# BIOCHEMISTRY

The biochemistry major provides interdisciplinary training, education and experience in the chemical and biological sciences. Biochemistry focuses on understanding the chemical processes of living organisms, the reaction pathways that sustain life, the principles of how structure defines function and the physical basis of biomolecular interactions. Students who major in biochemistry are prepared for diverse careers in medicine, scientific research, biotechnology, pharmacy, biomedical consulting, teaching and education, among other professions.

Because biochemistry connects to scientific disciplines ranging from genetics, human physiology, microbiology, neuroscience, cell biology, chemistry and geology, biochemistry majors are given the freedom to explore advanced electives in many of these subjects. Additional information about the biochemistry degree can be found on the Biochemistry Department website (https://www.colorado.edu/biochemistry/).

**Course code for this program is BCHM.**

## Bachelor's Degree

- Biochemistry - Bachelor of Science (BA) (https://catalog.colorado.edu/undergraduate/colleges-schools/arts-sciences/programs-study/biochemistry/biochemistry-bachelor-arts-ba/)

## Minor

- Biochemistry - Minor (https://catalog.colorado.edu/undergraduate/colleges-schools/arts-sciences/programs-study/biochemistry/biochemistry-minor/)

## Faculty

While many faculty teach both undergraduate and graduate students, some instruct students at the undergraduate level only. For more information, contact the faculty member's home department.

Ahn, Natalie (https://experts.colorado.edu/display/fisid_106044/)
Distinguished Professor; PhD, University of California, Berkeley

Aydin, Halil (https://experts.colorado.edu/display/fisid_167398/)
Assistant Professor; PhD, University of Toronto

Batey, Robert T. (https://experts.colorado.edu/display/fisid_122668/)
Professor; PhD, Massachusetts Institute of Technology

Cameron, Jeffrey C. (https://experts.colorado.edu/display/fisid_156473/)
Assistant Professor; PhD, Washington University

Caruthers, Marvin H. (https://experts.colorado.edu/display/fisid_103328/)
Distinguished Professor; PhD, Northwestern University

Cech, Thomas R. (https://experts.colorado.edu/display/fisid_103252/)
Distinguished Professor; PhD, University of California, Berkeley

Falke, Joseph J. (https://experts.colorado.edu/display/fisid_101970/)
Professor; PhD, California Institute of Technology

Goodrich, James (https://experts.colorado.edu/display/fisid_109239/)
Professor, Chair; PhD, Carnegie Mellon University

Khanal, Akhil
Instructor; PhD, University of Delaware

Kuchta, Robert (https://experts.colorado.edu/display/fisid_100844/)
Professor; PhD, Brandeis University

Kugel, Jennifer F. (https://experts.colorado.edu/display/fisid_109472/)
Research Professor; PhD, University of Colorado Boulder

Liu, Xuedong (https://experts.colorado.edu/display/fisid_118458/)
Professor; PhD, University of Wisconsin–Madison

Mchenry, Charles
Professor Emeritus; PhD, University of California, Santa Barbara

Palmer, Amy E. (https://experts.colorado.edu/display/fisid_141901/)
Professor; PhD, Stanford University

Pardi, Arthur
Professor Emeritus; PhD, University of California, Berkeley

Parker, Roy Robert (https://experts.colorado.edu/display/fisid_151440/)
Distinguished Professor; PhD, University of California, San Francisco

Rinn, John (https://experts.colorado.edu/display/fisid_159338/)
Professor; PhD, Yale University

Schnizer-Luger, Karoline (https://experts.colorado.edu/display/fisid_156579/)
Endowed Chair, Professor; PhD, Univ of Basel (Switzerland)

Sousa, Marcelo Carlos (https://experts.colorado.edu/display/fisid_122806/)
Professor; PhD, Univ of Buenos Aires (Argentina)

Spencer, Sabrina Leigh (https://experts.colorado.edu/display/fisid_154911/)
Associate Professor; PhD, Massachusetts Institute of Technology

Stephen, Ricardo Hugh (https://experts.colorado.edu/display/fisid_145994/)
Senior Instructor; PhD, University of Colorado Boulder

Taatjes, Dylan J. (https://experts.colorado.edu/display/fisid_102436/)
Professor; PhD, University of Colorado Boulder

Whiteley, Aaron (https://experts.colorado.edu/display/fisid_166299/)
Assistant Professor; PhD, University of California, Berkeley

Whiteley, Alexandra (https://experts.colorado.edu/display/fisid_166300/)
Assistant Professor; PhD, University of California, San Francisco

Wuttke, Deborah S. (https://experts.colorado.edu/display/fisid_108412/)
Professor, Associate Chair; PhD, California Institute of Technology

# Courses

**BCHM 1020 (1) A Path to Success: Introduction to the Biochemistry Major**
This course will help students navigate their first year of college and develop the skills needed for academic success as Biochemistry majors. Students will improve academic strategies (i.e. time management, problem-solving and study skills), identify available campus resources, learn how to get involved in clubs and gain research experience, and explore career opportunities as a biochemistry graduate. This is a first-year elective course specifically designed for first year and other students exploring their educational and career opportunities.
**Recommended:** New BCHM majors.

**BCHM 1041 (3) Biotechnology and Society**
Covers recent advances in biotechnology and how those impact society. Content and discussion will focus on both the science behind technological advances, their impact on society, and the ethical issues raised by new technologies. Topics change each semester but can include: GMO crops, genome editing, drug discovery and development, stem cell therapies, development and use of new cancer treatments, human genome sequencing and its impact on diagnosis and treatments, human microbiome, neurodegenerative diseases. Formerly CHEM 1041.
**Requisites:** Restricted to students with 0-56 credits (Freshmen or Sophomore) only.
**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**BCHM 1701 (1) Biochemistry Program for Research Exploration and Planning**
Biochem PREP is focused on developing first and second year student interest and engagement in undergraduate research. The program is designed to present participants with mentorship and opportunities to identify whether research is an opportunity students wish to participate in, and if so, get students connected to potential research opportunities. Participants will be provided with a cohort of their peers to explore and plan for research together through preparation workshops, research information sessions, and mentorship. The ultimate goal of the program is for participants to understand their research interests, possess the necessary skills to identify and obtain a research opportunity, and develop community with their peers and the Department of Biochemistry at large.
**Requisites:** Restricted to Biochemistry (BCHM) majors and minors only.

**BCHM 2700 (4) Foundations of Biochemistry**
Covers chemistry of aqueous solutions; energetics in biology; structure of proteins, nucleic acids, carbohydrates, and membranes; protein evolution; macromolecular interactions; enzyme kinetics, mechanism and regulation. Will be taught from a strong chemical perspective and mastery of basic concepts of general and organic chemistry will be required. Familiarity with basic concepts of molecular and cellular biology encouraged.
**Requisites:** Requires prerequisite course of CHEM 3311 or CHEM 3451 (minimum grade C-). Restricted to Biochemistry (BCHM) majors and minors only.

**BCHM 3100 (2) Engineering RNA Aptamers**
Provides laboratory experience working on an RNA sensor research project. Students will generate libraries of RNA aptamers and select and isolate aptamers that bind a novel ligand of interest. Topics covered include principles of RNA molecular recognition, polymerase chain reaction and molecular cloning, bacterial transformation, fluorescence reporter assays and high throughput screening.
**Requisites:** Requires prerequisite or corequisite course of BCHM 2700 or BCHM 4611 (minimum grade C-).

**BCHM 3110 (1) Literature-based Co-seminar for BCHM 3100 CURE Laboratory Course**
This course involves reading and discussion of primary literature. Each week students will read a scientific research article, and engage in a class discussion about the significance and impact, the scientific merits, the underlying premise of the research question and experimental plan, and whether data support conclusions of the paper. Papers will be focused on RNA structure and function, RNA molecular recognition, RNA aptamers, RNA engineering, RNA as a drug target, and fluorescent probes for RNA. Students will be responsible for reading each paper, one student will prepare a powerpoint and lead a class discussion each week, and all students are expected to participate in the discussion.
**Requisites:** Requires corequisite course of BCHM 3100. Requires prerequisite or corequisite course of BCHM 2700 or BCHM 4611 (minimum grade C-).

**BCHM 3220 (3) Cannabis Sativa Biochemistry**
This course explores the biochemistry of Cannabis sativa, focusing on cannabinoid and terpene biosynthesis, human endocannabinoid signaling, and extraction methods. Designed for advanced undergraduates, it covers trichome anatomy, enzyme specificity, pharmacokinetics, analytical testing, and compound stability. Students gain a strong foundation in plant and human molecular interactions, with applications in pharmaceutical sciences, biotechnology, and natural products.
**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 3220
**Recommended:** Prerequisite basic biology and chemistry classes, and EBIO 3000 -Basic Cannabis science.

**BCHM 3300 (3) Genetic Engineering: Science, Technology, and Society**
This course explores the frontiers of genetic engineering, starting with a brief historical perspective and moving forward through time to current and future technologies. Students will learn how CRISPR-Cas and other gene editing methodologies are used to engineer proteins, bacteria, viruses, fungi, plants, animals, and humans. The course includes critical analysis of social, environmental, and economic implications of genetic engineering, including discussions on bioethics, regulatory frameworks, and sustainability. Students will gain a nuanced understanding of how this technology shapes our world and will emerge prepared to engage in the ongoing dialogue about its impact on society and our environment.
**Requisites:** Prerequisite course of: MCDB 2150, MCDB 2222, or EBIO 2070 (minimum grade C-).

**BCHM 3400 (3) Mechanisms of Cancer**
This course is devoted to the mechanisms that drive cancer, with an emphasis on how the biochemistry of normal cells teaches us how regulation goes awry in cancer cells. The course will include an analysis of historical and current developments in cancer biology. Topics covered: principles of transformation, viral and cellular oncogenes, tumor suppressor genes, signal transduction, cell cycle, cell death, DNA damage and repair, cancer genetics, cancer genomics, cancer risk factors, carcinogens, chemotherapies, targeted therapies, drug resistance, modern technologies in cancer research.
**Requisites:** Requires prerequisite course of MCDB 2150 or MCDB 2222 or EBIO 2070 or BCHM 4740 (all minimum grade C-).
**Grading Basis:** Letter Grade
**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**BCHM 3450 (3) Principles of Pharmacology and Toxicology**
This is an introductory course presenting the fundamentals of Pharmacology and Toxicology. This course will be divided into four sections. Section I introduces the mechanisms of drug action, their cellular targets, their absorption and distribution, and elimination pharmacokinetics. Section II will discuss the interaction of drugs with physiological systems via the role of chemical mediators and how this affects major organ systems. This will introduce broad principles of pharmacology, pharmacokinetics, pharmacodynamics, toxicology, membrane transporters, metabolism, cell signaling, and an introduction to pharmacogenetics. Section III will focus on specific cases of drugs used for the treatment of cancer, antibacterials, and antifungals. Section IV will discuss the harmful nature of drugs, their use in lifestyle and in sports.
**Requisites:** Requires prerequisite course of CHEM 1133 or CHEM 1400 (minimum grade C-).
**Grading Basis:** Letter Grade

**BCHM 3491 (4) Organic Chemistry 2 for Biochemistry Majors**
Covers amines, alkylation reactions, additions to unsaturated C-C bonds, aromaticity and aromatic reactivity, organic materials, biomolecules, nomenclature of organic compounds, reaction mechanism. Department enforced corerquisite: CHEM 3341 or CHEM 3381. Formerly CHEM 3491.
**Equivalent - Duplicate Degree Credit Not Granted:** CHEM 3471 and CHEM 3331
**Requisites:** Requires prerequisite courses of CHEM 3451 and CHEM 3321 or CHEM 3361 (all minimum grade C-). Restricted to Chemistry (CHEM) or Biochemistry (BCHM) majors only.
**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**BCHM 4312 (3) Quantitative Optical Imaging**
Explores the fundamentals of optical imaging in biology, especially molecular and cellular biology. Covered topics include an introduction to optics and microscopes, fluorescence microscopy and image analysis, and biological applications. MATLAB will be taught at the beginning of the course and used throughout for image processing. Prior experience with MATLAB (or Python) is highly recommended but not required.
**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 4312, MCDB 5312 and BCHM 5312
**Grading Basis:** Letter Grade

**BCHM 4400 (4) Core Concepts in Physical Chemistry for Biochemists**
Introduces thermodynamics, kinetics and spectroscopy, emphasizing macromolecule and biochemical applications. Includes thermodynamics, chemical and physical equilibriums, solution chemistry, rates of chemical and biochemical reactions, chemical bonds and principles and selected examples of spectroscopies applied to biological systems. Formerly CHEM 4411.
**Equivalent - Duplicate Degree Credit Not Granted:** CHEM 4511 BCHM 5400
**Requisites:** Requires prerequisite courses BCHM 2700 or BCHM 4611 and PHYS 1110 or PHYS 2010 and MATH 2300 or APPM 1360 (all minimum grade C-).
**Recommended:** Prerequisite or corequisite PHYS 1120 or PHYS 2020.
**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**BCHM 4491 (3) Modern Biophysical Methods**
Covers the basic theory of biophysical methods widely employed in biochemistry and biology, including: electrophoresis, mass spec, calorimetry, evanescent waves, plasmon resonance, Xray diffraction, absorbance and fluorescence spectroscopy, magnetic resonance, electron and optical microscopy and single molecule methods. Discusses ways to maximize rigor and reproducibility in biophysical studies. Department enforced prerequisites: undergraduate chemistry (general, organic physical); physics; calculus. Formerly CHEM 4491.
**Equivalent - Duplicate Degree Credit Not Granted:** BCHM 5491
**Requisites:** Requires prerequisite courses of PHYS 1110 or PHYS 2010 and MATH 2300 or APPM 1360 and BCHM 2700 or BCHM 4611 (all minimum grade C-).
**Recommended:** Prerequisite or corequisite BCHM 4400 or CHEM 4531.
**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**BCHM 4611 (3) Principles of Biochemistry**
One-semester overview of the main themes of modern biochemistry: biomolecular structure/function, metabolism, biosynthesis, DNA from genome to proteome and cellular signaling. For biology and engineering majors and others wanting an overview of biochemistry. Formerly CHEM 4611.
**Equivalent - Duplicate Degree Credit Not Granted:** BCHM 5611
**Requisites:** Requires prerequisite course of CHEM 3311 or CHEM 3451 (minimum grade C-).
**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**BCHM 4631 (3) Computational Genomics Lab**
Designed as an inquiry based computational genomics laboratory course. Students will learn fundamental principles of BASH, R, NEXTFLOW, GIT and more by applying these skills to publicly available genomic data. The course aims to mimic a real world genomics research project. Overall this course aims to provide students with key skills needed for future research and career opportunities.
**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**BCHM 4720 (4) Metabolic Pathways and Human Disease**
Covers energy metabolism and anabolic/catabolic pathways; metabolism of carbohydrates, lipids, amino acids, and nucleic acids; photosynthesis; special topics on human diseases with pathologies and metabolic pathways. Formerly CHEM 4720.
**Equivalent - Duplicate Degree Credit Not Granted:** BCHM 5720
**Requisites:** Requires prerequisite courses of BCHM 2700 and CHEM 3331 or CHEM 3471 or BCHM 3491 (all minimum grade C-).
**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**BCHM 4740 (4) Biochemistry of Gene Transmission, Expression and Regulation**
Covers biosynthesis and function of macromolecules including DNA, RNA and proteins; molecular basis of replication, transcription and translation; biochemistry of subcellular systems; signaling and regulation of gene expression in eukaryotes; and special topics. Formerly CHEM 4740.
**Equivalent - Duplicate Degree Credit Not Granted:** BCHM 5740
**Requisites:** Requires a prerequisite course of BCHM 2700 (minimum grade C-).
**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**BCHM 4751 (3) Current Topics in Biochemical Research**
Lec. Covers current topics in modern biochemical research through lectures, reading recent research articles, critical thinking and class discussion. Topics include protein and nucleic acid structure and function, biomolecular interactions, enzyme function and cellular signaling and regulation. Formerly CHEM 4751.
**Equivalent - Duplicate Degree Credit Not Granted:** BCHM 5751
**Requisites:** Requires prerequisite courses of MCDB 3135 or BCHM 4700 or BCHM 2700 and BCHM 4740 (all minimum grade C-).
**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**BCHM 4761 (3) Biochemistry Laboratory**
Two 4-hour periods per week. Introduction to modern biochemical techniques. Topics include enzymology, spectrophotometry, electrophoresis, multi-step protein purification, recombinant DNA techniques and molecular cloning. Formerly CHEM 4761.
**Requisites:** Requires prerequisite courses of BCHM 2700 or CHEM 4700 and CHEM 3341 or 3381 (all minimum grade C-). Restricted to Chemistry (CHEM) or Biochemistry (BCHM) majors only.
**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab
Arts Sci Gen Ed: Distribution-Natural Sciences

**BCHM 4850 (3) Therapeutic and Diagnostic Nucleic Acids**
A comprehensive course in topics of the application of nucleic acids to the advancement of human health. Topics will include an introduction to the basic principles of pharmacology and drug development, action of small molecule therapeutics based upon nucleosides and nucleotides, antisense oligonucleotides and emerging CRISPR-based therapeutics, gene therapy, application of nucleic acids in commonly used diagnostics and emerging applications of nucleic acids.
**Equivalent - Duplicate Degree Credit Not Granted:** BCHM 5850
**Requisites:** Requires prerequisite course of BCHM 2700 or BCHM 4611 (minimum grade C-).
**Grading Basis:** Letter Grade

**BCHM 4901 (1-6) Independent Study in Biochemistry**
For undergraduate study. Department consent required.
**Repeatable:** Repeatable for up to 8.00 total credit hours.

**BCHM 4906 (1-3) Internship in Biochemistry**
Provides an opportunity for Biochemistry majors to gain real world experience by performing research in a company or institute outside of the CU Boulder academic environment. May be repeated for 6 total credit hours.
**Repeatable:** Repeatable for up to 6.00 total credit hours.
**Requisites:** Restricted to Biochemistry (BCHM) majors only.