Problems
All graduate students beyond the first year must register for this course.
Independent research for the MS and PhD degrees. Specific sections for individual faculty members as requested.
Staff

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.
Staff

Cross-Listed Courses

PHYS 105a
Biological Physics

QBIO 110a
Numerical Modeling of Biological Systems

QBIO 120b
Quantitative Biology Instrumentation Laboratory

CHEM 123b
Bioinorganic Chemistry

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

CHEM 130a
Advanced Organic Chemistry: Structure

CHEM 131a
Advanced Organic Chemistry: Topics in Structure and Reactivity

CHEM 132b
Advanced Organic Chemistry: Spectroscopy

CHEM 134b
Advanced Organic Chemistry: Synthesis

CHEM 137b
The Chemistry of Organic Natural Products

CHEM 143b
Kinetics, Dynamics, and Transport

CHEM 144a
Computational Chemistry

CHEM 146a
Single Molecule Spectroscopy

CHEM 147b
Mass Spectrometry

COSI 230a
Topics in Computational Biology

CHEM 246b
Advanced NMR Spectroscopy

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 a 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.

BIPH 11a,b (Seminar in Biological Physics) 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 11a,b or PHYS 15a,b; PHYS 19a,b; PHYS 20a; PHYS 31a (formerly 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

BIPH 11a,b (Seminar in Biological Physics) 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 in an earlier section of this *Bulletin* for details concerning the equivalent Brandeis courses for sufficient scores in the tests in Mathematics (AB or BC), Physics (C), and Chemistry. Credit toward the major is given for all these tests except for Physics C: Electrical. Students who take advanced placement credit for PHYS 15b will be required to take PHYS 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 in the following sections. 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, QBIO 110a.

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, PHYS 40a
Year 3: BIOL 18a,b; BIOL 22a,b; PHYS 39a
Year 4: PHYS 31a (formerly PHYS 30b); 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; PHYS 40a
Year 2: BIOL 18a,b; BIOL 22a,b; CHEM 25a,b; CHEM 29a,b
Year 3: BCHM 100a; PHYS 39a, one elective
Year 4: PHYS 30a; PHYS 31a (formerly PHYS 30b); 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 11a,b or PHYS 15a,b; PHYS 19a,b
Year 3: BIOL 18b; BIOL 22b; PHYS 20a; PHYS º40a; one elective
Year 4: PHYS 31a (formerly PHYS 30b); PHYS 39a; 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
See BIPH 98a for course description.
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 11a
Introductory Physics I

PHYS 11b
Introductory Physics II

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 31a
Quantum Theory I

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

QBIO 110a
Numerical Modeling of Biological Systems