BIO 462 IMMUNOLOGY
Reiness
Content: The cellular basis of the immune response, with emphasis on biochemical, molecular genetic, and cell biological approaches. Generation of antibody diversity. The functions of B lymphocytes, T lymphocytes, and antigen presenting cells. The structure and function of proteins encoded by the Major Histocompatibility Complex. Immunity to infection, autoimmunity, and cancer immunology. Lecture; reading and discussion of original scientific literature.
Prerequisite and/or restriction: Biology 151 and 311 or 361, or consent of instructor.
Taught: Alternate years, 4 semester credits.

BIO 490 SPECIAL TOPICS IN BIOLOGY
Staff
Content: Advanced study of current issues in biology, as determined by student and/or faculty interest. May extend existing areas of the curriculum or explore new subjects.
Prerequisite and/or restriction: Biology 141, 151, 200, or consent of instructor.
Taught: Alternate years (contingent on student interest and faculty availability), 4 semester credits.

BIO 495 BIOLOGY SENIOR THESIS
Staff
Content: Yearlong field or laboratory research project designed and executed by a student with guidance from two faculty mentors.
Prerequisite and/or restriction: Senior standing. GPA of 3.500 in major and overall. Approval of research proposal by department and two supervising faculty members.
Taught: Annually, 3 semester credits each semester.

BIO 499 INDEPENDENT STUDY
Staff
Content: Participation in a faculty-supervised research or individual study project at Lewis & Clark or another research institution. Requires approval of research proposal and a written report. Further information available on biology department website.
Prerequisite and/or restriction: Consent of instructor.
Taught: Each semester, 2-4 semester credits.

Chemistry

CHAIR: LOUIS Y. KUO
The Department of Chemistry curriculum serves four groups of students: chemistry and biochemistry/molecular biology majors; biology, engineering, and environmental studies majors; students planning to apply to professional schools in the health sciences; and nonscience majors satisfying their scientific and quantitative reasoning General Education requirement.

THE MAJOR PROGRAM
The Department of Chemistry provides a flexible, challenging curriculum to accommodate and encourage a diversified approach to the major. Following a core of required courses in general, organic, and physical chemistry, including laboratories, students select advanced courses from several electives.

In all chemistry courses, instructors encourage students to think for themselves and work independently. This is accomplished in some classes by having students work at the blackboard in small discussion groups to solve problems. In

other courses, students survey chemical literature to make class presentations or write papers to discuss the nature of the work under study.

All students are encouraged to participate in research with a faculty member at the first opportunity, which may be as early as the sophomore year. The department uses research not only to foster independence of thought but also as a means of teaching students to teach themselves. Although the emphasis is on educating students, projects explore current areas of research and are often supported by grants. Frequently, projects result in publications coauthored by students and faculty.

Since the department's curriculum is regularly reviewed and approved by the Committee on Professional Training of the American Chemical Society (ACS), a student may select the specific set of courses that leads to an ACS-certified degree. Students also have the option of meeting the major requirements with courses that more closely reflect their particular interests and more optimally prepare them for certain advanced fields of study. Students who expect to attend a professional school after graduation (medicine, dentistry, pharmacy, and so on) will find that the flexible chemistry major curriculum more than meets their needs. A chemistry major may also elect to complete a series of education and certification courses and teach chemistry at the high school level following graduation.

MAJOR REQUIREMENTS

A minimum of 42 semester credits in chemistry, plus courses in mathematics and physics, distributed as follows:

- General chemistry: 110 and 120.
- Organic chemistry: 210 and 220.
- Physical chemistry: 310 and 320.
- Advanced laboratory: 365 and 366.
- Seminar: 405.
- Advanced courses: 420 plus 4 semester credits of an upper-division elective selected from 300, 305, 330, 335, 355, 415, 421, 443, 453, 460, and 464.
- Mathematics 131 and 132.
- Physics 141 and 142, or Physics 151, 152, and 251.

For an American Chemical Society–certified major, in addition to the above requirements, the student must complete 330 or 335 and 355, and an additional four semester credits at the 300 or 400 level (greater than 310). Students may also be required to take 299, 480, 490, or 499 so they have a total of 500 laboratory contact hours. Mathematics 225, 233, and 235 are recommended, with preference given to Mathematics 225 and 235.

MINOR REQUIREMENTS

A minimum of 28 semester credits (six courses) taken for a grade, including the following:

- General chemistry: 110 and 120.
- Organic chemistry: 210 and 220.
- Eight semester credits of chemistry courses at the 300 or 400 level in at least two different subdisciplines. Students may use a maximum of 4 semester credits from the 310, 320 sequence and a maximum of 4 semester credits from the 330, 335 sequence to meet minor requirements.

SPECIAL PROGRAMS

The departments of chemistry and biology offer an interdisciplinary biochemistry/molecular biology major. See Biochemistry and Molecular Biology listing.

HONORS AND SENIOR RESEARCH

Students are especially encouraged to do senior-level thesis research. Students who have distinguished themselves academically through the junior year (GPA

of 3.500 or higher in chemistry and overall) are invited to participate in the honors program. Students who complete the program are, with faculty approval, awarded honors in chemistry on graduation. Students not qualifying for the honors program may elect to participate in the senior research program. In both programs, each student proposes a research project in consultation with a faculty member, presents the proposal to the department in a seminar, performs the laboratory work, prepares a written thesis, and defends the thesis orally before the department faculty.

Resources for Nonmajors

Perspectives in Environmental Chemistry (Chemistry 100), Perspectives in Nutrition (Chemistry 105), and The Origins of Life in the Universe (Chemistry 114) are specifically designed to help nonscience majors learn chemistry and relate it to the world around them.

Facilities

The Olin Center for Physics and Chemistry has more than 40,000 square feet of classroom, laboratory, and study space. Facilities and equipment used by the chemistry department include one lecture-demonstration theatre; a well-equipped biochemistry laboratory; modern scientific instrumentation (FT-NMR, FT-IR, GC-MS, HPLC, UV-VIS, AA, 12 molecular modeling workstations); a data analysis room; an organic chemistry instrumentation room; special laboratories for general chemistry, organic chemistry, and advanced analytical, physical, and inorganic chemistry; and student-faculty research laboratories.

Faculty and Staff

Barbara A. Balko, associate professor. Physical chemistry.
Anne K. Bentley, assistant professor. General, inorganic, and materials chemistry; nanotechnology.
Julio C. de Paula, professor. Physical chemistry, biophysical chemistry, nanotechnology.
James A. Duncan, professor. Physical organic chemistry.
Louis Y. Kuo, professor. Organometallic/bioorganic chemistry.
Janis E. Lochner, Dr. Robert B. Pamplin Jr. Professor of Science. Biochemistry.
Nikolaus M. Loening, associate professor. Physical chemistry, biophysical chemistry.

CHEM 100 Perspectives in Environmental Chemistry

Balko, Bentley, Staff
Content: General and organic chemistry concepts developed for a more thorough understanding of chemically related environmental issues such as meeting energy needs (including nuclear energy), atmospheric pollution (the greenhouse effect, stratospheric ozone depletion, photochemical smog, acid rain), toxicology, and plastics. Lecture, laboratory.
Prerequisite and/or restriction: Mathematics 055 or equivalent.
Taught: Annually, 4 semester credits.

CHEM 105 Perspectives in Nutrition

Lochner, Staff
Content: The fundamental basis of human nutritional needs and contemporary controversies in nutrition. Extracting energy from carbohydrates, fats, and proteins; essential amino acids and the cellular synthesis of proteins; water-soluble vitamins in major nutrient metabolism; biological function of fat-soluble vitamins; physiological roles of minerals. Readings on contemporary controversies in nutrition including the relationship between diet and disease. Lecture, laboratory.
Prerequisite and/or restriction: None.
Taught: Annually, 4 semester credits.

CHEM 110 General Chemistry I
Balko, Bentley, Loening, Staff
Content: Introduction to the general principles of chemistry required for students planning a professional career in chemistry, a related science, the health professions, or engineering. Stoichiometry, atomic structure, chemical bonding and geometry, thermochemistry, gases, types of chemical reactions, statistics. Weekly laboratory exercises emphasizing qualitative and quantitative techniques that complement the lecture material. Lecture, discussion, laboratory.
Prerequisite and/or restriction: Mathematics 055 or equivalent. Previous high school chemistry not required.
Taught: Annually, 5 semester credits.

CHEM 114 The Origins of Life in the Universe
Clifton, Loening, Safran, Tufte
Content: Processes of stellar evolution and planet formation that set the stage for life on Earth. Theories and evidence from diverse scientific disciplines on the origins of life and how physical and chemical aspects of the environment contributed to the emergence and transformations of life-forms. Scientific evaluation of the possibility of extraterrestrial life. Attention is devoted both to the processes and content of scientific discovery. Lecture, discussion, laboratory. Cross-listed with Biology 114, Geology 114, and Physics 114. Not applicable toward any major.
Prerequisite and/or restriction: Mathematics 055 or equivalent.
Taught: Alternate years, 4 semester credits.

CHEM 120 General Chemistry II
Balko, Bentley, Kuo, Loening, Staff
Content: Continuation of General Chemistry I. Chemical equilibrium, kinetics, thermodynamics, electrochemistry, descriptive inorganic chemistry, coordination chemistry, nuclear chemistry. Weekly laboratory exercises emphasizing quantitative techniques that complement the lecture material. Lecture, discussion, laboratory.
Prerequisite and/or restriction: Chemistry 110 or equivalent.
Taught: Annually (spring), 5 semester credits.

CHEM 210 Organic Chemistry I
Duncan, Kuo
Content: The basic principles of organic chemistry from a mechanistic perspective. Bonding (Lewis structures, atomic and molecular orbitals); stereochemistry (chiral compounds, enantiomers, diastereomers, conformers, optical activity, Fischer projections); nomenclature; chemistry of alkanes (free radical substitution, reaction-coordinate energy diagrams, asymmetric induction); chemistry of alkyl halides, alcohols, ethers (substitution and elimination reactions, carbocations, pKa, nucleophilicity, leaving groups, kinetics); infrared (IR) and nuclear magnetic resonance (NMR) spectroscopy; chemistry of alkenes (addition and elimination reactions, oxidation and reduction, hydroboration, inductive and resonance effects of substituents, regio- and stereoselectivity); chemistry of alkynes (acidity, addition reactions); introduction to organometallic compounds. Lecture, discussion, laboratory.
Prerequisite and/or restriction: Chemistry 120.
Taught: Annually, 5 semester credits.

CHEM 220 Organic Chemistry II
Duncan, Kuo
Content: Chemistry of aldehydes and ketones (reactions at and adjacent to the carbonyl group, enolization, conjugate addition, oxidation, reduction). Lecture, conference, laboratory. Synthesis; chemistry of carboxylic acids and derivatives (pKa of acids, nucleophilic substitution of derivatives, acyl chlorides, esters, amides, anhydrides, nitriles). Carbohydrates (stereochemistry, aldoketoses, aldopentoses, aldohexoses, ketosugars, derivatives, furanose and pyranose forms, reducing and nonreducing sugars, disaccharides and polysaccharides); fats and oils; aromatic hydrocarbons (benzene, resonance and molecular orbital approaches, electrophilic and nucleophilic aromatic substitution); aromatic nitrogen and oxygen chemistry (diazotization, synthesis); chemistry of amines, amino acids, peptides, proteins, DNA; other topics. Lecture, discussion, laboratory.
Prerequisite and/or restriction: Chemistry 210.
Taught: Annually, 5 semester credits.

CHEM 299 Independent Study
Staff
Content: Laboratory research or individual study topics arranged in consultation with a faculty supervisor.
Prerequisite and/or restriction: Consent of department chair and supervising faculty member.
Taught: Each semester, 1-4 semester credits.

CHEM 305 Aquatic Chemistry
Balko
Content: Principles of chemistry applied to processes governing the composition of natural waters. Focus on the solubility equilibria that control the concentration of inorganic compounds (e.g. carbonate and silicates), kinetics of mineral growth and dissolution, the role of acid-base reactions and redox equilibria.
Prerequisite and/or restriction: Chemistry 210 and 220 (may be taken concurrently), or consent of instructor.
Taught: Alternate years, 2 semester credits.

CHEM 310 Physical Chemistry: Thermodynamics and Kinetics
Balko, Loening
Content: Fundamental concepts of classical physical chemistry. Thermodynamics—first, second, and third laws; phase equilibria; chemical equilibria; kinetics—theory and practice; reaction rates.
Prerequisite and/or restriction: Chemistry 120. Physics 142 or 152. Mathematics 132.
Taught: Annually, 4 semester credits.

CHEM 320 Physical Chemistry: Statistical Mechanics and Quantum Chemistry
Balko, Loening
Content: Statistical mechanics; quantum mechanics; quantum theory; molecular orbital theory; atomic and molecular spectroscopy; magnetic resonance spectroscopy; molecular modeling.
Prerequisite and/or restriction: Chemistry 120. Physics 142 or 152. Mathematics 132.
Taught: Annually, 4 semester credits.

CHEM 330 Structural Biochemistry
Lochner, Staff
Content: The structure-function relationship of biological molecules. Principles governing protein folding and methods used to assess protein structure; case studies illustrating how protein structure dictates function; DNA structure and the chemistry of protein-DNA interactions; membrane biochemistry and the dynamics of membrane organization; role of the membrane in facilitating transport, intracellular communication, and mediating the transmission of nerve signals.
Prerequisite and/or restriction: Chemistry 220.
Taught: Annually, 4 semester credits.

CHEM 335 Metabolic Biochemistry
Lochner, Staff
Content: Systematic assessment of how the cell derives metabolic energy and uses the energy to drive biosynthetic reactions. Principles of thermodynamics as applied to biological transformations of energy; allosterism and enzyme reaction mechanism; metabolic regulation in guiding the flow of cellular metabolites; defects in metabolic pathways; the biochemical basis of disease.
Prerequisite and/or restriction: Chemistry 220.
Taught: Annually, 4 semester credits.

CHEM 336 Biochemistry Laboratory
Lochner, Staff
Content: Contemporary biochemical techniques introduced in a project-based format. Protein purification using both recombinant DNA techniques and classical tools such as affinity chromatography; functional characterization of the purified protein. Cellular metabolic responses and transmembrane signaling reactions studied using HPLC, radioisotope studies, enzyme analyses.
Prerequisite and/or restriction: Chemistry 330 or 335 (may be taken concurrently).
Taught: Annually, 2 semester credits.

CHEM 355 Experimental Methods in the Physical Sciences
Loening, Tufte, Staff
Content: Experimental methods and instrumentation in the physical sciences. Design experiments, construct instrumentation, make measurements, and analyze and interpret data in order to reach meaningful conclusions. Discussion and use of modern experimental techniques, including analog and digital electronics, many types of sensors, computerized data acquisition, spectroscopy (atomic, fluorescence, and infrared), mass spectrometry, and chromatography. Final student-designed project provides opportunities for interdisciplinary investigations. This course is taught in conjunction with Physics 201. Credit may not be earned for both Chemistry 355 and Physics 201.
Prerequisite and/or restriction: Chemistry 120 and Physics 141 or 151, or consent of instructor.
Corequisites: Chemistry 220 and Physics 142 or 152, or consent of instructor.
Taught: Annually, 4 semester credits.

CHEM 365 Physical Chemistry Laboratory
Balko, Loening
Content: Laboratory course to demonstrate the principles of physical chemistry and to develop research aptitude in chemistry. Investigation of thermochemistry, phase equilibria, kinetics, spectroscopy, and solid-state studies using techniques such as calorimetry, UV-visible, IR, NMR, Mass spectroscopies, and diffraction. Attendance at departmental seminars required. Lecture, laboratory, oral presentations.

Prerequisite and/or restriction: Chemistry 310 or 320 (may be taken concurrently).
Taught: Annually, 2 semester credits.

CHEM 366 Inorganic Chemistry Laboratory
Bentley, Kuo
Content: Introduction to classical and modern techniques for synthesizing inorganic compounds of representative and transition metal elements and the extensive use of IR, NMR, Mass, and UV-visible spectroscopies and other physical measurements to characterize products. Syntheses and characterization of inorganic and organic materials/polymers are included. Attendance at departmental seminars required. Lecture, laboratory, oral presentations.
Prerequisite and/or restriction: Chemistry 220.
Taught: Annually, 3 semester credits.

CHEM 405 Chemistry Seminar
Staff
Content: Preparation and delivery of a seminar with accompanying abstract and bibliography. The seminar focus is either on a relevant topic in the chemical literature or, for students pursuing senior and honors research, on the thesis proposal.
Prerequisite and/or restriction: Senior standing.
Taught: Each semester, 1 semester credit.

CHEM 415 Nanochemistry
Bentley
Content: Chemical preparation and characterization of materials featuring at least one physical dimension constrained to 100 nm or less. Emphasis on applications chosen from energy, medicine, catalysis, and information storage. Emerging public understanding of nanotechnology and research into environmental health and safety impacts.
Prerequisite and/or restriction: Chemistry 210 and 220 (220 may be taken concurrently).
Taught: Alternate years, 2 semester credits.

CHEM 420 Advanced Inorganic Chemistry
Bentley
Content: Modern concepts of inorganic and transition metal chemistry with emphasis on bonding, structure, thermodynamics, kinetics and mechanisms, periodic and family relationships. Atomic structure, theories of bonding, symmetry, molecular shapes (point groups), crystal geometries, acid-base theories, survey of familiar elements, boron hydrides, solid-state materials, nomenclature, crystal field theory, molecular orbital theory, isomerism, geometries, magnetic and optical phenomena, spectra, synthetic methods, organometallic compounds, cage structures, clusters, lanthanides, actinides.
Prerequisite and/or restriction: Chemistry 320 or consent of instructor.
Taught: Annually, 4 semester credits.

CHEM 421 Neurochemistry
Lochner
Content: Neurochemistry of synaptic transmission and an introduction to chemical approaches used to unravel the mechanistic basis of neuronal communication. Neurotransmitters, neuromodulatory proteins, and the mechanistic workings of ion channels and neuroreceptors. Neuronal processing of sensory information and intracellular signal transduction pathways. Neurochemical mechanisms that underlie memory, learning, and behavior. Behavioral sequellae that result from neurochemical abnormalities.
Prerequisite and/or restriction: Chemistry 220. Biology 200 recommended.
Taught: Alternate years, 2 semester credits.

CHEM 443 Medicinal Organic Chemistry
Kuo
Content: Bioorganic chemistry for selected medicinal compounds. Biophysical and chemical concepts of drug-receptor interactions and drug action. Biochemical basis for drug action elucidated in the context of fundamental organic mechanisms.
Prerequisite and/or restriction: Chemistry 220.
Taught: Annually, 2 semester credits.

CHEM 460 Topics in Modern Physical Organic Chemistry
Duncan
Content: Modern approach to the study of the interrelationships between structure and reactivity in organic molecules: Advanced stereochemistry; energy surfaces and kinetics; advanced electronic structure theory, including computational methods; thermal pericyclic reactions. Subject to interests of students and instructor, substitute physical organic topics might include, among others: Photochemistry, linear free-energy relationships, catalysis, electronic organic materials, molecular recognition, supramolecular chemistry.
Prerequisite and/or restriction: Chemistry 220
Corequisite: Chemistry 320 or consent of instructor.
Taught: Alternate years, 2 semester credits.

CHEM 464 Biomolecular NMR Spectroscopy
Loening
Content: Advanced topics in nuclear magnetic resonance spectroscopy, with an emphasis on structural biology applications. Fundamental NMR theory, multidimensional methods, heteronuclear experiments, correlation spectroscopy, the nuclear Overhauser effect, chemical exchange, protein structure determination, protein dynamics.
Prerequisite and/or restriction: Chemistry 220. Chemistry 320 and/or 330 are recommended.
Taught: Alternate years, 2 semester credits.

CHEM 480 Senior Research
Staff
Content: Experimental and/or theoretical research on an advanced topic of current significance in chemistry. Students present their thesis proposals in an early fall seminar and detail results of their investigations in a thesis in the spring.
Prerequisite and/or restriction: Senior standing. Consent of instructor.
Taught: Annually, 4 semester credits each semester of the senior year.

CHEM 490 Chemistry Honors Research
Staff
Content: Experimental and/or theoretical research on an advanced topic of current significance in chemistry. Students present their thesis proposals in an early fall seminar and detail results of their investigations in theses in the spring.

Prerequisite and/or restriction: By invitation only.
Taught: Annually, 4 semester credits each semester of the senior year.

CHEM 499 INDEPENDENT RESEARCH
Staff
Content: Participation in a faculty-supervised research project. Details, including academic credit, determined by the student in consultation with faculty supervisor.
Prerequisite and/or restriction: Junior standing. Research experience. Consent of department chair and supervising faculty member.
Taught: Each semester, 1-4 semester credits.

Classical Studies

DIRECTOR: ROBERT A. KUGLER
Classical studies is an interdisciplinary field focused on the study of ancient Greece and Rome, as well as the influences on them from the neighboring cultures of Egypt and the Near East. Echoes of Greece and Rome saturate our culture, from the shapes of our traditional buildings to the political institutions we embrace, from the mythological stories that reappear in our literature and art to the intellectual disciplines that form the liberal arts. The Classical Studies Program seeks to provide students the opportunity to gain intellectual grounding in a minor program that explores our debts to the ancient Greeks and Romans.

In addition to their historical significance, Greek and Roman works of art, literature, and philosophy have substantial continuing value, and the Classical Studies Program exposes students to many of the great works of these cultures. Serious engagement with these works can be forever enriching.

THE MINOR PROGRAM
The minor is inherently interdisciplinary. The courses required for the minor include two classical studies courses and an appropriate balance of disciplinary perspective within the minor and courses in a minimum of three of the traditional academic disciplines, including Greek or Latin language through 201. A student may choose specific courses of interest within Greco-Roman studies, but the minor grows from the foundation course and culminates in Classical Studies 450. For Latin and Greek course listings, see Foreign Languages listings elsewhere in this catalog.

MINOR REQUIREMENTS
A minimum of 28 semester credits are required, distributed as follows:
- Program core courses: 200 and 450.
- Language: Greek 101, 102, and 201, or Latin 101, 102, and 201.
- Eight semester credits from a minimum of two disciplines, selected from a list of approved electives that usually include the following (when available), as well as relevant history courses listed as 298 or 398:

Art
101 History of Western Art: Ancient to Medieval
English
279 Classical Backgrounds
Greek
101, 102 Classical Greek
201 Readings in Hellenistic and Classical Greek
Latin
101, 102 Beginning Latin
201 Intermediate Latin