Biochemistry

Chair

• Charles M. Brenner

Undergraduate major: biochemistry (B.A., B.S.)

Graduate degrees: M.S. in biochemistry; Ph.D. in biochemistry

Faculty: http://www.medicine.uiowa.edu/dept_primary_apr.aspx?appointment=Biochemistry

Web site: http://www.medicine.uiowa.edu/biochemistry/

Biochemistry is the study of basic chemical processes that occur in and govern all living systems. Nearly all areas of the life sciences engage in biochemical research.

Biochemistry graduates with bachelor's degrees often work as research assistants in industry, government, education, or health services; teach in secondary schools; or go on to advanced study in medicine, dentistry, or other areas. Those with advanced degrees pursue careers as teachers, researchers, or administrators in universities and medical schools, government, research agencies, and varied industries.

The Department of Biochemistry offers an undergraduate major and graduate degree programs and determines the curricula for those programs. Undergraduates majoring in biochemistry receive their degrees (Bachelor of Arts or Bachelor of Science) from the College of Liberal Arts and Sciences, and their studies are governed by that college's undergraduate academic policies. Graduate degrees in biochemistry are conferred by the Graduate College.

Undergraduate Programs of Study

• Major in biochemistry (Bachelor of Arts, Bachelor of Science)

Bachelor of Arts, Bachelor of Science

The Bachelor of Arts with a major in biochemistry requires a minimum of 120 s.h., including 57-58 s.h. of work for the major. The Bachelor of Science with a major in biochemistry requires a minimum of 120 s.h., including 69-70 s.h. of work for the major. Students must maintain a g.p.a. of at least 2.00 in all courses for the major and in all UI courses for the major. They also must complete the College of Liberal Arts and Sciences General Education Program.

The biochemistry major for the Bachelor of Arts degree provides a rigorous education in biochemical concepts and practice in the laboratory while giving students flexibility to specialize in additional disciplines or to obtain clinical volunteer experience. The B.A. program is intended for most students majoring in biochemistry, including those with pre-medicine, pre-pharmacy, pre-dental, and other pre-health professions interests. It also is appropriate for students earning more than one major.

The biochemistry major for the Bachelor of Science degree is intended primarily for students planning careers in research. The B.S. program prepares students to pursue graduate degrees, such as an M.S., Ph.D., or joint M.D./Ph.D., or to work as research technicians. The B.S. program requires 12 s.h. more credit in science and laboratory electives than the B.A. program does.

The first two years of the curriculum are the same for all students majoring in biochemistry. Students decide to earn a B.A. or a B.S. during the second semester of their sophomore year, in consultation with their biochemistry advisor. Transfer students select the B.A. or B.S. after completing one semester at the University of Iowa and meeting with their biochemistry advisor.

Qualified students in either degree program may graduate with honors in the biochemistry major; see “Honors in the Major” below.

The major in biochemistry (B.A. and B.S.) requires the following work.

Common Requirements (B.A. and B.S.)

All biochemistry majors complete the following course work during their first two years.

All of these:

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<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>S.H.</th>
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<tbody>
<tr>
<td>BIOL:1411-BIOL:1412</td>
<td>Foundations of Biology - Diversity of Form and Function</td>
<td>8 s.h.</td>
</tr>
<tr>
<td>CHEM:1110 &amp; CHEM:1120</td>
<td>Principles of Chemistry I-II</td>
<td>8 s.h.</td>
</tr>
<tr>
<td>MATH:1850 &amp; MATH:1860</td>
<td>Calculus I-II</td>
<td>8 s.h.</td>
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<tbody>
<tr>
<td>CHEM:2210</td>
<td>Organic Chemistry I</td>
<td>3 s.h.</td>
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<tr>
<td>CHEM:2230</td>
<td>Organic Chemistry I for Majors</td>
<td>3 s.h.</td>
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<tr>
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<th>Course Title</th>
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<tbody>
<tr>
<td>CHEM:2220</td>
<td>Organic Chemistry II</td>
<td>3 s.h.</td>
</tr>
<tr>
<td>CHEM:2240</td>
<td>Organic Chemistry II for Majors</td>
<td>3 s.h.</td>
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<tbody>
<tr>
<td>CHEM:2410</td>
<td>Organic Chemistry Laboratory</td>
<td>3 s.h.</td>
</tr>
<tr>
<td>CHEM:2420</td>
<td>Organic Chemistry Laboratory for Majors</td>
<td>3 s.h.</td>
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<tbody>
<tr>
<td>PHYS:1511</td>
<td>College Physics I</td>
<td>4 s.h.</td>
</tr>
<tr>
<td>PHYS:1611</td>
<td>Introductory Physics I</td>
<td>4 s.h.</td>
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<tr>
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<th>Course Title</th>
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<tbody>
<tr>
<td>PHYS:1512</td>
<td>College Physics II</td>
<td>4 s.h.</td>
</tr>
<tr>
<td>PHYS:1612</td>
<td>Introductory Physics II</td>
<td>3-4 s.h.</td>
</tr>
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All of these:

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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>S.H.</th>
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<tbody>
<tr>
<td>BIOC:3120 &amp; BIOC:3130</td>
<td>Biochemistry and Molecular Biology I-II</td>
<td>6 s.h.</td>
</tr>
<tr>
<td>BIOC:3140</td>
<td>Experimental Biochemistry</td>
<td>2 s.h.</td>
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Additional Requirements for the B.A.

In addition to the common requirements listed above, biochemistry majors who elect to earn a Bachelor of Arts must complete the following work.

One of these:

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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>S.H.</th>
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<tbody>
<tr>
<td>BIOC:5241</td>
<td>Biophysical Chemistry I</td>
<td>3 s.h.</td>
</tr>
<tr>
<td>BIOC:5242</td>
<td>Biophysical Chemistry II</td>
<td>3 s.h.</td>
</tr>
<tr>
<td>CHEM:4430</td>
<td>Principles of Physical Chemistry</td>
<td>3 s.h.</td>
</tr>
</tbody>
</table>
CHEM:4431 Physical Chemistry I 3 s.h.
CHEM:4432 Physical Chemistry II 3 s.h.

And:

Advanced science electives approved by biochemistry advisor 6 s.h.

Bachelor of Arts students intending to earn advanced degrees in the biological or health sciences are advised to earn at least 4 s.h. in BIOC:3993 Undergraduate Independent Study or BIOC:4999 Research, Independent Study. There are no prerequisites for BIOC:3993. The course involves experience in an active biochemistry research lab, which must be arranged ahead of time with a supervising faculty member. Students may make arrangements directly with the faculty member, or they may request assistance from an undergraduate advisor. Credit earned in BIOC:3993 does not count toward the major, but it does count toward the minimum of 120 s.h. required to graduate.

In order to register for BIOC:4999 Research, Independent Study, students must have completed BIOC:3120 Biochemistry and Molecular Biology I, BIOC:3130 Biochemistry and Molecular Biology II, and BIOC:3140 Experimental Biochemistry. They must have a grade of B or higher in the three courses and a grade of B-minus or higher in each course. They also must have completed BIOC:3101 Technical Communication in Biochemistry and should have prior research experience (e.g., BIOC:3993 Undergraduate Independent Study or HONR:3994 Honors Research Practicum) or consent of the instructor.

Additional Requirements for the B.S.

In addition to the common requirements listed above, biochemistry majors who elect to earn a Bachelor of Science must complete the following work.

Two of these:

BIOC:5241 Biophysical Chemistry I 3 s.h.
BIOC:5242 Biophysical Chemistry II 3 s.h.
CHEM:4430 Principles of Physical Chemistry 3 s.h.
CHEM:4431 Physical Chemistry I 3 s.h.
CHEM:4432 Physical Chemistry II 3 s.h.

All of these:

Advanced science electives approved by biochemistry advisor 9 s.h.
Advanced laboratory courses, including BIOC:4999 6 s.h.

Students are encouraged to begin research by taking BIOC:3993 Undergraduate Independent Study, which has no prerequisites. The course involves experience in an active biochemistry research lab, which must be arranged ahead of time with a supervising faculty member. Students may make arrangements directly with the faculty member, or they may request assistance from an undergraduate advisor. Credit earned in BIOC:3993 does not count toward the major, but it does count toward the minimum of 120 s.h. required to graduate.

In order to register for BIOC:4999 Research, Independent Study, students must have completed BIOC:3120 Biochemistry and Molecular Biology I, BIOC:3130 Biochemistry and Molecular Biology II, and BIOC:3140 Experimental Biochemistry. They must have a grade of B or higher in the three courses and a grade of B-minus or higher in each course. They also must have completed BIOC:3101 Technical Communication in Biochemistry and should have prior research experience (e.g., BIOC:3993 Undergraduate Independent Study or HONR:3994 Honors Research Practicum) or consent of the instructor.

B.A. or B.S. with Teacher Licensure

Biochemistry majors interested in earning licensure to teach in elementary and/or secondary schools must complete the College of Education's Teacher Education Program (TEP) in addition to the requirements for the major and all requirements for graduation. The TEP requires several College of Education courses and student teaching. Contact the Office of Education Services for details.

Students must satisfy all degree requirements and complete Teacher Education Program licensure before degree conferral.

Four-Year Graduation Plan

The following checkpoints list the minimum requirements students must complete by certain semesters in order to stay on the University's Four-Year Graduation Plan. (Courses in the major are those required to complete the major; they may be offered by departments other than the major department.)

Bachelor of Arts


Before the seventh semester begins: PHYS:1611 Introductory Physics I or PHYS:1511 College Physics I, PHYS:1612 Introductory Physics II or PHYS:1512 College Physics II, BIOC:3120 Biochemistry and Molecular Biology I, BIOC:3130 Biochemistry and Molecular Biology II, BIOC:3140 Experimental Biochemistry, two science electives, and at least 90 s.h. earned toward the degree

Before the eighth semester begins: CHEM:4430 Principles of Physical Chemistry or CHEM:4431 Physical Chemistry I or CHEM:4432 Physical Chemistry II or BIOC:5241 Biophysical Chemistry I or BIOC:5242 Biophysical Chemistry II, and a science elective

During the eighth semester: enrollment in all remaining course work in the major, all remaining General Education courses, and a sufficient number of semester hours to graduate

Bachelor of Science

Before the third semester begins: CHEM:1110 Principles of Chemistry I, CHEM:1120 Principles of
Chemistry II, MATH:1850 Calculus I, and MATH:1860 Calculus II

**Before the fifth semester begins:** BIOC:1411 Foundations of Biology, BIOC:1412 Diversity of Form and Function, CHEM:2210 Organic Chemistry I or CHEM:2230 Organic Chemistry I for Majors, CHEM:2220 Organic Chemistry II or CHEM:2240 Organic Chemistry II for Majors, and CHEM:2410 Organic Chemistry Laboratory or CHEM:2420 Organic Chemistry Laboratory for Majors

**Before the seventh semester begins:** PHYS:1611 Introductory Physics I or PHYS:1511 College Physics I, PHYS:1612 Introductory Physics II or PHYS:1512 College Physics II, BIOC:3101 Technical Communication in Biochemistry, one semester of BIOC:3993 Undergraduate Independent Study for students planning to take BIOC:4999 Research, Independent Study, BIOC:3120 Biochemistry and Molecular Biology I, BIOC:3130 Biochemistry and Molecular Biology II, BIOC:3140 Experimental Biochemistry, two science electives, and at least 90 s.h. earned toward the degree

**Before the eighth semester begins:** CHEM:4431 Physical Chemistry I or CHEM:4432 Physical Chemistry II or BIOC:5241 Biophysical Chemistry I or BIOC:5242 Biophysical Chemistry II, a science elective, and at least 3 s.h. of BIOC:4999 Research, Independent Study

**During the eighth semester:** enrollment in all remaining course work in the major, all remaining General Education courses, and a sufficient number of semester hours to graduate

**Honors in the Major**

Students majoring in biochemistry have the opportunity to graduate with honors in the major. Departmental honors students must maintain a cumulative University of Iowa g.p.a. of at least 3.33. To graduate with honors in the biochemistry major, students must earn 6 s.h. in BIOC:4999 Research, Independent Study. They must present their research results in a report written in the form of a journal article and in an oral report given at a special open departmental seminar.

In addition to honors in their major, undergraduate students have a variety of opportunities for honors study and activities through membership in the University of Iowa Honors Program; visit Honors at Iowa to learn about the University’s honors program.

**Joint B.S./Ph.D.**

The joint Bachelor of Science/Doctor of Philosophy program in biochemistry permits students to transition into the Ph.D. program during their senior year and to count 12 s.h. of credit toward both the B.S. and Ph.D. requirements. The joint program provides a research-intensive experience and shortens the training time for students interested in pursuing independent biochemistry research careers. Students in the program receive financial support during the second half of their senior year and throughout their Ph.D. study.

Students must apply to enter the joint B.S./Ph.D. program. They must be pursuing a Bachelor of Science with a major in biochemistry, and by the beginning of their senior year they must:

- have 108 s.h. of undergraduate credit;
- have a minimum grade-point average of 3.50;
- have completed four semesters of research experience (summer research counts as one semester); and
- have completed BIOC:3120 Biochemistry and Molecular Biology I, BIOC:3130 Biochemistry and Molecular Biology II, and BIOC:3140 Experimental Biochemistry.

Students interested in the joint program should speak with their academic advisor and the biochemistry honors advisor during their first year or at the beginning of their sophomore year. They should apply to the program in spring of their junior year; applications are due at the beginning of the spring semester. Application materials must include a letter of application and statement of purpose; official scores on the Graduate Record Exam (GRE) General Test; and three letters of recommendation, including at least one from a research advisor.

**Graduate Programs of Study**

**Master of Science**

The Master of Science program in biochemistry requires a minimum of 32 s.h. of graduate credit, thesis research, and a thesis. See "Doctor of Philosophy" for information about the graduate curriculum.

**Doctor of Philosophy**

The Doctor of Philosophy program in biochemistry requires a minimum of 72 s.h. of graduate credit. Students complete 34 s.h. of course work and earn 38 s.h. of credit for research. The focus of the graduate program is on the individual student, so students work with the director of the biochemistry graduate programs to tailor the curriculum to their educational goals.

The Ph.D. in biochemistry requires the following work:

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<tr>
<th>Course Code</th>
<th>Description</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>BIOC:5261</td>
<td>Research Techniques (first-year laboratory rotation)</td>
<td>1-5 s.h.</td>
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<tr>
<td>GRAD:7270</td>
<td>Principles of Scholarly Integrity</td>
<td>0-1 s.h.</td>
</tr>
<tr>
<td></td>
<td>&quot;Biophysical chemistry requirement&quot;</td>
<td>3 s.h.</td>
</tr>
<tr>
<td>Molec or cellular biology</td>
<td>(students typically earn 6 s.h.); see &quot;Molecular and cell biology requirement&quot; below</td>
<td>4 s.h.</td>
</tr>
<tr>
<td>Graduateseminar</td>
<td></td>
<td>3 s.h.</td>
</tr>
<tr>
<td>Additional courses offered by the Department of Biochemistry and by other UI departments, as appropriate for the student's program of study</td>
<td>13 s.h.</td>
<td></td>
</tr>
<tr>
<td>Research</td>
<td></td>
<td>38 s.h.</td>
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**Biophysical chemistry requirement:** the following courses may be used to fulfill the 3 s.h. requirement. Students choose courses to meet their individual educational goals, completing one 3 s.h. course or a combination of three 1 s.h. courses (modules).
BIOC:5241 Biophysical Chemistry I 3 s.h.
BIOC:5242 Biophysical Chemistry II 3 s.h.
BIOC:5243 Biophysical Chemistry Module 1 1 s.h.
BIOC:5244 Enzyme Mechanisms and Ligand Interactions 1 s.h.
BIOC:5245 Biophysical Chemistry Module 2 1 s.h.
BIOC:5246 Techniques for Atomic Resolution Structure Determination 1 s.h.
BIOC:5247 Biophysical Chemistry Module 3 1 s.h.
BIOC:5248 Techniques for Determining Bimolecular Dynamics and the Structure of Large Systems 1 s.h.

Molecular and cell biology requirement: the following courses are among those that students may use to fulfill the molecular and cell biology requirement.

MCB:6215 Transcription and Multi-Functional Regulation by RNA 1 s.h.
MCB:6217 Epigenetics, Cancer, and Mouse Models of Disease 1 s.h.
MCB:6225 Growth Factor Receptor Signaling 1 s.h.
MCB:6226 Cell Cycle Control 1 s.h.
MCB:6227 Cell Fate Decisions 1 s.h.
BISC:5201 Fundamentals of Gene Expression 1 s.h.
BISC:5203 Fundamentals of Dynamic Cell Processes 1 s.h.
BISC:5204 Biostatistics for Biomedical Research 1 s.h.
BISC:5205 Practical Bioinformatics 1 s.h.
BISC:5265 Biosciences Critical Thinking and Communication 2 s.h.

Students take the comprehensive examination before the end of June in their second year, after which they are admitted formally to candidacy and begin to concentrate on thesis research. The program culminates in successful defense of completed thesis work before an examining committee.

In addition to meeting these requirements and those of the Graduate College, students are expected, as part of their training, to assist in teaching biochemistry for one semester.

Throughout the program, students are associated with faculty-directed research groups. They receive close personal attention from the biochemistry faculty members who serve as research advisors.

Admission

Most graduate students in biochemistry work toward a Doctor of Philosophy. Applicants who wish to earn a master's degree must contact the Department of Biochemistry before they apply.

The graduate program in biochemistry is flexible enough to accommodate students with bachelor's degrees in any of the biological, biochemical, or physical sciences. Appropriate preparation includes one-year, college-level courses in organic and physical chemistry, biology, physics, and mathematics through calculus. Students are expected to have had one or more introductory courses in biochemistry.

Applicants must have an undergraduate g.p.a. of at least 3.00 and must submit acceptable verbal, quantitative, and analytical scores on the Graduate Record Examination (GRE) General Test. Applicants are encouraged to submit their scores on the GRE Subject Test in Chemistry; Biology; or Biochemistry, Cell, and Molecular Biology.

Applicants must meet the admission requirements of the Graduate College; see the Manual of Rules and Regulations of the Graduate College.

Financial Support

Students admitted to the Ph.D. program in biochemistry routinely receive a stipend and tuition support.

Faculty and Research

The department's faculty members supervise research in biochemistry; molecular, cellular, developmental, computational, and structural biology; and model system genetics. Their work is supported by grants from the National Institutes of Health, the National Science Foundation, the American Heart Association, the American Cancer Society, the Muscular Dystrophy Association, and other sources. To learn more about the department's faculty members and areas of research, visit the Department of Biochemistry web site.

Facilities

The Department of Biochemistry occupies 36,700 square feet on the fourth floor of the Bowen Science Building and 7,500 square feet on the third floor of the Medical Education Research Facility on the University's health sciences campus. It has a number of well-equipped research laboratories; other departmental facilities include the Biochemistry Stores, the Mattill Biochemistry Reading Room, and the Heath Conference Room.

The department makes available a number of shared instruments; among them are an Applied PhotoPhysics stopped flow spectrometer SX20 (2009); a Jasco spectropolarimeter, model J815 (2010); a Horiba fluorlog-3 spectrofluorometer (2010); and a Beckman Coulter ultra XLI analytical centrifuge (1996).

Faculty, staff, and students in the department have access to a variety of shared Carver College of Medicine resources, including the X-ray Crystallography Facility, the IIHG Genomics Division (DNA Facility), the Medical NMR Facility, the Proteomics Facility, the Flow Cytometry Facility, the Viral Vector Core Facility, the Small Animal Imaging Core Facility, and the Genome Editing Core Facility. The University also supports resources such as the Central Microscopy Research Facilities and the High Throughput Screening Facility.

Courses

Lower-Level Undergraduate

BIOC:1001 CLAS Master Class 1-3 s.h.
Exploration of a single topic in a series of lectures by faculty presenting divergent perspectives; illuminates intellectual adventure inherent in liberal arts and sciences; encourages discovery of majors and other areas of study within the College of Liberal Arts and Sciences. Same as CLAS:1001, RELS:1010, THTR:1001, CS:1001, CSD:1001, PHIL:1001, ENGL:1001, ARTS:1001.
Upper-Level Undergraduate and Graduate

**BIOC:3101 Technical Communication in Biochemistry**
1 s.h.
How to communicate technical information through writing and speaking; students present research findings in several formats, read journal articles, and write a proposal for their senior project in BIOC:4999. Prerequisites: BIOC:3120 or BIOC:3130 or BIOC:3140. Requirements: biochemistry major, and junior or senior standing.

**BIOC:3110 Biochemistry**
3 s.h.
Basic concepts in modern biochemistry and molecular biology; understanding of life processes in molecular terms. Requirements: one year each of college-level biology and chemistry. Recommendations: one semester of organic chemistry.

**BIOC:3120 Biochemistry and Molecular Biology I**
3 s.h.
Physical and chemical foundations of biochemistry, structure of biological molecules, catalysis, transport, and oxidative reactions in biology; first course of two-semester sequence that concludes with BIOC:3130. Requirements: two semesters of general chemistry and one of organic chemistry. Recommendations: BIOL:1411, BIOL:1412, and an additional organic chemistry course.

**BIOC:3130 Biochemistry and Molecular Biology II**
3 s.h.
Carbohydrate biosynthesis, lipid metabolism, hormone regulation and integration of metabolism, signal transduction, genes and chromosomes, DNA replication and repair, transcription, RNA processing, protein translation and regulation of gene expression. Prerequisites: BIOC:3120.

**BIOC:3140 Experimental Biochemistry**
2 s.h.
Use of modern instruments and techniques to fractionate, identify, and characterize constituents of biochemical systems. Prerequisites: BIOC:3120. Requirements: grade of C or higher in BIOC:3120, two semesters of general chemistry, and one semester of organic chemistry.

**BIOC:3993 Undergraduate Independent Study**
arr.
Experience in an active biochemistry research lab, learning and performing experiments relevant to the current projects in that lab; exploration of scientific literature on topic of interest; arranged in advance by student and faculty member. Requirements: first-year, sophomore, or junior standing.

**BIOC:4999 Research, Independent Study**
arr.
Independent study and research in areas of interest to the student; arranged in advance by student and biochemistry honors advisor. Prerequisites: BIOC:3101. Requirements: grades of B- or higher in BIOC:3120, BIOC:3130, and BIOC:3140; average grade of B or higher for all three courses; and BIOC:3993 or HONR:3994 or prior research experience or lab practicum.

Graduate

**BIOC:5215 Directed Readings for Graduate Students**
arr.
Directed readings with course content arranged with professor.

**BIOC:5226 Enzyme Kinetics and Bioorganic Mechanisms**
1-2 s.h.
Principles and applications of steady-state and transient enzyme kinetics; mechanisms of catalysis of biochemical reactions. Prerequisites: BIOC:3120.

**BIOC:5241 Biophysical Chemistry I**
3 s.h.
Principles and experimental approaches used to study structure and function of biological macromolecules; protein structure, stability, and dynamics; macromolecular interactions; common biophysical methods. Requirements: one year of biochemistry. Recommendations: physical chemistry course and one semester of calculus.

**BIOC:5242 Biophysical Chemistry II**
3 s.h.
Principles and experimental approaches used to study structure and function of biological macromolecules; ligand binding and enzyme catalysis; X-ray crystallography; NMR spectroscopy. Requirements: one year of biochemistry. Recommendations: physical chemistry course and one semester of calculus.

**BIOC:5243 Biophysical Chemistry Module 1**
1 s.h.
Overview of principles of protein structure, stability, folding, and dynamics; brief treatment of structural biology approaches to help students become critical users of models derived from X-ray crystallography and NMR; taken alone or as part of BIOC:5241. Requirements: introductory course in biochemistry. Same as BISC:5206.

**BIOC:5244 Enzyme Mechanisms and Ligand Interactions**
1 s.h.
Enzymes as unparalleled catalysts that represent a unique class of drug targets; focus on organic chemistry of enzyme catalyzed reactions and enzyme inhibition by small molecules from a medicinal chemistry perspective; chemical and enzyme kinetics, sources of catalytic power, chemical mechanisms used in enzyme catalysis, role of coenzymes; strategies in enzyme inhibition, drug resistance, drug synergism, reversible enzyme inhibitors, transition state analogs, slow tight binding inhibitors, irreversible inhibition; taken alone or with BIOC:5242. Requirements: introductory course in biochemistry. Same as PHAR:5542.

**BIOC:5245 Biophysical Chemistry Module 2**
1 s.h.
In-depth examination of statistical thermodynamics and molecular forces in biological systems as related to protein structure, stability, and folding; nucleic acid structure and stability; taken alone or as part of BIOC:5241. Requirements: introductory course in biochemistry.

**BIOC:5246 Techniques for Atomic Resolution Structure Determination**
1 s.h.
Utilization of X-ray crystallography and NMR spectroscopy in determining atomic resolution biomolecular structures; crystal geometry, X-ray diffraction, the phase problem, data collection, structure solving and refinement; basic principles of NMR spectroscopy including magnetic properties of nuclei, chemical shift, resonance assignments, determination of NOEs, scalar couplings, RDCs, and simulated annealing approaches to structure determination; for students interested in structural biology; taken alone or with BIOC:5242. Requirements: introductory course in biochemistry.

BIOC:5247 Biophysical Chemistry Module 3 1 s.h.
In-depth examination of protein-protein interactions and protein-nucleic acid interactions; implications in biological motility, transcription, and replication; taken alone or as part of BIOC:5241. Requirements: introductory course in biochemistry.

BIOC:5248 Techniques for Determining Bimolecular Dynamics and the Structure of Large Systems 1 s.h.
Methods for studying biomolecular dynamics, structure of large biomolecules and biomolecular complexes; measurement and analysis of NMR parameters for characterization of dynamics including T1, T2, hetNOE, CPMG-RD, and RDCs; introduction to computational approaches (e.g., molecular dynamics); NMR methods for studying large biomolecular systems and survey of other approaches including cryoEM and SAX; for students interested in structural biology; taken alone or with BIOC:5242. Requirements: one year of biochemistry. Recommendations: basic knowledge of spectroscopy and some previous exposure to NMR from basic chemistry courses.

BIOC:5261 Research Techniques 1-6 s.h.
Laboratory rotation for first-year graduate students in biochemistry.

BIOC:5282 Seminar 0-1 s.h.
How to evaluate reports of scientific investigations critically; techniques for presenting scientific information.

BIOC:5875 Perspectives in Biocatalysis 1-3 s.h.
Applied enzymology, protein design, structure-activity relationships, biosensor technology, microbial transformations, biodegradation of environmental pollutants. Requirements: graduate standing in a participating department supported by the Predoctoral Training Program in Biotechnology. Same as CHEM:5875, PHAR:5875, CBE:5875, CEE:5875, MICR:5875.

BIOC:7251 Introduction to Protein Structures arr.
Basics of protein structures. Recommendations: first-year graduate standing in biosciences or physical sciences.

BIOC:7252 Enzymes, Carbohydrates, Nucleic Acids, and Bioenergetics arr.
Basics of enzyme kinetics and enzyme mechanisms, carbohydrates, nucleic acids, and bioenergetics; module covers chapters 6, 7, 8, and 13 of Lehninger's Principles of Biochemistry. Recommendations: first-year graduate standing in biosciences or physical sciences.

BIOC:7253 Metabolism I 1 s.h.
Basics of carbohydrate metabolism (glycolysis, gluconeogenesis, the pentose phosphate pathway), hormonal regulation of carbohydrate metabolism, the citric acid cycle, amino acid catabolism, oxidative phosphorylation; assignment of an advanced topic related to material, typically a recent research paper, extending inquiry beyond that presented in class and presented orally at end of five-week module. Requirements: undergraduate biochemistry course or background in enzyme function.

BIOC:7254 Metabolism II 1 s.h.
Central carbon metabolism, carbohydrate biosynthesis in plants and bacteria, lipid structure/function, fatty acid catabolism, lipid biosynthesis, and biological membranes/transport; assignment of an advanced topic related to material, typically a recent research paper, extending inquiry beyond that presented in class and presented orally at end of five-week module. Prerequisites: BIOC:7253.

BIOC:7255 Metabolism III and Biosignaling arr.
Basics of membranes and transport, biosignaling, nitrogen metabolism, integration of metabolism, genes, and chromosomes; module covers chapters 11, 12, 22, 23, and 24 of Lehninger's Principles of Biochemistry. Requirements: undergraduate biochemistry course. Recommendations: first-year graduate standing in biosciences or physical sciences.

BIOC:7256 Molecular Biology 1 s.h.
DNA, RNA, and protein metabolism, regulation of gene expression, and DNA-based information technologies.

BIOC:7292 Research Biochemistry arr.
Thesis research.

BIOC:8101 Biochemistry for Dental Students 3 s.h.