The Department of Chemistry and Biochemistry is internationally recognized for its research and education. 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 analytical, atmospheric, biochemistry, biophysical, chemical physics, environmental, organic, materials and nanoscience, and physical chemistry.

Graduate students enjoy extensive scientific collaboration with chemistry and biochemistry faculty, with other departments such as Molecular, Cellular and Developmental Biology, and Physics, and with research institutes and agencies such as the Cooperative Institute for Research in Environmental Sciences (CIRES), Joint Institutes of Laboratory Astrophysics (JILA) and the National Oceanic and Atmospheric Administration (NOAA).

Course code for this program is CHEM.

**Master's Degrees**
- Biochemistry - Master of Science (MS) (catalog.colorado.edu/graduate-colleges-schools/arts-sciences/programs-study/chemistry-biochemistry/biochemistry-master-science-ms)
- Chemistry - Master of Science (MS) (catalog.colorado.edu/graduate-colleges-schools/arts-sciences/programs-study/chemistry-biochemistry/chemistry-master-science-ms)

**Doctoral Degrees**
- Biochemistry - Doctor of Philosophy (PhD) (catalog.colorado.edu/graduate-colleges-schools/arts-sciences/programs-study/chemistry-biochemistry/biochemistry-doctor-philosophy-phd)
- Chemistry - Doctor of Philosophy (PhD) (catalog.colorado.edu/graduate-colleges-schools/arts-sciences/programs-study/chemistry-biochemistry/chemistry-doctor-philosophy-phd)
- Chemical Physics - Doctor of Philosophy (PhD) (catalog.colorado.edu/graduate-colleges-schools/arts-sciences/programs-study/chemistry-biochemistry/chemical-physics-doctor-philosophy-phd)

**Certificate**
- Molecular Biophysics - Graduate Certificate (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/fsid_106044)
Professor; PhD, University of California-Berkeley

Anseth, Kristi (https://experts.colorado.edu/display/fsid_103471)
Distinguished Professor; PhD, University of Colorado Boulder

Asirvatham, Margaret (https://experts.colorado.edu/display/fsid_103670)
Senior Instructor; PhD, Kansas State University of Agriculture and App Sci

Batey, Robert T. (https://experts.colorado.edu/display/fsid_122668)
Professor; PhD, Massachusetts Institute of Technology

Bierbaum, Veronica (https://experts.colorado.edu/display/fsid_101124)
Professor; PhD, University of Pittsburgh

Browne, Eleanor Carol (https://experts.colorado.edu/display/fsid_156464)
Assistant Professor; PhD, University of California-Berkeley

Cameron, Jeffrey Carlyle (https://experts.colorado.edu/display/fsid_156473)
Assistant Professor; PhD, Harvard University

Cuk, Tanja
Associate Professor; PhD, Stanford University

Damrauer, Niels Harley (https://experts.colorado.edu/display/fsid_129797)
Associate Professor; PhD, University of California-Berkeley

Dukovic, Gordana (https://experts.colorado.edu/display/fsid_147414)
Associate Professor; PhD, Columbia University In the City of New York

Eaves, Joel David (https://experts.colorado.edu/display/fsid_147419)
Assistant Professor; PhD, Massachusetts Institute of Technology

Ellison, G. Barney
Professor Emeritus; PhD, Yale University

Falke, Joseph (https://experts.colorado.edu/display/fsid_101970)
Professor; PhD, California Institute of Technology

George, Steven (https://experts.colorado.edu/display/fsid_103289)
Professor; PhD, University of California-Berkeley

Gin, Douglas L. (https://experts.colorado.edu/display/fsid_122861)
Professor; PhD, California Institute of Technology

Goodrich, James Andrew (https://experts.colorado.edu/display/fsid_109239)
Professor; PhD, Carnegie Mellon University

Gough, Raina V (https://experts.colorado.edu/display/fsid_149207)
Instructor

Hendrickson, Susan Marie (https://experts.colorado.edu/display/fsid_145101)
Senior Instructor; PhD, Colorado State University

Hynes, James T (https://experts.colorado.edu/display/fsid_106076)
Distinguished Professor; PhD, Princeton University
Chemistry and Biochemistry

Jimenez-Palacios, Jose Luis (https://experts.colorado.edu/display/fisid_125580)
Professor; PhD, Massachusetts Institute of Technology

Jonas, David (https://experts.colorado.edu/display/fisid_107145)
Professor; PhD, Massachusetts Institute of Technology

Koch, Tad H.
Professor Emeritus; PhD, Iowa State University

Koval, Carl A (https://experts.colorado.edu/display/fisid_101151)
Professor; PhD, California Institute of Technology

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

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

Lineberger, William Carl (https://experts.colorado.edu/display/fisid_101695)
Distinguished Professor; PhD, Georgia Institute of Technology

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

Luca, Oana (https://experts.colorado.edu/display/fisid_157952)
Assistant Professor; PhD, Yale University

Marshak, Michael Pesek (https://experts.colorado.edu/display/fisid_156422)
Assistant Professor; PhD, Massachusetts Institute of Technology

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

Nozik, Arthur (https://experts.colorado.edu/display/fisid_113395)
Research Professor; PhD, Yale University

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

Pardi, Arthur (https://experts.colorado.edu/display/fisid_105996)
Professor; PhD, University of California-Berkeley

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

Parson, Robert (https://experts.colorado.edu/display/fisid_101032)
Professor; PhD, University of Michigan Ann Arbor

Peters, Kevin
Professor Emeritus

Pierpont, Cortlandt G.
Professor Emeritus; PhD, Brown University

Sammakia, Tarek (https://experts.colorado.edu/display/fisid_101597)
Professor; PhD, Yale University

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

Schwartz, Daniel K. (https://experts.colorado.edu/display/fisid_118479)
Professor; PhD, Harvard University

Sharma, Sandeep (https://experts.colorado.edu/display/fisid_158286)
Assistant Professor; PhD, Massachusetts Institute of Technology

Sievers, Robert E (https://experts.colorado.edu/display/fisid_102866)
Professor; PhD, University of Illinois at Urbana-Champaign

Skodje, Rex T (https://experts.colorado.edu/display/fisid_103448)
Professor; PhD, University of Minnesota Twin Cities

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)
Assistant Professor; PhD, Massachusetts Institute of Technology

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

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

Tan, Zhongping (https://experts.colorado.edu/display/fisid_149809)
Assistant Professor; PhD, Columbia University In the City of New York

Tolbert, Bert Mills
Professor Emeritus

Tolbert, Margaret A (https://experts.colorado.edu/display/fisid_104976)
Distinguished Professor; PhD, California Institute of Technology

Vaida, Veronica (https://experts.colorado.edu/display/fisid_100313)
Professor; PhD, Yale University

Volkamer, Rainer (https://experts.colorado.edu/display/fisid_144988)
Associate Professor; PhD, Univ of Heidelberg (Germany)

Walba, David M (https://experts.colorado.edu/display/fisid_105830)
Professor; PhD, California Institute of Technology

Walczak, Maciej Andrzej (https://experts.colorado.edu/display/fisid_153323)
Assistant Professor; PhD, University of Pittsburgh

Wang, Xiang (https://experts.colorado.edu/display/fisid_145812)
Associate Professor; PhD, Boston University

Weber, Jorg Mathias (https://experts.colorado.edu/display/fisid_142930)
Associate Professor; PhD, Univ of Kaiserslautern (Germany)

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

Yin, Hang Hubert (https://experts.colorado.edu/display/fisid_144763)
Associate Professor; PhD, Yale University

Zhang, Wei (https://experts.colorado.edu/display/fisid_146429)
Associate Professor; PhD, University of Illinois at Urbana-Champaign
Courses

**CHEM 5011 (3) Advanced Inorganic Chemistry 1**
Lect. Inorganic chemistry based on principles of bonding, structure, reaction mechanisms, and modern synthetic methods. Chemistry and general properties of representative and transition elements and their compounds.
Requisites: Requires prerequisite courses of CHEM 4011 and CHEM 4531 (all minimum grade B-) or graduate standing.

**CHEM 5061 (3) Advanced Inorganic Chemistry 2**
Lectures in physical inorganic chemistry with an emphasis on topics for understanding modern solar energy conversion to electricity and fuels. Includes a description of bonding and properties of coordination compounds in terms of the ligand field and molecular orbital theories. The primary research literature will be used to motivate exploration of relevant themes including spectroscopy, electron transfer, energy transfer, bioenergetic conversion, and small-molecule activation.
Requisites: Requires prerequisite course of CHEM 4011 (minimum grade C-) or graduate standing.

**CHEM 5141 (3) Environmental Water and Soil Chemistry**
Application of basic chemical principles to understanding the processes that determine the chemical composition of oceans, lakes, rivers, soils and sediments. Topics include air-water exchange; acid-base, redox, coordination, precipitation and dissolution, ion exchange and sorption reactions; nutrient chemistry; and the use of simple equilibrium and kinetic models for describing the chemistry of inorganic and organic species in air-water-soil systems.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 4141
Requisites: Restricted to graduate students only.

**CHEM 5151 (3) Atmospheric Chemistry**
Lect. Basic kinetics and photochemistry of atmospheric species. Stratospheric chemistry with emphasis on processes controlling ozone abundance. Tropospheric chemistry focusing on photochemical smog, acid deposition, oxidative capacity of the atmosphere and global climate change.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 5151
Requisites: Restricted to graduate students only.
Recommended: Prerequisite one semester of college-level chemistry.

**CHEM 5152 (3) Advanced Atmospheric Chemistry**
Follows Graduate Atmospheric Chemistry (CHEM 5151) and explores advanced topics in atmospheric chemistry, such as secondary aerosol formation, oxidant formation, the chemistry of global climate change and/or design of advanced laboratory experiments.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 5152
Requisites: Prerequisite CHEM 5151 or ATOC 5151.

**CHEM 5161 (3) Analytical Atmospheric Spectroscopy**
Optical spectrochemical analysis, atmospheric transmittance, including atomic and molecular spectroscopy, line-by-line spectral databases such as HITRAN, absorption, emission, fluorescence, scattering processes of gases, surface enhancements, aerosols, optical spectroscopic instrument components, and techniques, and their applications to atmospheric, and environmental problems. Department enforced prereq., undergraduate physical chemistry or instructor consent.
Requisites: Restricted to graduate students only.

**CHEM 5171 (3) Electroanalytical Chemistry**
Lect. Establishes a background for understanding electrochemical systems through a review of the relevant thermodynamic, kinetic and electronic principles. Compares classical and modern electrochemical methods of analysis. Several special topics are discussed in depth. Department enforced prerequisite: undergraduate physical chemistry or instructor consent.
Requisites: Restricted to graduate students only.

**CHEM 5181 (3) Mass Spectrometry and Chromatography**
Mass spectrometry, including instrumentation, ionization techniques and interpretation of mass spectra. Theory and practice of analytical separation processes including ion mobility, capillary electrophoresis and liquid gas chromatography. Introduction to applications in e.g. atmospheric and biological mass spectrometry. Introduction to computer simulation of instrumentation and physical processes. Department enforced prerequisite: undergraduate physical chemistry or instructor consent.
Requisites: Restricted to graduate students only.

**CHEM 5251 (3) Materials Chemistry and Properties**
Lec. Understanding of materials from chemistry perspective including metals, oxides, semiconductors and polymers. Basic description of chemical preparation of materials. Overview of fundamental properties of materials including structural, chemical, mechanical, thermal, electrical, and optical properties. Description of behavior of materials and various applications in modern technology. Discussion of materials characterization methods.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 4251
Requisites: Requires prerequisite course of CHEM 4431 or CHEM 4531 (all minimum grade C-) or graduate standing.

**CHEM 5261 (3) Organic Materials: Structures and Functions**
Overview of the preparation and functioning mechanism of novel organic materials that have recently been developed, including conductive polymers, 2-D macrocyclic structures, 3-D molecular cages, molecular machines/muscles/switches, fullerene derivatives and carbon nanotube composites. Emphasizes the use of organic and physical chemistry as tools to develop novel materials and probe their structure-property relationship.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 4261
Requisites: Requires prerequisite course of CHEM 4431 or CHEM 4531 (all minimum grade C-) or graduate standing.

**CHEM 5271 (3) Chemistry of Solar Energy**
Chemical principles of conversion of solar energy into electricity and fuels in molecular and semiconductor-based systems. Overview of solid-state electronic structure of materials and interfaces, light-matter interactions, principles of harvesting photoexcited currents and useful chemical species. Description of processes utilized in established and emerging solar energy technologies.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 4271
Requisites: Requires prerequisite course of CHEM 4431 or CHEM 4531 (all minimum grade C-) or graduate standing.

**CHEM 5281 (3) Semiconductor Processing and Device Fabrication**
Understanding of semiconductor processing and device fabrication from chemistry perspective. Overview of processing steps used to fabricate inorganic semiconductor devices including deposition, patterning and etching techniques. Description of process integration during device fabrication. Discussion of key issues facing advanced semiconductor fabrication.
Requisites: Restricted to graduate students only.
Grading Basis: Letter Grade
CHEM 5311 (3) Advanced Synthetic Organic Chemistry
Lect. Surveys synthetic transformations emphasizing important functional group transformations and carbon-carbon, bond-forming reactions. Required of all organic chemistry graduate students. Department enforced prerequisite: one year of organic chemistry or graduate standing.

CHEM 5321 (3) Advanced Physical Organic Chemistry
Lect. Modern concepts of physical organic chemistry and their use in interpreting data in terms of mechanisms of organic reactions and reactivities of organic compounds. Required of all organic chemistry graduate students. Department enforced prerequisites: one year of organic chemistry and one year of physical chemistry or graduate standing.

CHEM 5331 (3) Advanced Spectroscopic Techniques in Organic Chemistry
Lect. Advanced spectroscopic techniques for structure and determination in organic chemistry. Emphasizes proton and carbon-13 NMR spectroscopy. Department enforced prerequisites: one year of organic chemistry and one year of physical chemistry or graduate standing.

CHEM 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.

Requisites: Restricted to graduate students only.

CHEM 5400 (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 5411.

Equivalent - Duplicate Degree Credit Not Granted: CHEM 4400 and CHEM 4511

Requisites: Restricted to graduate students only.

CHEM 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); physics; calculus.

Equivalent - Duplicate Degree Credit Not Granted: CHEM 4491

Requisites: Restricted to graduate students only.

Grading Basis: Letter Grade

CHEM 5501 (3) Advanced Topics in Physical Chemistry
Covers various topics in physical chemistry focusing on their mathematical and physical background. Topics include the application of classical mechanics and electrodynamics in chemistry, the classical mechanics background for the description of atoms and molecules, the use of vector spaces in wave mechanics and quantum mechanics and the classical description of spectroscopy in terms of interaction of light and matter. Department enforced prerequisites: undergraduate physical chemistry, graduate standing or instructor consent.

Requisites: Restricted to graduate students only.

CHEM 5511 (3) Statistical Mechanics

Requisites: Restricted to graduate students only.

CHEM 5541 (3) Chemical Dynamics
Lect. Discussion of mechanism and rate of chemical reactions from a fundamental point of view. Discusses nature of collision and develops concepts of cross section and rate constant. Theories of elementary bimolecular and decay processes are critically examined. Department enforced prerequisite: undergraduate physical chemistry.

Requisites: Restricted to graduate students only.

CHEM 5551 (3) Chemical Dynamics
Lect. Discussion of mechanism and rate of chemical reactions from a fundamental point of view. Discusses nature of collision and develops concepts of cross section and rate constant. Theories of elementary bimolecular and decay processes are critically examined. Department enforced prerequisite: undergraduate physical chemistry.

Requisites: Restricted to graduate students only.

CHEM 5555 (4) Theoretical and Computational Chemistry
Explores computational methods to understand chemical systems. Topics include: atomic and molecular electronic structure calculations, Monte Carlo and molecular dynamics simulations and thermodynamic calculations.

Equivalent - Duplicate Degree Credit Not Granted: CHEM 4555

Requisites: Restricted to graduate students only.

Grading Basis: Letter Grade

CHEM 5571 (3) Surface Science
Lect. Principles of surface science with emphasis on fundamental surface phenomena, surface techniques and surface chemistry. Basic description of surfaces, adsorbate-surface interactions, surface kinetics and methods of surface analysis. Surface science of heterogeneous catalysis, semiconductor processing, and environmental interfaces.

Department enforced prerequisites: undergraduate physical chemistry and graduate standing or instructor consent.

Requisites: Restricted to graduate students only.

CHEM 5581 (3) Introductory Quantum Chemistry
Lect. Basic principles and techniques of quantum mechanics with applications to questions of chemical interest. Quantum dynamics of atoms, molecules and spin; electronic structure of atoms and molecules. Department enforced prerequisite: two semesters of physical chemistry and graduate standing or instructor consent.

Requisites: Restricted to graduate students only.

CHEM 5591 (3) Advanced Molecular Spectroscopy
Lect. Rotational, vibrational and electronic spectra of molecules, and their interpretation in terms of the quantum theory of molecular structure. Department enforced prerequisites: two semesters of physical chemistry and graduate standing or instructor consent.

Requisites: Restricted to graduate students only.
CHEM 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: MCDB 4621 or MCDB 5621 CHEM 4621
Requisites: Restricted to graduate students only.

CHEM 5700 (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 organic and physical chemistry will be required. Formerly CHEM 5711.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 4700
Requisites: Restricted to graduate students only.

CHEM 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.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 4720
Requisites: Restricted to graduate students only.

CHEM 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.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 4740
Requisites: Restricted to graduate students only.

CHEM 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.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 4751
Requisites: Restricted to graduate students only.

CHEM 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 CHEM 5771 covering the same topics except for the requirement of a written research proposal.
CHEM 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.

CHEM 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.
Equivalent - Duplicate Degree Credit Not Granted: MCDB 5776
Requisites: Requires prerequisite course of CHEM 5771 or CHEM 5271 (minimum grade B-). Restricted to graduate students only.

CHEM 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.
Requisites: Requires prerequisite course of CHEM 5770 (minimum grade B-). Restricted to graduate students only.

CHEM 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).
Requisites: Requires prerequisite course of CHEM 5771 (minimum grade B-). Restricted to graduate students only.

CHEM 5791 (3) Bioorganic Chemistry in Biotechnology
Lec. Explores examples of antibodies, peptides, proteins, RNA, DNA, carbohydrates and lipids. Uses the primary literature and requires student participation.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 4791
Requisites: Restricted to graduate students only.

CHEM 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.
Requisites: Restricted to graduate students only.
Recommended: Prerequisites CHEM 5771 and CHEM 5781 and MCDB 5210 or MCDB 5220.

CHEM 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.
Requisites: Restricted to graduate students only.
Recommended: Prerequisites CHEM 5771 and CHEM 5781 and MCDB 5210.

CHEM 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.
Repeatable: Repeatable for up to 5.00 total credit hours.
Requisites: Restricted to graduate students only.
CHEM 6001 (1) Seminar: Inorganic Chemistry
Student, faculty, and guest presentations and discussions of current research in inorganic chemistry and related topics (transition element and main group element compound properties, inorganic compound in biological, industrial, and materials applications). Required of all inorganic chemistry graduate students. Credit deferred until presentation of satisfactory seminar.
Requisites: Restricted to graduate students only.

CHEM 6021 (1-3) Special Topics in Inorganic Chemistry
Lect. Subjects of current interest in inorganic chemistry. Primarily used for graduate-level presentations of special topics by visiting and resident faculty. Variable class schedule.
Repeatable: Repeatable for up to 7.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 6031 (3) Special Topics in Nanoscience
Introduces the synthesis, physical properties, and applications of nanometer-scale materials and devices. Includes synthesis of metal and semiconductor nanoparticles and nanowires, optical and electronic properties of nanoscale systems, and applications in biotechnology and energy.
Requisites: Requires prerequisite course of CHEM 4431 or CHEM 4511 (all minimum grade B-) or graduate standing.

CHEM 6101 (1) Seminar: Analytical Chemistry
Student, faculty, and guest presentations and discussions of current research in analytical chemistry. Required of all analytical chemistry graduate students. Credit deferred until presentation of satisfactory seminar.
Requisites: Restricted to graduate students only.

CHEM 6111 (1-3) Special Topics in Analytical Chemistry
Lect. Subjects of current interest in analytical chemistry. Used for graduate-level presentations of special topics by visiting and resident faculty. Variable class schedule.
Repeatable: Repeatable for up to 7.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 6301 (1-3) Seminar in Organic Chemistry
Discussions principally concerned with recent literature in organic chemistry. Required of all organic chemistry graduate students.
Requisites: Restricted to graduate students only.

CHEM 6311 (1-3) Special Topics in Synthetic Organic Chemistry
Lect. Selected topics in synthetic organic chemistry, encompassing both methods and/or total synthesis of complex molecules.
Requisites: Requires prerequisite course of CHEM 5311 (minimum grade B-). Restricted to graduate students only.

CHEM 6321 (1-3) Special Topics in Physical Organic Chemistry
Lect. Selected topics in physical organic chemistry, which may include photochemistry, carbene chemistry, free radical chemistry, molecular orbital methods, organic materials, or gas phase ion chemistry.
Requisites: Requires prerequisite course of CHEM 5321 (minimum grade B-). Restricted to graduate students only.

CHEM 6401 (1-3) Seminar: Physical Chemistry
Student, faculty, and guest presentations of current research in physical chemistry. Discussion of research topics related to the subject of weekly physical chemistry/chemical physics seminar and appropriate journal articles.
Requisites: Restricted to graduate students only.

CHEM 6411 (1-3) Advanced Topics in Physical Chemistry
Lect.
Repeatable: Repeatable for up to 7.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 6601 (1) Biochemistry Seminar
Required of all biochemistry graduate students. Credit is deferred until presentation of satisfactory seminar.
Requisites: Restricted to graduate students only.

CHEM 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.
Repeatable: Repeatable for up to 12.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 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.
Repeatable: Repeatable for up to 12.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 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.
Repeatable: Repeatable for up to 12.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 6801 (0) Departmental Research Seminar
Lectures by visiting scientists and occasionally by staff members and graduate students on topics of current research. Meets once a week. Required for all graduate students in chemistry.
Requisites: Restricted to graduate students only.

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

CHEM 6941 (1) Master's Candidate
Requisites: Restricted to graduate students only.
Grading Basis: Pass/Fail

CHEM 6951 (1-6) Master's Thesis
Requisites: Restricted to graduate students only.

CHEM 7021 (2) Seminar: Structural Inorganic Chemistry
Current research in the area of structural inorganic chemistry. Concerns topics related to electronic and molecular structure of transition metal complexes. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7101 (2) Seminar: Chromatography and Trace Analysis
Student and faculty discussions and reports on research advances in chromatography, trace analysis and environmental chemistry. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7111 (2) Seminar: Electrochemistry
Student and faculty discussions and reports on research advances in electrochemistry. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.
CHEM 7211 (1) Seminar: Product Synthesis
Discusses advances and developments in biomolecular dynamics, and considers the connection of protein dynamics with function. Emphasizes new methods to achieve coherent control. Department consent required.
Repeatable: Repeatable for up to 2.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7212 (1) Seminar: Synthetic and Mechanistic Chemistry
Studies gas phase ion chemistry relevant to thermochemical rate processes. Focuses on chemical reactions in liquids, absorption-desorption on surfaces, nucleation reactions, and energy flow in molecules. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7261 (1) Seminar: Negative Ion Chemistry
Discusses recent advances in atmospheric aerosol chemistry, with emphasis on new methods for analysis and their application to laboratory and field studies. Repeatable: Repeatable for up to 2.00 total credit hours.
Requisites: Restricted to graduate students only.
Recommended: Prerequisites CHEM 5151 and CHEM 5181.

CHEM 7161 (1) Seminar: Heterogeneous Atmospheric Chemistry
Topics in atmospheric chemistry emphasizing the structure and reactivity of atmospheric particulates. Presentations on current research and critical evaluations of recent literature. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7221 (1) Seminar: Photochemistry and Free Radical Chemistry
Current research in areas of organic free radical chemistry, photochemistry, and related topics are presented and discussed. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7231 (1) Seminar: Reactive Intermediates
Application of contemporary ideas of chemical physics to organic molecules. Special attention to structures and bonding in organic ions and radicals. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7241 (1) Seminar: Synthetic Organic Chemistry
Series of seminars on directed total synthesis. Emphasizes modern synthetic methodology and applications to total synthesis of natural products. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7251 (1) Seminar: Selected Topics in Chemical Genetics
Discusses recent advances in molecular self-assembly, with emphasis on new liquid crystal designs and applications. Repeatable: Repeatable for up to 2.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7261 (1) Seminar: Molecular Self-Assembly
Discusses current topics and recent advances in molecular self-assembly, with emphasis on new liquid crystal designs and applications. Repeatable: Repeatable for up to 2.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7191 (1) Seminar: Physical Organic Chemistry
Modern experimental techniques and theoretical models in physical organic chemistry are discussed in relation to the development of new materials, such as molecular size tinkertoys to the development of novel photochemical systems and their spectroscopies. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7301 (1) Seminar: Synthetic and Mechanistic Chemistry
Discusses the brief history of the emerging field of chemical genetics, and focuses on the recent development of concepts, techniques, applications, and its impact on both science and human health. Repeatable: Repeatable for up to 2.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7311 (1) Seminar: Topics in Synthetic Methodology and Natural Product Synthesis
Discussion of contemporary synthetic organic chemistry with a focus on new methodology and total synthesis of natural products. Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7301 (1) Seminar: Heterogeneous Atmospheric Chemistry
Topics in atmospheric chemistry emphasizing the structure and reactivity of atmospheric particulates. Presentations on current research and critical evaluations of recent literature. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7321 (1) Seminar: Selected Topics in Chemical Genetics
Current research in the area of organic/materials chemistry. Concerns topics related to organic materials synthesis, carbon nanotube functionalization, artificial photosynthesis, gas storage and catalysis. Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7401 (1) Seminar in Photochemical Reaction Control
Discusses advances in atmospheric aerosol chemistry, with emphasis on new methods for analysis and their application to laboratory and field studies. Repeatable: Repeatable for up to 2.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7401 (1) Seminar in Atmospheric Aerosol Chemistry
Discusses current and recent advances in molecular self-assembly, with emphasis on new liquid crystal designs and applications. Repeatable: Repeatable for up to 2.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7411 (1) Seminar in Ultrafast Spectroscopy of Proteins
Discusses recent advances in biomolecular dynamics, and considers the connection of protein dynamics with function. Emphasizes experimental studies via ultrafast laser spectroscopy. Repeatable: Repeatable for up to 2.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7421 (2) Research Seminar: Theoretical Chemistry
Studies theoretical description of molecular dynamics as related to rate processes. Focuses on chemical reactions in liquids, absorption-desorption on surfaces, nucleation reactions, and energy flow in molecules. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7431 (1) Seminar: Topics in Theoretical Chemical Physics
Seminar presented on a variety of topics in theoretical chemical physics. Molecular collisions and unimolecular dynamics predominantly featured. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7441 (1) Seminar: Gas Phase Ion Chemistry
Studies gas phase ion chemistry relevant to thermochemical measurements and atmospheric, interstellar, and biomedical applications. Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7441 (1) Seminar: Topics in Theoretical Chemical Physics
Seminar presented on a variety of topics in theoretical chemical physics. Molecular collisions and unimolecular dynamics predominantly featured. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7461 (1) Seminar: Gas Phase Ion Chemistry
Studies gas phase ion chemistry relevant to thermochemical measurements and atmospheric, interstellar, and biomedical applications. Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7471 (1) Seminar in Ultraviolet Spectroscopy of Proteins
Discusses recent advances in biomolecular dynamics, and considers the connection of protein dynamics with function. Emphasizes experimental studies via ultrafast laser spectroscopy. Repeatable: Repeatable for up to 2.00 total credit hours.
Requisites: Restricted to graduate students only.
CHEM 7481 (2) Seminar: Molecular Spectroscopy and Photochemistry
Discussion and presentation of current research in spectroscopy and photochemistry of organic as well as organometallic systems. Reviews state of the art techniques available for the theoretical and experimental characterization of excited states. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7491 (1) Seminar: Molecular Vibrational Dynamics
Topics pertaining to vibrational dynamics of small molecules are discussed, with particular emphasis upon IR laser spectroscopy, van der Waals’ clusters, vibrationally induced dipole moments, and predissociation. Discussion of current research and recently published literature. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7501 (1) Seminar: Theoretical Molecular Dynamics
Variety of topics in theoretical chemical physics, emphasizing dynamics of molecules in dissipative environments or in radiation fields. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7511 (1) Seminar: Reaction Dynamics in Condensed Phases
Studies elementary steps in chemical reactions and their observation by ultrafast spectroscopy. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7521 (1) Seminar: Atmospheric Kinetics and Photochemistry
Discusses laboratory studies of degradation mechanisms. Applies these studies to atmospheric phenomena such as global warming and stratospheric ozone loss. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7531 (1) Seminar: Surface Chemistry and Thin Film Growth
Topics in surface chemistry and thin film growth with focus on atomic layer deposition (ALD) and molecular layer deposition (MLD). Properties of thin films grown using ALD and MLD. Applications of thin films in areas including flexible displays, energy storage and catalysis. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 7551 (1) Selected Topics in Ion Spectroscopy
Treats current topics in the spectroscopy of ions. Seminar lectures are given by graduate students on their research and on literature topics, and the results of both in-house and external research groups are studied. Additionally, ideas for interesting directions of research and new experiments are proposed and discussed.
Repeatable: Repeatable for up to 2.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEM 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.

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

CHEM 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.
Requisites: Restricted to graduate students only.

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

CHEM 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.
Requisites: Restricted to graduate students only.

CHEM 7671 (1) Seminar: Topics in Designing Probes for Signaling 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.
Requisites: Restricted to graduate students only.

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

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

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

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

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

CHEM 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.
**Requisites:** Restricted to graduate students only.

CHEM 7791 (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.
**Requisites:** Restricted to graduate students only.

CHEM 8991 (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.
**Repeatable:** Repeatable for up to 30.00 total credit hours.
**Requisites:** Restricted to graduate students only.