CHEMISTRY AND BIOCHEMISTRY

College of Science and Engineering
Interim Dean: Dr. Carmen Domingo

Department of Chemistry and Biochemistry
TH 806
Phone: (415) 338–1288
Chair: Teaster Baird, Jr.
Graduate Coordinators: Andrew Ichimura, Bruce Manning

Program Scope and Career Outlook
The Department of Chemistry and Biochemistry offers an outstanding educational environment for undergraduate and graduate students. Our mission is to educate, train, and produce versatile chemists and biochemists who understand both the theoretical basis and practical applications of their discipline. Department faculty provide quality instruction across a wide range of sub-disciplines. Our degree programs are designed to prepare students for various professional positions (i.e., biotechnology and pharmaceutical companies, chemical manufacturing, and other laboratory-based industries), health professions (i.e., medical, pharmacy, and dental school), graduate study, and teaching positions.

Students receive significant hands-on experience with modern instrumentation in our relatively small-sized lab classes, and the opportunity to participate in research projects under the direct supervision of our faculty. The department houses a variety of state-of-the-art research instrumentation, laboratory facilities, and computational labs. These include a Nuclear Magnetic Resonance (NMR) facility, a Mass Spectrometry (MS) facility, a Scanning Electron Microscopy (SEM) facility and the Computational Chemistry and Visualization (CCV) laboratory.

The Bachelor of Arts in Chemistry program is particularly well-suited for those students whose career goals involve the integration of chemistry with other fields. This program can be combined with another degree or minor to develop the unique synthesis of experience needed for careers in health professions, forensic science, environmental science, regulatory affairs, chemical engineering, patent law, management, sales, marketing, technical writing, scientific journalism, library science, and art restoration. This program also provides excellent preparation for high school science teachers. Students planning to become K–12 chemistry or science teachers should note that additional preparation beyond the major is required to meet the breadth requirements and should consult with the credential advisor in the Department of Chemistry and Biochemistry to review the state-mandated requirements.

The Bachelor of Science in Chemistry, which is approved by the American Chemical Society (ACS), prepares students to pursue a career in chemically-oriented industry or to begin graduate study in chemistry and other molecular sciences. The degree provides a solid foundation in mathematics and physics, breadth in chemical sub-disciplines (analytical, biochemical, inorganic, organic, and physical chemistry), and excellent hands-on training in laboratory and instrumental techniques.

The Bachelor of Science in Biochemistry is designed for students who wish to be particularly well qualified at the rapidly expanding interface between biology and chemistry. The degree includes extensive laboratory training, provides exceptional preparation for careers in biotechnology, and enjoys a favorable reputation among biotechnology companies in the Bay Area. This degree also provides a strong foundation for a graduate degree in biochemistry.

The Master of Science degree in Chemistry and the Master of Science degree in Chemistry with a concentration in Biochemistry are programs of study with research at the core. As the student focuses in depth on an independent scientific investigation, solid research and communication skills are developed. The goal of both M.S. degree programs is to provide students with a thorough grounding in laboratory and research skills, and in-depth training in their areas of specialization. Our M.S. program provides excellent training for

1. careers in all aspects of the chemical industry (biotechnology, environment, process and analytical, basic research);
2. science educators seeking to increase their skill and knowledge base; and
3. students whose goal is advanced study at the Ph.D. level.

The M.S. in Chemistry program is approved by the ACS.

Significant features of our department include high-quality teaching, one-on-one advising for all of our majors, and opportunities for students to participate in research under the direct supervision of active faculty members who are recognized authorities in their field. Students interested in becoming involved in research should consult with an advisor and review faculty research interests on our department website (www.chembiochem.sfsu.edu (http://www.chembiochem.sfsu.edu)). Examples of research projects currently under investigation by our faculty members and their research students include:

Analytical Chemistry
Identification and quantitation of organic pollutants via Gas Chromatography/Mass Spectrometry (GC/MS) and Direct Sampling Mass Spectrometry (DSMS). Application of X-Ray Fluorescence spectrometry (XRF) to the determination of toxic elements in foods, supplements, and other products. Development of novel analytical techniques for separation and detection of redox-sensitive trace species.

Biochemistry
Biophysical Chemistry
Biophysical spectroscopic methods, including nanosecond time-resolved polarized absorption spectroscopy, to characterize biological function and examine the molecular basis of disease. Chromatin folding, dynamics, and stability.

Chemical Education
Identify student experiences and instructional practices that promote student success in chemistry courses and persistence in STEM majors. Design experiences to engage students in applying course-based chemistry knowledge to address community questions and societal needs.

Environmental Chemistry
Detection of trace levels of volatile organic compounds and heavy metals in urban air, water, and soil samples. Determination of structures and speciation of metals and trace elements adsorbed on environmental surfaces by X-ray absorption spectroscopy. Modeling speciation, precipitation, and adsorption reactions of trace elements in environmental systems. Development and characterization of reactive metallic and mineral-based remediation materials for soil and water contaminants. Investigation of the composition and degradation of organic matter in marine systems through quantification and modeling of natural carbon isotopes.

Organic/Bioorganic Chemistry

Materials and Inorganic Chemistry
Synthesis and characterization of semiconducting thin films with applications to solar cells, water splitting, water remediation and CO2 reduction. Growth and nucleation of crystalline TiO2 by atomic force microscopy (AFM) and in situ grazing incidence X-ray diffraction (GIXRD). Computational approaches to speed the development of solid-state batteries, photocatalysts, and quantum computers using Density Functional Theory and Molecular dynamics.

Natural Products Chemistry
Isolation and characterization of novel compounds from marine microorganisms from sediments, algae, and sponges with anti-cancer, or anti-malarial properties.

Physical Chemistry
Synthesis and characterization of heteroatom substituted zeolites by XRD, solid-state MAS–NMR, and optical spectroscopy, with applications to photocatalysis of carbon dioxide to fuels. Photophysics and electron spin resonance (ESR) investigation of thin films for applications in photovoltaics and photocatalysis.

Professor
TEASTER BAIRD JR. (2002), Professor of Biochemistry; B.S. (1992), Tougaloo College; Ph.D. (1997), Duke University.

JANE G. DeWITT (1995), Professor of Chemistry; B.S. (1986), University of California, Santa Barbara; Ph.D. (1993), Stanford University.


RAYMOND ESQUERRA (2000), Professor of Biochemistry; B.S. (1990), Stanford University; Ph.D. (1997), University of California, Santa Cruz.

GEORGE GASSNER (2000), Professor of Biochemistry; B.S. (1989), University of Minnesota; Ph.D. (1995), University of Michigan, Ann Arbor.


BRUCE MANNING (1999), Professor of Chemistry; B.S. (1985), University of Massachusetts; Ph.D. (1993), University of California, Davis.


URSULA SIMONIS (1993), Professor of Chemistry; Diploma in Chemistry (1982), Ph.D. (1985), Westfalishe Wilhelms Universitat, Munster, Germany.

WEIMING WU (1995), Professor of Chemistry; B.S. (1986), Nanjing University, China; Ph.D. (1992), University of Illinois.

Associate Professor

MARC ANDERSON (2007), Associate Professor of Chemistry; B.S. (1995), University of Colorado, Boulder; Ph.D. (2001), University of California, Santa Cruz.

ANTON GULIAEV (2007), Associate Professor of Biochemistry; M.S. (1993), Moscow State University, Moscow, Russia; Ph.D. (1999), Bowling Green State University.

ANDREW S. ICHIMURA (2001), Associate Professor of Chemistry; B.S. (1986), Bates College; Ph.D. (1992), University of Massachusetts.

Assistant Professor
NICOLE ADELSTEIN (2015), Assistant Professor of Chemistry; B. A. (2006), Reed College; M.S. (2010), Ph.D. (2012), University of California, Berkeley.

AURA ALEGRA EROY-REEVELES (2011), Assistant Professor of Chemistry; B.A. (2001), Amherst College; Ph.D. (2008), University of California, Santa Cruz.

MISTY L. KUHN (2014), Assistant Professor of Chemistry and Biochemistry; B.A. (2002), Hanover College; Ph.D. (2009), Loyola University Chicago.

JINGJING QIU (2018), Assistant Professor of Chemistry; B.S. (2010), Xiamen University; Ph.D. (2015), University of Florida.
KRISTA VIKSE (2016), Assistant Professor of Chemistry; B.Sc. (2006), University of British Columbia Okanagan; Ph.D. (2011), University of Victoria.

**Majors**
- Bachelor of Arts in Chemistry (bulletin.sfsu.edu/colleges/science-engineering/chemistry-biochemistry/ba-chemistry)
- Bachelor of Science in Chemistry (bulletin.sfsu.edu/colleges/science-engineering/chemistry-biochemistry/bs-chemistry)
- Bachelor of Science in Biochemistry (bulletin.sfsu.edu/colleges/science-engineering/chemistry-biochemistry/bs-biochemistry)

**Minor**
- Minor in Chemistry (bulletin.sfsu.edu/colleges/science-engineering/chemistry-biochemistry/minor-program-chemistry)

**Masters**
- Master of Science in Chemistry (bulletin.sfsu.edu/colleges/science-engineering/chemistry-biochemistry/ms-chemistry)
- Master of Science in Chemistry: Concentration in Biochemistry (bulletin.sfsu.edu/colleges/science-engineering/chemistry-biochemistry/ms-chemistry-concentration-biochemistry)

**CHEM 100 Preparation for Chemistry (Units: 3)**
Prerequisites: Category I or II placement for QR/Math. Category III or IV placement for QR/Math must co-enroll in MATH 122 and an associated B4 course; or in MATH 123 and MATH 124; or in MATH 107 or MATH 197; or have completed these courses with grades of C or better. Elementary concepts of chemistry. Development of skills in applying mathematics to solving problems in chemistry. Preparation for CHEM 115 or CHEM 180. (Plus-minus ABC/NC grading only)

**CHEM 101 Survey of Chemistry (Units: 3)**
Prerequisites: Category I or II placement for QR/Math. Category III or IV placement for QR/Math must have completed MATH 197 with a grade of C or better or satisfied the B4 requirement. Lecture, 2 units; laboratory, 1 unit. Extra fee required. (Charges for missing or damaged laboratory locker items apply.)

**CHEM 102 Survey of Chemistry Laboratory (Unit: 1)**
Laboratory to accompany or follow CHEM 101. Extra fee required. (Charges for missing or damaged laboratory locker items apply)

**CHEM 109 Fundamentals of Food Chemistry: Natural Constituents and Additives (Units: 3)**
The chemical composition of foods including sugars, starches, fats, oils, protein, vitamins, minerals, and additives. The government’s role in food processing and distribution.

**CHEM 110 Fundamentals of Food Chemistry: Natural Constituents and Additives Laboratory (Unit: 1)**
Prerequisite: Concurrent enrollment in CHEM 109; laboratory to accompany CHEM 109.

Hands-on experience in assessing food constituents using modern chemical methods and techniques including chemical instrumentation. Laboratory. (Charges for missing or damaged laboratory locker items apply)

**CHEM 115 General Chemistry I: Essential Concepts of Chemistry (Units: 5)**
Prerequisites: Category I or II placement for QR/Math, or ELM score of 50 or higher or exemption, or MATH 70 or ESM 70 with a grade of C or better. Category III or IV for QR/Math placement or students who have not completed MATH 70 with a grade of C or better must have completed MATH 197 with a grade of C or better, or have satisfied the B4 requirement. CHEM 100 with a grade of C or better (letter grade only) or satisfactory score on chemistry placement exam.

Essential concepts of atomic properties, atomic interactions, reaction chemistry, stoichiometry, thermodynamics, chemical kinetics, and equilibria. Lecture, 3 units; seminar, 1 unit; laboratory, 1 unit. Extra fee required. (Charges for missing or damaged laboratory locker items apply)

**CHEM 130 General Organic Chemistry (Units: 3)**
Prerequisite: CHEM 115* with a grade of C or better.

Common organic compounds and basic principles. For laboratory, see CHEM 234. Cannot be used for the Chemistry or Biochemistry degrees.

**CHEM 180 Chemistry for the Energy and the Environment (Units: 3)**
Prerequisites: Category I or II placement for QR/Math placement, or an ELM score of 50 or ELM exemption, or MATH 70 with a grade of C or better. Category III or IV for QR/Math placement must have completed MATH 197 with a grade of C or better or satisfied the GE Area B4 requirement. High school chemistry recommended.

Study of the fundamental chemical principles that underlie chemical processes in the environment and the chemical processes that are important to the generation of energy. Suitable for Engineering and Environmental Studies majors. Lecture, 2 units; laboratory, 1 unit. Extra fee required. (Charges for missing or damaged laboratory locker items apply)

Course Attributes:
- B1: Physical Science
- B3: Lab Science
- Environmental Sustainability

**CHEM 215 General Chemistry II: Quantitative Applications of Chemistry Concepts (Units: 3)**
Prerequisite: CHEM 115* with a grade of C or better.

Quantitative aspects of chemistry with an emphasis on kinetics, equilibria (acid-base, solubility, and buffer), thermodynamics, and electrochemistry.

**CHEM 216 General Chemistry II Laboratory: Quantitative Applications of Chemistry Concepts (Units: 2)**
Prerequisite: CHEM 215 with a grade of C or better (may be taken concurrently).

Determination of thermodynamic quantities including rate laws, acid dissociation constants, preparation and analysis of buffer solutions, and synthesis and analysis of a molecular complex. Laboratory. Extra fee required. (Charges for missing or damaged laboratory locker items apply)
CHEM 233 Organic Chemistry I (Units: 3)  
Prerequisites: Priority enrollment for Chemistry and Biochemistry majors; CHEM 115* and CHEM 215* with grades of C or better; other majors permitted on a space-available basis. 


CHEM 234 Organic Chemistry I Laboratory (Units: 2)  
Prerequisite: CHEM 233 or CHEM 130 with a grade of C or better (may be taken concurrently). 

Techniques and selected experiments in organic chemistry. Lecture, 1 unit; laboratory, 1 unit. Extra fee required. (Charges for missing or damaged laboratory locker items apply) 

CHEM 251 Mathematics and Physics for Chemistry (Units: 3)  
Prerequisites: CHEM 215, MATH 226, MATH 227, PHYS 220, PHYS 222, PHYS 230, and PHYS 232 with grades of C or better; or consent of the instructor; concurrent enrollment in CHEM 351 is strongly recommended. 

Integrated mathematics and physics for physical chemistry including fluids, wave motion, thermodynamics, partial derivatives, multiple integrals, introductory vector calculus, and introductory differential equations. (Plus-minus letter grade only) 

CHEM 300 General Physical Chemistry I (Units: 3)  
Prerequisites: CHEM 321*, CHEM 335*, MATH 227*, and PHYS 121* or PHYS 230* or PHYS 240* with grades of C or better; CHEM 340 or CHEM 349 recommended. For Chemistry, Biochemistry, and Biology majors. 

Chemical thermodynamics, kinetic theory of gases, and properties of solutions. Designed for students in Biology, pre-professional curricula, Biochemistry, and Chemistry majors. 

CHEM 301 General Physical Chemistry II (Units: 3)  
Prerequisite: CHEM 300 with a grade of C or better or consent of the instructor. 

Quantum mechanics, spectroscopy, biophysical spectroscopy, intermolecular forces, macromolecules, and statistical thermodynamics. 

CHEM 321 Quantitative Chemical Analysis (Units: 3)  
Prerequisites: CHEM 215* and CHEM 216* with grades of C or better. Intended for Chemistry, Biochemistry, and Biology majors. 

Foundation course in analytical chemistry with a focus on quantitative analysis. Topics include uncertainties, statistics, equilibria, titrimetric methods, electrochemistry and potentiometry, molecular and atomic spectroscopy, mass spectroscopy, and chromatography. (Plus-minus letter grade only) 

CHEM 322 Quantitative Chemical Analysis Laboratory (Units: 2)  
Prerequisite: CHEM 321 with a grade of C or better (may be taken concurrently). Intended for Chemistry, Biochemistry, and Biology majors. 

Practical experience in performing accurate and precise measurements of chemical species in a variety of real-world samples using gravimetric, titrimetric, potentiometric, spectroscopic, and chromatographic methods. Laboratory. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only) 

CHEM 325 Inorganic Chemistry (Units: 3)  
Prerequisites: CHEM 215 and CHEM 335 with grades of C or better. Intended for Chemistry, Biochemistry, and Biology majors. 

Theories of chemical bonding and their application to inorganic systems with an emphasis on transition metal complexes. Molecular Symmetry. Acid/base, redox, and solid-state chemistry. An introduction to organometallic and bioinorganic chemistry. 

CHEM 327 Practical GC and HPLC (Units: 4)  
Prerequisites: CHEM 234, CHEM 321, and CHEM 322 with grades of C or better. 

Theory, hardware, and experience in GC and HPLC separations. Emphasis on practical skills and common applications in natural products, environmental, and pharmaceutical analyses. Lecture, 2 units; laboratory, 2 units. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only) 

CHEM 335 Organic Chemistry II (Units: 3)  
Prerequisite: CHEM 233* with a grade of C or better. 

Continuation of CHEM 233. 

CHEM 336 Organic Chemistry II Laboratory (Units: 2)  
Prerequisites: CHEM 234 and CHEM 335 (may be taken concurrently) with grades of C or better. Intended for science majors. 

Techniques and experiments in organic synthesis, isolation, purification, and characterization. Activity, 1 unit; laboratory, 1 unit. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only) 

CHEM 338 Organic Chemistry II: Laboratory Honors (Units: 3)  
Prerequisites: CHEM 233 and CHEM 234 with grades of B or better; concurrent enrollment in CHEM 335. Substitute for CHEM 336. 

Experiments in organic synthesis and analysis plus a research project directed by faculty. Lecture, 1 unit; laboratory, 2 units. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only) 

CHEM 340 Biochemistry I (Units: 3)  
Prerequisites: CHEM 215*, CHEM 233*, and CHEM 335* with grades of C or better. Intended for Chemistry, Biochemistry, and Biology majors. 

Introduction to Biochemistry including protein structure and function, carbohydrate metabolism, enzyme kinetics and thermodynamics, and electron transport chain. 

CHEM 341 Biochemistry II (Units: 3)  
Prerequisite: CHEM 340 with a grade of C or better. 

Biosynthesis and degradation of lipids, amino acids, and nucleotides. Protein synthesis, folding, and degradation. DNA and RNA structure. DNA replication and transcription. 

CHEM 343 Biochemistry I Laboratory (Units: 3)  
Prerequisites: Restricted to Chemistry and Biochemistry majors; CHEM 216*, CHEM 234*, and CHEM 340* (may be taken concurrently) or CHEM 349* (may be taken concurrently) with grades of C or better; CHEM 321 is recommended. 

Chemical and enzymatic experiments involving proteins, carbohydrates, and nucleic acids with emphasis on enzyme kinetics. Utilization of standard and modern biochemical techniques. Lecture, 1 unit; laboratory, 2 units. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)
CHEM 349 General Biochemistry (Units: 3)
Prerequisites: CHEM 215* with a grade of C or better, and CHEM 130* with a grade of C or better or CHEM 335* with a grade of C- or better. Not intended for B.S. Biochemistry or Chemistry majors. Students who have completed CHEM 340 may not take CHEM 349 for credit.

Survey of major areas in Biochemistry including enzymology, bioenergetics, and carbohydrate, lipid, and nucleic acid metabolism.

CHEM 370 Computer Applications in Chemistry and Biochemistry (Units: 3)
Prerequisites: CHEM 321 and CHEM 233 with grades of C or better.

Data acquisition, manipulation, and presentation with an emphasis on software used in chemistry and biochemistry laboratories. Computational chemistry and molecular visualization software for small and large molecules. Development of interactive molecular visualization web pages. Lecture, 2 units; activity, 1 unit.

CHEM 422 Instrumental Analysis (Units: 4)
Prerequisites: CHEM 321 and CHEM 322 with grades of C or better.

Instrumental methods for chemical and biochemical analysis including basic electronics, molecular and atomic spectroscopy, IR and Raman spectroscopy, mass spectrometry, and chromatography. Lecture, 2 units; laboratory, 2 units. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 443 Advanced Organic Chemistry (Units: 3)
Prerequisites: CHEM 335 with a grade of C or better and CHEM 301 or CHEM 353 (may be taken concurrently).

Theoretical aspects of organic chemistry, molecular structure, and reaction mechanisms.

CHEM 451 Experimental Physical Chemistry Laboratory (Units: 2)
Prerequisites: CHEM 321, CHEM 322, CHEM 351, CHEM 353 or CHEM 300 and CHEM 301, with grades of C or better, or consent of instructor.

Experiments using modern techniques in biochemistry, bioinformatics, molecular biology, and biophysics for the study of biological macromolecules. Lecture, 2 units; laboratory, 2 units. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 459 Careers in Chemistry and Biochemistry (Unit: 1)
Prerequisite: Senior standing.

Discussion of the full spectrum of careers in Chemistry and Biochemistry including career counseling, resume and interview guidance and strategies, and outside speakers from education and industry. (CR/NC grading only)

CHEM 460 Environmental Analysis (Units: 3)
Prerequisites: CHEM 321 and CHEM 322 with grades of C or better.

Practical analysis of real-world samples and environmental pollutants. Statistics, QA/QC, heavy metal analysis via atomic spectroscopy, and organic pollutant analysis via GC/MS. Lecture, 2 units; laboratory, 1 unit. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)
CHEM 470 Research (Units: 3)
Prerequisites: One year each of general and organic chemistry; consent of the instructor and faculty research adviser.

Intended for motivated students interested in independent research. Requires 6-9 hours of research each week, lecture attendance, formal poster presentation, and a written report. Laboratory. May be repeated for a total of 6 units. (Plus-minus letter grade only)

CHEM 640 Advanced Topics in Biochemistry (Units: 3)
Prerequisites: BIOL 350 and CHEM 349 or CHEM 341 or CHEM 340 with grades of C or better; or consent of the instructor.

Topics to be specified in Class Schedule. May be repeated when topics vary.

CHEM 645 Research Trends in Chemistry and Biochemistry (Units: 3)
Prerequisites: CHEM 340 and one semester of physical chemistry; GPA of 3.0 or better.

Self-directed learning experience for undergraduates in modern research topics in chemistry and biochemistry.

CHEM 680 Chemical Oceanography (Units: 3)
Prerequisite: CHEM 215 or equivalent.

Investigation of the composition and dynamics of the ocean through chemistry. (Plus-minus letter grade only)

CHEM 685 Projects in the Teaching of Chemistry and Biochemistry (Unit: 1)
Prerequisites: A grade of B or better in the course in which student will be instructing; consent of the instructor,

Instructional methods and techniques for effective student teaching, leading class discussions and activities, and carrying out class demonstrations. May be repeated for a total of 4 units.

CHEM 693 Cooperative Education Program (Units: 6-12)
Prerequisite: Consent of the instructor.

Supervised chemistry laboratory employment. Enrollment by prior arrangement with the employer and department. A final written report is required. A maximum of 2 units (1 unit for each semester) may be used to meet elective requirements in the Chemistry major programs. May be repeated for up to 24 units. (CR/NC grading only)

CHEM 694 Cooperative Education in Chemistry (Unit: 1)
Prerequisites: Upper-division standing or consent of the instructor.

Enrollment by prior arrangement with supervising faculty member and industry supervisor. See department advisor for details.

Supervised chemistry laboratory experience in the industry. A final written report is required. May be repeated for a total of 3 units. (Plus-minus letter grade only)

CHEM 699 Independent Study (Units: 1-6)
Prerequisite: Consent of the department and instructor.

Laboratory or library research work focused on chemistry and biochemistry problems directed by a department faculty. For advanced, superior students majoring or minoring in Chemistry or Biochemistry. Final written report required. May be repeated. (Plus-minus letter grade only)

CHEM 741 Electron Microscopy (Units: 4)
Prerequisite: Graduate or senior standing; or consent of the instructor.

Preparation of biological and inorganic materials for scanning and transmission electron microscopy, x-ray microanalysis, EBSD, CL, the operation of the electron microscope(s), and data interpretation. Seminar, 1 unit; laboratory, 3 units. Extra fee required. (This course is offered as BIOL 741, CHEM 741, and ERTH 741. Students may not repeat the course under an alternate prefix.)

CHEM 800 Special Topics in Chemistry (Units: 3)
Prerequisite: Graduate standing in Chemistry or consent of instructor.

Topic to be specified in Class Schedule. May be repeated as topics vary.

CHEM 820 NMR Applications and Techniques (Units: 3)
Prerequisite: Classified graduate standing in Chemistry or consent of instructor.

FT NMR concepts and operating techniques; 1D and 2D experiments; relaxation and dynamics. Spectral interpretation. Classwork, 2 units; laboratory, 1 unit.

CHEM 821 Mass Spectrometry - Principles and Practice (Units: 3)
Prerequisite: Classified graduate standing in Chemistry or consent of instructor.

Fundamental principles and modern practice of mass spectrometry, instrumentation (mass analyzers, ionization modes, sample introduction systems) and applications (qualitative and quantitative analysis, environmental and biomedical applications). (Plus-minus letter grade only)

CHEM 832 Organic Synthesis (Units: 3)
Prerequisite: Classified graduate standing in Chemistry or consent of instructor.

Problems relating to current organic synthetic methods. Synthesis and reactions of the major classes of mono- and polyfunctional compounds.

CHEM 834 Organic Spectroscopic Methods (Units: 3)
Prerequisites: Classified graduate standing in Chemistry; CHEM 301 or CHEM 353; or consent of instructor.

Relations between molecular structure and spectroscopic behavior. Mass spectrometry, infrared, electronic and magnetic resonance spectroscopy.

CHEM 841 Enzymology (Units: 3)
Prerequisites: Classified graduate standing in Chemistry; CHEM 341, CHEM 301 or CHEM 353; or consent of instructor.

The relationships between enzyme structure and catalytic activity, including enzyme kinetics and mechanisms.

CHEM 842 Bioorganic and Medicinal Chemistry (Units: 3)
Prerequisite: Classified graduate status in Chemistry or consent of instructor.

Molecular recognition, enzymatic reaction mechanisms, catalytic antibodies/polymers, enzymes in organic synthesis, pharmacodynamics, and drug action, drug design for pharmacokinetic problems.
CHEM 846 Biology and Chemistry of Signaling Pathways (Units: 3)
Prerequisite: Graduate standing or consent of the instructor.
An interdisciplinary presentation of the mechanisms by which extracellular stimuli trigger intracellular biochemical reactions that lead to alterations in cellular function. (Plus-minus letter grade)
(This course is offered as BIOL 732 and CHEM 846. Students may not repeat the course under an alternate prefix.)

CHEM 850 Valency and Spectroscopy (Units: 3)
Prerequisites: Graduate Chemistry students; passing score on the ACS diagnostic examination in quantum chemistry; or consent of the instructor.
Quantum mechanics of atomic and molecular structure using computers and group theory. Elementary microwave, infrared, optical, and magnetic resonance spectroscopy.

CHEM 851 Biochemical Spectroscopy (Units: 3)
Prerequisites: Graduate chemistry students; passing ACS diagnostic examination in quantum chemistry; a biochemistry course; or consent of the instructor.
Quantum chemistry elements. Principles, techniques, and biochemical applications of spectroscopy.

CHEM 852 Statistical Mechanics: Molecular Relaxation (Units: 3)
Prerequisites: CHEM 351 and CHEM 353 or equivalents.

CHEM 870 Computational Methods in Chemistry (Units: 3)
Prerequisites: Upper-division or graduate standing; one year of undergraduate physical chemistry.
Introduction to quantum chemical and classical mechanical methods for the computation of molecular structure, molecular spectroscopy, liquid state transport properties and molecular reactivity for small and large molecules, including solids and interactions at surfaces. Hands-on use of four software packages: Gaussian 09, AMBER molecular dynamics, LAMMPS dynamics for mesoscopic systems, and BEST for molecular hydrodynamics. (Plus-minus letter grade only)

CHEM 877 Introduction to Cellular Engineering (Units: 2)
Prerequisite: BIOL 230, MATH 226, and MATH 227; BIOL 240 recommended.
A quantitative approach to understanding, predicting, and engineering cellular behavior. Learn how to describe complex biological systems with protein, RNA, and DNA components using a mathematical framework. Consider the cell as a compartmentalized reactor with many simultaneously ongoing chemical processes and build models for natural and engineered biological systems. Design new biological circuits and predict their behavior. (Plus-minus letter grade only)
(This course is offered as BIOL 877 and CHEM 877. Students may not repeat the course under an alternate prefix.)

CHEM 879 Research Methods I (Units: 3)
Prerequisite: Graduate standing or consent of the instructor.
Development of background, specific research aims, methods, and outcomes. Includes literature review, writing assignments, and oral presentations. (Plus-minus letter grade, RP grading only)