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.
Mr. Salameh

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

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.
Mr. Salameh

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.
Mr. Salameh

(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.
Mr. Salameh

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.
Mr. Salameh

Department of Biochemistry

Courses of Study:
Major (B.A./B.S.)
Combined B.S./M.S.
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 track 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 track 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, as described above.

How to Become an Undergraduate 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 Ph.D. 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

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

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

Ulrich Genick
Structural investigation of signaling in the phytochrome system. Time-resolved X-ray crystallography.

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.

John Lowenstein
Role of phospholipids in hormone action. Regulation of lipogenesis. Regulation and function of the purine nucleotide cycle. Regulation and function of adenosine production in the heart. Techniques of cloning and high-level expression of proteins.

Christopher Miller
Structure and function of ion channel proteins. Membrane transport and mechanisms of electrical excitation.

Melissa Moore, Undergraduate Advising Head
Molecular biology of self-splicing introns and the splicesome. Mechanisms of RNA catalysis.

Gregory Petsko (Director, Rosenstiel Center)
X-ray crystallographic analysis of protein structure and enzyme mechanisms.

Dagmar Ringe (Rosenstiel Center)
Structures of enzymes and enzyme-substrate complexes. X-ray crystallography.

Requirements for the Undergraduate 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 11a,b or 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 41a (Physical Chemistry, Lectures I) and either BCHM 104b (Physical Chemistry of Macromolecules) or CHEM 41b (Physical Chemistry, Lectures II); and one elective from any 100-level course (excluding research courses) offered in the biochemistry and biology departments. With advance approval from the biochemistry department advising head, an upper-level course offered by another department (e.g., chemistry or physics) may also fulfill the elective requirement. The laboratory associated with CHEM 41a is optional.

Degree of Bachelor of Science
In addition to the degree requirements listed above for the Bachelor of Arts degree, the Bachelor of Science degree requires one year of BCHM 101a and 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 (CHEM 41a and b, and any course numbered 100 or above) 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.

Honors Program
In addition to the degree requirements listed above, departmental honors require completion of two semesters of BCHM 99 (Research for Undergraduates), submission of an acceptable research thesis, and a final grade point average of 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 four semester credits.

Combined B.S./M.S. Program

In addition to all courses required for the Bachelor of Science degree, the B.S./M.S. degree required completion of one additional elective (excluding research courses) approved in advance by the biochemistry department 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 coursework) summer research residency lasting at least 10 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 38 courses; no more than four semesters of research (BCHM 99 or 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 B.S. is awarded. To qualify for the B.S./M.S. degree, the thesis must constitute a significant research contribution; if a thesis is found unacceptable under B.S./M.S program, it will automatically be considered under the Honors program.

In order to complete the Honors Program or the combined B.S./M.S. 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:

BCHM 101a	Advanced Biochemistry: Enzyme Mechanisms
BCHM 103b	Advanced Biochemistry: Information Transfer Mechanisms
BCHM 102a	Quantitative Approaches to Biochemical Systems
BCHM 104b	Physical Chemistry of Macromolecules
BCHM 300a,b	Biochemical Techniques (Lab rotations)

Residence Requirement
The minimum residence requirement is one year.

Language Requirement
There is no language requirement.

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

Requirements for the Degree of Doctor of Philosophy

Program of Study: Biochemistry Ph.D.
Students must successfully complete the curriculum defined below.

A. The core curriculum consisting of:

BCHM 101a	Advanced Biochemistry: Enzyme Mechanisms
BCHM 103b	Advanced Biochemistry: Information Transfer Mechanisms
BCHM 102a	Quantitative Approaches to Biochemical Systems
BCHM 104b	Physical Chemistry of Macromolecules
BCHM 300a,b	Biochemical Techniques (Lab Rotations)
BCHM 401d	Biochemical Research
CONT 300b	Ethical Practices in Health-Related Sciences

B. Four advanced elective courses or seminars (100-200 level) offered in biochemistry, biophysics and structural biology programs, or other advanced courses can be subsituted with approval of the chair.

C. 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 towards completion the the thesis defense.

Students will typically complete the core curriculum in the first year and complete the remaining requirements in subsequent years in the program.

Program of Study: Bioorganic Chemistry Track
In order to receive a Ph.D. in biochemistry with a specialization in bioorganic chemistry, students must complete:

A. The core curriculum defined above

B. CHEM 134a Advanced Organic Chemistry: Synthesis

C. One other advanced chemistry course, chosen from the following:

CHEM 111a	Computational Chemistry
CHEM 130a	Advanced Organic Chemistry: Structure
CHEM 131a	Advanced Organic Chemistry: Topics in Structure and Reactivity
CHEM 132b	Advanced Organic Chemistry: Spectroscopy
CHEM 137b	The Chemistry of Organic Natural Products
CHEM 229b	Introduction to X-Ray Structure Determination
CHEM 235b	Advanced NMR Spectroscopy

D. Two advanced elective courses or seminars (100-200 level) offered in biochemistry, biophysics and structural biology programs. Other advanced courses can be substituted with approval of the chair.

Students typically complete the core curriculum in the first year and complete the remaining requirements in subsequent years in the program. However bioorganic track students have the option of replacing BCHM 102a or BCHM 104b with CHEM 134a in the first year and completing the replaced course in the second year.

Teaching Requirement
As a part of their Ph.D. 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 Ph.D. program. This support is provided by a combination of University funds, training grants, and individual research grants.

Qualifying Examinations
An oral qualifying examination must be taken following the first year of course work. In this examination, the student will be asked to present two propositions. The subject of one proposition will be assigned and the other will be 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
A dissertation will be required that summarizes 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 below, 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 stored in genes as DNA, the hereditary material of life, and the conversion of this information into proteins. Identifying undesirable mutations. Creating desirable mutations. Cloning of cells, organs, and animals in agriculture and medicine. Present and future applications. Usually offered every second year.
Mr. Lowenstein

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); and BCHM 100a; 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. Gelles (fall) and Mr. Lowenstein (spring)

BCHM 101a Advanced Biochemistry: Enzyme Mechanisms
[sn]
Prerequisites: One year of organic chemistry with laboratory and BCHM 100a or their equivalent.
Describes the principles of biological catalysts and the chemical logic of metabolic pathways. Representative enzymes from each reaction class are discussed 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]
Prerequisites: PHYS 11a, b and BCHM 100, or their 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. The physical bases of spectroscopic and diffraction methods commonly used in the study of proteins and nucleic acids will also be discussed. Usually offered every year.
Ms. Kern

BCHM 103b Advanced Biochemistry: Information Transfer Mechanisms
[sn]
This course may not be repeated for credit by students who have taken BCHM 101B in previous years) Prerequisites: One year of organic chemistry with laboratory and BCHM 100a or their equivalent.
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]
Prerequisite: CHEM 41a or equivalent and BCHM 100a or equivalent.
Illustrates the basic principles on which biological macromolecules are constructed and by which they function. Overall structures of proteins, nucleic acids, and membranes are described 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. Genick

BCHM 150a Research for B.S./M.S. Candidates
[sn]
Prerequisites: BIOL 22a (formerly BIBC 22a) and BCHM 100a; one year of organic chemistry and laboratory; BCHM 99.
The final semester(s) of laboratory research under the B.S./M.S. Program, to be pursued under the supervision of a faculty advisor. Usually offered every year.
Ms. Moore and Staff

BCHM 150b Research for the B.S./M.S. Candidates
[sn]
See BCHM 150a for special notes and course description. Usually offered every year.
Ms. Moore and Staff

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 second year.
Ms. Ringe

(200 and above) Primarily for Graduate Students

BCHM 219b Enzyme Mechanisms
Ms. Hedstrom

BCHM 220a Proteases
Ms. Hedstrom

BCHM 223a Signal Transduction
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 year.
Ms. Kern

BCHM 251b Structure and Function of Membrane Proteins
This course may not be repeated for credit by students who took BCHM 151b in previous years.
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 271b Protein X-ray Crystallography
Prerequisite: CHEM 229b.
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. Petsko

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

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 two public lectures during the course. Usually offered every year.
Ms. Press, Mr. Simister

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 M.S. and Ph.D. degrees. Specific sections for individual faculty members as requested.
Staff

Cross-Listed Courses

CHEM 111a
Computational Chemistry

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 229b
Special Topics in Inorganic Chemistry: Introduction to X-Ray Structure Determination

CHEM 235b
Advanced NMR Spectroscopy