**BIOCHEMISTRY**

The Department of Biochemistry is internationally recognized for its research and education and offers a world-class interdisciplinary research environment in a beautiful mountain setting. As part of a commitment to continuing this tradition of excellence, the department provides a graduate program that integrates opportunities for cutting-edge creative research and study across a wide range of areas including:

- Computational Biology
- Nucleic acids
- Gene expression
- Cell signaling
- Membranes
- Proteins and enzymology
- Molecular biophysics
- Structural biology
- Systems biology

Graduate students enjoy extensive scientific collaboration with biochemistry faculty, with other departments such as Molecular, Cellular and Developmental Biology, Chemistry, and Physics, and with research institutes and agencies such as the BioFrontiers Institute, Joint Institutes of Laboratory Astrophysics (JILA), the Renewable and Sustainable Energy Institute.

Course code for this program is BCHM.

**Master's Degree**

- Biochemistry - Master of Science (MS) (https://catalog.colorado.edu/graduate/colleges-schools/arts-sciences/programs-study/chemistry-biochemistry/biochemistry-master-science-ms/)

**Doctoral Degree**

- Biochemistry - Doctor of Philosophy (PhD) (https://catalog.colorado.edu/graduate/colleges-schools/arts-sciences/programs-study/chemistry-biochemistry/biochemistry-doctor-phd/)

**Certificate**

- Molecular Biophysics - Graduate Certificate (https://catalog.colorado.edu/graduate/colleges-schools/arts-sciences/programs-study/chemistry-biochemistry/molecular-biophysics-graduate-certificate/)

**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

Kasinath, Vignesh (https://experts.colorado.edu/individual/fisid_167418/) Assistant Professor; PhD, University of Pennsylvania

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 5312 (3-4) 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:** BCHM 4491
**Grading Basis:** Letter Grade

**BCHM 5341 (3) Chemical Biology and Drug Design**
Develop knowledge base and skills in the interdisciplinary field of chemical biology, including aspects of chemistry and biology, and integrating both with respect to hierarchical levels of structure (atomic, molecular, cellular). Students will receive training that helps to develop their careers in biotech, pharmaceutical and other research-oriented industries as well as in academia. Department enforced prerequisites: introductory organic chemistry and general biochemistry. Formerly CHEM 5341.
**Requisites:** Restricted to graduate students only.

**BCHM 5400 (4) Core Concepts in Physical Chemistry for Biochemists**
Introduces thermodynamics, kinetics and spectroscopy, emphasizing macromolecular 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 5400.
**Equivalent - Duplicate Degree Credit Not Granted:** BCHM 4400
**Grading Basis:** Letter Grade

**BCHM 5412 (3) Chemical Biology and Drug Design**
Introduces thermodynamics, kinetics and spectroscopy, emphasizing macromolecular 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 5412.
**Equivalent - Duplicate Degree Credit Not Granted:** BCHM 4412
**Grading Basis:** Letter Grade

**BCHM 5491 (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, X-ray 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), biochemistry, physics, calculus.
**Equivalent - Duplicate Degree Credit Not Granted:** BCHM 4491
**Grading Basis:** Letter Grade

**BCHM 5611 (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.
**Equivalent - Duplicate Degree Credit Not Granted:** BCHM 4611

**BCHM 5621 (3) Genome Databases: Mining and Management**
Lec. Develops essential skills for performing genomic analyses, with focus on developing practical research tools. Introduces human genome and microbiome projects, Python/Sql scripting, accessing and understanding genomic data, sequence alignment and search, evolutionary models, expression data, biological networks, and macromolecular structure.
**Equivalent - Duplicate Degree Credit Not Granted:** BCHM 4621

**BCHM 5631 (4) Statistical and Computational Analysis of the Human Genome**
This lab course covers fundamental statistical and computational approaches to large scale data. Students will learn the unix command line to: access public human genome data, learn what statistics apply to which types of data and apply them to study specific regions of the human genome involved in development and disease. This lab course will cover fundamental aspects of Virtual computing, Container analysis pipelines (e.g. NextFlow, GitHub) in an intuitive and practical learning framework.
**Equivalent - Duplicate Degree Credit Not Granted:** BCHM 4631

**BCHM 5661 (3) Advances in Molecular Biophysics**
Discuss recent literature concerning biophysical studies of macromolecular structure and mechanism, including DNA, RNA, proteins, and their interactions.
**Recommended:** Prerequisites one year of physical chemistry or quantum mechanics, one year of biology, graduate standing, or instructor consent.

**BCHM 5720 (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 5720.
**Equivalent - Duplicate Degree Credit Not Granted:** BCHM 4720
**Requisites:** Restricted to graduate students only.

**BCHM 5740 (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 5740.
**Equivalent - Duplicate Degree Credit Not Granted:** BCHM 4740
**Requisites:** Restricted to graduate students only.

**BCHM 5751 (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. Department consent required. Formerly CHEM 5751.
**Equivalent - Duplicate Degree Credit Not Granted:** BCHM 4751
**Requisites:** Restricted to graduate students only.

**BCHM 5770 (3) Fundamentals of Biochemistry I**
Analysis of topics in biochemistry including DNA structure and replication, RNA synthesis and processing, protein synthesis, enzyme function and mechanism, and protein structure and dynamics. Intended as a comprehensive treatment of areas central to modern biochemistry for entering graduate students. Lectures concurrent with BCHM 5771 covering the same topics except for the requirement of a written research proposal. Formerly CHEM 5770.
BCHM 5771 (5) Advanced General Biochemistry 1
Lect. In-depth analysis of DNA structure and replication, RNA synthesis and processing, protein synthesis, enzyme function and mechanism, protein structure, protein dynamics, and physical chemistry of macromolecules. Intended as a comprehensive treatment of areas central to modern biochemistry for entering graduate students. Formerly CHEM 5771.

BCHM 5776 (1) Scientific Ethics and Responsible Conduct in Research
Lect. Advanced discussion of topics in scientific ethics, including requirements for responsible conduct of research, case histories of fraud, research misconduct, ethical misconduct and development of professional values and ethical standards.
Equivalence - Duplicate Degree Credit Not Granted: MCDB 5776
Requisites: Requires prerequisite course of BCHM 5771 or CHEM 5271 (minimum grade B-). Restricted to graduate students only.

BCHM 5780 (3) Fundamentals of Biochemistry II
Analysis of topics in biochemistry including protein structure, methods of structure determination and prediction, protein folding, and protein dynamics. Intended as a comprehensive treatment of areas central to modern biochemistry for entering graduate students. Lectures concurrent with CHEM 5781, covering the same topics except for the requirement of a written research proposal. Formerly CHEM 5780.
Requisites: Requires prerequisite course of BCHM 5770 (minimum grade B-). Restricted to graduate students only.

BCHM 5781 (5) Advanced General Biochemistry 2
Lect. Detailed consideration of contemporary topics in biochemistry, including protein structure (primary, secondary, tertiary, and quaternary), methods of structure determination and prediction, protein folding (kinetics, thermodynamics, denaturation, and renaturation), and protein dynamics (internal motions and methods of analysis). Formerly CHEM 5781.
Requisites: Requires prerequisite course of BCHM 5771 (minimum grade B-). Restricted to graduate students only.

BCHM 5801 (3) Advanced Signal Transduction and Cell Cycle Regulation
Lect. Advanced discussion of current research and literature in signal transduction, including ligands, receptors, and intracellular signaling pathways, as well as control on transcription, chromatin structure, DNA replication, mitosis, and cell cycle progression. Formerly CHEM 5801.
Requisites: Restricted to graduate students only.
Recommended: Prerequisites CHEM 5771 and CHEM 5781 and MCDB 5210 or MCDB 5220.

BCHM 5811 (3) Advanced Methods in Protein Sequencing and Analysis
Lect. Advanced discussion of current methods in protein sequencing, sequence analysis, and posttranslational modifications, emphasizing techniques of mass spectrometry, use of protein databases, sequence alignment and motifs, structure prediction, and modeling of signaling pathways. Department consent required. Formerly CHEM 5811.
Requisites: Restricted to graduate students only.
Recommended: Prerequisites CHEM 5771 and CHEM 5781 and MCDB 5210.

BCHM 5821 (1) Special Topics in Signaling and Cell Regulation
Lect. Reviews and evaluates literature on subjects of current interest in signal transduction transcription, cell cycle progression, and cell regulation. Primarily for graduate level presentation of special topics by students, faculty, and research staff. Department consent required. Formerly CHEM 5821.
Repeatable: Repeatable for up to 5.00 total credit hours.
Requisites: Restricted to graduate students only.

BCHM 5850 (3) Chemistry and Biology of Nucleic Acids
A comprehensive course in advanced topics in nucleic acid chemistry and biology. Topics will include the chemical properties of nucleic acids, chemical and biological synthesis, structure, biology of ribozymes and ribonuclear complexes, protein recognition, nucleic acids as targets and therapeutics and diagnostic and other applications of nucleic acids.
Equivalent - Duplicate Degree Credit Not Granted: BCHM 4850
Requisites: Requires prerequisite courses of BCHM 2700, BCHM 4720 and BCHM 4740 (all minimum grade C-).
Grading Basis: Letter Grade

BCHM 6601 (1) Biochemistry Seminar
Restricted to and required for all currently funded NIH/CU Biophysics trainees and current NIH/CU Biophysics affiliates. Credit is deferred until presentation of satisfactory seminar. Formerly CHEM 6601.
Requisites: Restricted to graduate students only.

BCHM 6711 (3-6) Advanced Topics in Biochemistry
Detailed study of current literature relative to one main topic is undertaken each semester. Topics covered on a rotating basis include enzyme kinetics and mechanisms; lipids and lipoproteins; chemistry and enzymology of nucleic acids; biochemistry of nucleic acids in eukaryotic cells; protein chemistry. Presentations include faculty lectures and student reports. Department enforced prerequisite: one year of biochemistry courses. Department consent required. Formerly CHEM 6711.
Repeatable: Repeatable for up to 12.00 total credit hours.
Requisites: Restricted to graduate students only.

BCHM 6731 (3-6) Advanced Topics in Biochemistry
Detailed study of current literature relative to one main topic is undertaken each semester. Topics covered on a rotating basis include enzyme kinetics and mechanisms; lipids and lipoproteins; chemistry and enzymology of nucleic acids; biochemistry of nucleic acids in eukaryotic cells; protein chemistry. Presentations include faculty lectures and student reports. Department enforced prerequisite: one year of biochemistry courses. Department consent required. Formerly CHEM 6731.
Repeatable: Repeatable for up to 12.00 total credit hours.
Requisites: Restricted to graduate students only.

BCHM 6901 (1-6) Research in Biochemistry
Repeatable: Repeatable for up to 15.00 total credit hours.
Requisites: Restricted to graduate students only.

BCHM 6941 (1) Master's Candidate for Degree
Students are not admitted for the master's degree but may be transferred to the MS plan if they are unable to meet the demands of the PhD program.
Requisites: Restricted to graduate students only.

BCHM 6951 (1-6) Master's Thesis
Students are not admitted for the master's degree but may be transferred to the MS plan if they are unable to meet the demands of the PhD program.
Requisites: Restricted to graduate students only.

BCHM 7601 (2) Seminar: Nucleic Acid Chemistry
Topics in various aspects of current research; emphasizes student readings and presentations. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.
BCHM 7611 (1) Seminar: Structures and Dynamics of Biopolymers in Solution
Discussion of experimental and theoretical approaches for probing structures and dynamics of proteins, peptides, and nucleic acids; and computations in molecular dynamics simulation, modeling, and geometry. Department consent required. Formerly CHEM 7611.
Requisites: Restricted to graduate students only.

BCHM 7621 (1) Seminar: Biochemistry and Molecular Biology of Signal Transduction
Discusses and reviews the current literature and experimental results in signal transduction, cell cycle and tumor suppressor gene regulation. Emphasizes the understandings of molecular and biochemical mechanisms of the origin of human tumor cells. Formerly CHEM 7621.
Requisites: Restricted to graduate students only.

BCHM 7651 (2) Seminar: Environmental Biochemistry
Topics in various aspects of current biochemical and environmental research. Department consent required. Formerly CHEM 7651.
Repeatability: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

BCHM 7661 (1) Structure/Function of Human Mediator Transcription Complexes
Study of the mechanisms of eukaryotic gene expression with an emphasis on the structure and function of human mediator transcription complexes. Formerly CHEM 7661.
Requisites: Restricted to graduate students only.

BCHM 7671 (1) Seminar: Topics in Structural Biology
Discussion of advances and developments in structural biology with emphasis on new methods for protein expression, purification and crystallization; and structure solution implementation. Formerly CHEM 7781.
Requisites: Restricted to graduate students only.

BCHM 7691 (1) Seminar: Protein Dynamics and the Mechanism of Sensory Proteins
Discusses recent results and current literature in the areas of the mechanism of sensory proteins, internal motions of proteins, and protein folding. Department consent required. Formerly CHEM 7691.
Repeatability: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

BCHM 7701 (1) Seminar: Enzyme Mechanisms and Kinetics
Studies experimental approaches to understand the mechanisms of enzymic catalysis. Techniques include steady-state and pre-steady-state kinetics, isotope trapping and partitioning, inhibition by substrate analogues, and covalent modification of proteins. Department consent required. Formerly CHEM 7701.
Repeatability: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

BCHM 7711 (1) RNA Mediated Inorganic and Organic Reactions
Discussion of advances and developments in biomolecular dynamics, with emphasis on experimental studies via ultrafast laser spectroscopy. The connection of protein dynamics with function will also be considered. Formerly CHEM 7711.
Requisites: Restricted to graduate students only.

BCHM 7741 (1) Seminar: Signal Transduction and Protein Phosphorylation
Devoted to experimental methods for understanding mechanisms of signal transduction in mammalian cells through pathways involving regulation of protein phosphorylation. Department consent required. Formerly CHEM 7741.
Repeatability: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

BCHM 7751 (1) Seminar: Protein Structure and Folding
Studies structure and folding of proteins and protein complexes using biophysical methods, including nuclear magnetic resonance (NMR), circular dichroism, and fluorescence spectroscopies. Department consent required. Formerly CHEM 7751.
Repeatability: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

BCHM 7761 (1) Seminar: Eukaryotic Transcriptional Regulation
Studies the regulation of transcription by RNA Polymerase II from human promoters. Department consent required. Formerly CHEM 7761.
Repeatability: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

BCHM 7771 (1) Seminar: Topics in Ribonucleoprotein Assemblies
Studies aspects of the biochemical and structural analysis of ribonucleic acid (RNA) and its interactions with proteins and assemblies into functional ribonucleoprotein (RNP) enzymes. Techniques focus on x-ray crystallography, spectroscopic methods, and biochemical probing. Formerly CHEM 7771.
Requisites: Restricted to graduate students only.

BCHM 7791 (1) Seminar: Signal Transduction and Protein Phosphorylation
Devoted to experimental methods for understanding mechanisms of signal transduction in mammalian cells through pathways involving regulation of protein phosphorylation. Department consent required. Formerly CHEM 7791.
Repeatability: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

BCHM 7781 (1) Seminar: Topics in Structural Biology
Discussion of advances and developments in structural biology with emphasis on new methods for protein expression, purification and crystallization; and structure solution implementation. Formerly CHEM 7781.
Requisites: Restricted to graduate students only.

BCHM 7751 (1) Seminar: Protein Structure and Folding
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Repeatability: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

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Repeatability: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

BCHM 7771 (1) Seminar: Topics in Ribonucleoprotein Assemblies
Studies aspects of the biochemical and structural analysis of ribonucleic acid (RNA) and its interactions with proteins and assemblies into functional ribonucleoprotein (RNP) enzymes. Techniques focus on x-ray crystallography, spectroscopic methods, and biochemical probing. Formerly CHEM 7771.
Requisites: Restricted to graduate students only.

BCHM 7781 (1) Seminar: Topics in Structural Biology
Discussion of advances and developments in structural biology with emphasis on new methods for protein expression, purification and crystallization; and structure solution implementation. Formerly CHEM 7781.
Requisites: Restricted to graduate students only.

BCHM 7791 (1) Seminar: Signal Transduction and Protein Phosphorylation
Devoted to experimental methods for understanding mechanisms of signal transduction in mammalian cells through pathways involving regulation of protein phosphorylation. Department consent required. Formerly CHEM 7791.
Repeatability: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

BCHM 7891 (1-10) Doctoral Dissertation
All doctoral students must register for 30 hours of dissertation credit as part of the requirements for the degree. For a detailed discussion of doctoral dissertation credit, refer to the Graduate School section.
Repeatability: Repeatable for up to 30.00 total credit hours.
Requisites: Restricted to graduate students only.