BIOCHEMISTRY

Overview & Learning Goals

Learning Goals

Biochemistry lies at the interface of chemistry and biology, a diffuse and ever-changing junction. A student of this reductionist way of evaluating our natural world must master multiple disciplines and approaches to understand this interface.

The Bowdoin biochemistry curriculum provides the tools and the chemical and biological fundamentals needed to evaluate and explain observed phenomena. Students will understand the basic chemistry of molecules that form the basis of life, including nucleic acids, proteins, lipids, and carbohydrates. How these molecules combine to form the flow of information within and between cells and species, and from generation to generation, is fundamental.

Students start by learning principles of chemistry and biology as underpinned by mathematics and physics, and move on to mid-level courses that combine these concepts and apply them to the understanding of biochemistry. These courses also provide more advanced approaches for solving biochemical problems through experimentation.

Subsequent upper-level courses continue to explore the basis of energy and information flow in chemical and biological systems, and critically analyze structure and complex biochemical interactions that form the basis of life.

Biochemistry Core Competencies Map (PDF) (https://www.bowdoin.edu/biochemistry/pdf/biochemistry-core-competencies.pdf)

Fundamental Learning Goals

Knowledge competencies

1. Master the foundational concepts of general and organic chemistry, including equilibrium, kinetics, and reactivity, and apply these concepts to biological systems.
2. Identify the factors that determine the three-dimensional structures of biological macromolecules and the organization of cells.
3. Evaluate how the structure of biological macromolecules relates to function, and predict how changes in structure will impact function.
4. Develop a conceptual, mechanistic, and mathematical understanding of biomolecular interactions, including binding and catalysis.
5. Explain how energy is stored, transformed, and harnessed in biological systems.
6. Understand how information is stored, retrieved, and transmitted in biological systems.

Skill-based competencies

1. Solve complex data-based problems.
2. Critically evaluate the primary literature.
3. Independently propose and design experiments and approaches to address questions in biochemistry.
4. Safely perform laboratory-based experiments.
5. Effectively communicate scientific information in oral, written, and visual formats to specialized and general audiences.
6. Interpret and critically analyze data, while appropriately invoking the principles of probability and statistics.
7. Understand and apply theoretical, conceptual, and empirical models.

Options for Majoring in the Program

Students may elect to major in biochemistry or to coordinate a major in biochemistry with digital and computational studies, education, or environmental studies. Students pursuing a coordinate major may not normally elect a second major. Bowdoin does not offer a minor in biochemistry.

Program Website (https://www.bowdoin.edu/biochemistry/)

Faculty

Benjamin C. Gorske, *Program Director*
Sylvia Bosco, *Program Coordinator*

Professors: Danielle H. Dube (Chemistry), Bruce D. Kohorn (Biology)
Associate Professors: Benjamin C. Gorske (Chemistry), Anne E. McBride‡ (Biology), Kana Takematsu‡ (Chemistry)
Visiting Fellow: Dani Calles

Laboratory Instructors: Aimee Eldridge, Kate R. Farnham

Faculty/Staff Website (https://www.bowdoin.edu/biochemistry/faculty-and-staff/)

Requirements

Biochemistry Major

Code	Title	Credits
Required Courses		
BIOL 1102	Biological Principles II	1
or BIOL 1109	Scientific Reasoning in Biology	
BIOL 2124	Biochemistry and Cell Biology	1
Select one of the following:		1
CHEM 1092	Introductory Chemistry and Quantitative Reasoning II	
CHEM 1102	Introductory Chemistry II	
CHEM 1109	General Chemistry	
CHEM 2250	Organic Chemistry I	1
CHEM 2260	Organic Chemistry II	1
CHEM 2320	Biochemistry	1
CHEM 2510	Chemical Thermodynamics and Kinetics	1
MATH 1700	Integral Calculus (or higher)	1
PHYS 1130	Introductory Physics I	1
or PHYS 1140	Introductory Physics II	
Select two electives from the following (one must be 3000 or above):		2
BIOL 2130	Population Genomics	
BIOL 2210	Plant Ecophysiology	
BIOL 2112	Genetics and Molecular Biology	
BIOL 2118	Microbiology	
BIOL 2175	Developmental Biology	
BIOL 2566	Molecular Neurobiology	
BIOL 3280	Plant Responses to the Environment	
BIOL 3304	The RNA World	

BIOL 3314	Advanced Genetics and Epigenetics
BIOL 3333	Advanced Cell and Molecular Biology
CHEM 2100	Chemical Analysis
CHEM 3250	Structure Determination in Organic Chemistry
CHEM 3270	Biomimetic and Supramolecular Chemistry
CHEM 3320	Molecular Biophysics
CHEM 3310	Chemical Biology
CHEM 3510	Reactivity and Kinetics

A minimum of eleven courses from among the required and elective biochemistry courses must be completed for the major. Students placing into MATH 1800 Multivariate Calculus or higher must take MATH 1300 Biostatistics, MATH 1400 Statistics in the Sciences, or one math course at the 1800-level or above.

Students placing out of BIOL 1109 Scientific Reasoning in Biology, CHEM 1109 General Chemistry, PHYS 1130 Introductory Physics I, or PHYS 1140 Introductory Physics II must still complete a minimum of eleven courses related to biochemistry.

Additional Information

Additional Information and Program Policies

- Only one D grade is allowed in courses required for the major. This D must be offset by a grade of B or higher in another course also required for the major.
- Students may not count courses taken Credit/D/Fail toward the major.
- Advanced placement exams are used for placement in courses for the biochemistry major, but do not count toward the eleven courses required for the major.
- Biochemistry majors cannot minor or major in biology, chemistry, or neuroscience, and may only double-count courses to a second major or a minor with permission of the Biochemistry Program.
- Bowdoin does not offer a minor in biochemistry.
- Students may request transfer credit by talking with the program director the semester prior to enrolling in a course.
- Independent studies do not count as an elective, but can count as one of the eleven required courses for the major.
- Students may engage in independent study at the advanced (4000–4051) level. Majors pursuing honors in biochemistry are required to register for BIOC 4050 during the first semester of their senior year and BIOC 4051 during the second semester of their senior year.
- Advanced independent studies and honors projects do not count as electives, but may be applied to towards the total number of credits required to complete the major.
- Many research advisors require that students perform summer research in their laboratory prior to registering for advanced independent study, so interested students should aim to finalize such plans with their prospective research advisor in the first semester of their junior year.

Information for Incoming Students (p. 2)

The Biochemistry major requires a firm foundation in both chemistry and biology prior to enrollment in the core biochemistry courses. First-year students with an interest in biochemistry should complete introductory chemistry coursework (CHEM 1091 Introductory Chemistry and Quantitative Reasoning I, CHEM 1092 Introductory Chemistry and Quantitative Reasoning II, CHEM 1101 Introductory Chemistry I, CHEM 1102 Introductory Chemistry II or CHEM 1109 General Chemistry) and introductory biology coursework (BIOL 1101 Biological Principles I, BIOL 1102 Biological Principles II or BIOL 1109 Scientific Reasoning in Biology) by the end of the first year, if possible. Please consult the biology (https://bowdoin-public.courseleaf.com/departments-programs/biology/#additionalinformationtext) and chemistry (https://bowdoin-public.courseleaf.com/departments-programs/chemistry/#additionalinformationtext) sections of the Catalogue for information about introductory course sequences and proper placement.

If placement results indicate a two-semester introductory chemistry sequence is required, students are recommended to begin with introductory chemistry in their first semester. If the two-semester introductory biology sequence is also required, one option is to complete these courses in the sophomore year, in parallel with the organic chemistry sequence; please consult with a member of the biochemistry program for suggestions about timing. The most important planning step is to ensure that CHEM 1092 Introductory Chemistry and Quantitative Reasoning II, or CHEM 1102 Introductory Chemistry II, or CHEM 1109 General Chemistry is completed during the first year to enable enrollment in the two-semester organic chemistry sequence in the sophomore year. Please contact a member of the biochemistry program if you have any questions.

Note that completing the tiered biochemistry major requires, in most cases, that students take a math and a lab-science course, or take two lab-science classes, at the same time in their first year. This is most often during the second semester; for example, a student placed in CHEM 1101 Introductory Chemistry I/CHEM 1102 Introductory Chemistry II and BIOL 1109 Scientific Reasoning in Biology may choose to enroll in CHEM 1102 Introductory Chemistry II and BIOL 1109 Scientific Reasoning in Biology in their second semester of their first year. Taking more than one math/lab-science course in the same semester of the first year can be challenging, so students are encouraged to speak with their pre-major academic advisors about designing a feasible course schedule if they are considering future study in biochemistry.

Additional information: For a flow diagram of courses required for the biochemistry major, please visit the “Navigating the Major” page (https://www.bowdoin.edu/biochemistry/requirements/navigating-the-biochemistry-major.html) of the biochemistry program's website.

Courses

BIOC 2124 (a, INS, MCSR) Biochemistry and Cell Biology
Jake Muscato; Aimee Eldridge.
Every Fall. Fall 2023. Enrollment limit: 35.

Focuses on the structure and function of cells as we have come to know them through the interpretation of direct observations and experimental results. Emphasis is on the scientific (thought) processes that have allowed us to understand what we know today, emphasizing the use of genetic, biochemical, and optical analysis to understand fundamental biological processes. Covers details of the organization and expression of genetic information, and the biosynthesis, sorting, and function of cellular components within the cell. Concludes with examples of how cells perceive signals from other cells within cell populations, tissues, organisms, and the environment. Three hours of lab each week. Not open to students who have credit for Biology 2423. (Same as: BIOL 2124)

Prerequisites: BIOL 1102 or BIOL 1109 or Placement in BIOL 2000 level.

Previous terms offered: Fall 2022, Fall 2021, Fall 2020, Fall 2019.

BIOC 2320 (a, MCSR) Biochemistry
Danielle Dube; Dani Calles; Kate Farnham.
Every Spring. Spring 2024. Enrollment limit: 36.

Focuses on the chemistry of living organisms. Topics include structure, conformation, and properties of the major classes of biomolecules (proteins, nucleic acids, carbohydrates, and lipids); enzyme mechanisms, kinetics, and regulation; metabolic transformations; energetics and metabolic control. Lectures and four hours of laboratory work per week. This course satisfies a requirement for the biochemistry major. (Same as: CHEM 2320)

Prerequisites: CHEM 2260 or CHEM 2261.

Previous terms offered: Spring 2023, Spring 2022, Spring 2021, Spring 2020.

BIOC 2423 (a, INS) Biochemistry of Cellular Processes
Jake Muscato.
Non-Standard Rotation. Spring 2024. Enrollment limit: 35.

Explores the biochemical mechanisms that underlie the basis of life. Starts with the chemistry of proteins, DNA, lipids, and carbohydrates to build the main elements of a cell. Moves on to the process of gene organization and expression, emphasizing the biochemical mechanisms that regulate these events. Explores next the organization of the cell with emphasis on genetic and biochemical regulation. Concludes with specific examples of multicellular interactions, including development, cancer, and perception of the environment. This course does NOT satisfy a requirement for the biochemistry major and is not open to students who have credit for Biology 2124. Students who intend to enroll in Biology 2124 should not register for Biology 2423. (Same as: BIOL 2423)

Prerequisites: Two of: either BIOL 1102 or BIOL 1109 or BIOL 2100 or higher and CHEM 1092 or either CHEM 1102 or CHEM 1109 or CHEM 2250.

Previous terms offered: Spring 2023, Spring 2022, Spring 2021, Spring 2020.

BIOC 3320 (a, MCSR) Molecular Biophysics
Michael Henderson.
Non-Standard Rotation. Fall 2023. Enrollment limit: 16.

This course will take a quantitative approach relying on principles from thermodynamics, kinetics and mechanics to explore how the structure, function and assembly of molecular components like lipids, proteins and DNA govern biological systems and their physical-chemical behavior. Topics will include: (1) lipid membrane organization and lipid-protein interactions, (2) transport mechanisms, (3) compartmentalization through liquid-liquid phase separation, and (4) mechanisms of force generation through molecular motors and cytoskeletal polymers. Emphasis throughout the course will be placed on experimental methodologies employed in these topic areas such as optical microscopy, single-molecule approaches, and force spectroscopies. The format will be a combination of lectures, discussions and journal article presentations. (Same as: CHEM 3320)

Prerequisites: Two of: PHYS 1130 and CHEM 2320 (same as BIOC 2320).