CHEMISTRY
Sterling Chemistry Laboratory, 203.432.3913
http://chem.yale.edu
M.S., Ph.D.

Chair
Kurt Zilm (chemistry.chair@yale.edu)

Director of Graduate Studies
Jonathan Ellman (jonathan.ellman@yale.edu)


Associate Professors  Jason Crawford, Timothy Newhouse

Assistant Professors  Ziad Ganim, Stavroula Hatzios, Sarah Slavoff, Haijiang Wang

Lecturers  Paul Anastas, Christine DiMeglio, Narasimhan Ganapathi, Jonathan Parr

* A secondary appointment with primary affiliation in another department.

FIELDS OF STUDY
Fields include bio-inorganic chemistry, bio-organic chemistry, biophysical chemistry, chemical biology, chemical physics, inorganic chemistry, materials chemistry, organic chemistry, physical chemistry, physical-inorganic chemistry, physical-organic chemistry, synthetic-organic chemistry, and theoretical chemistry.

SPECIAL ADMISSIONS REQUIREMENTS
Applicants are expected to have completed or be completing a standard undergraduate chemistry major including a year of elementary organic chemistry with laboratory, and a year of elementary physical chemistry. Other majors are acceptable if the above requirements are met. The GRE General Test is required. The GRE Subject Test is strongly recommended though not required. Students whose native language is not English are required to take the Test of English as a Foreign Language (TOEFL).

SPECIAL REQUIREMENTS FOR THE PH.D. DEGREE
A foreign language is not required. Three term courses are required in each of the first two terms of residence. Courses are chosen according to the student's background and research area. To be admitted to candidacy a student must (1) receive at least two term grades of Honors, exclusive of those for research; (2) pass one oral examination (preparative chemistry students) or two oral examinations (physical chemistry students) by the end of the second year of study; and (3) submit a thesis prospectus no later than the end of the third year of study. Remaining degree requirements include completing a formal proposal (inorganic, organic, and chemical biology students), a written thesis describing the research, and an oral defense of the thesis. The ability to communicate scientific knowledge to others outside the specialized area is crucial to any career in chemistry. Therefore, all students are required to teach a minimum of two terms at a TF level 20. Students may be required by their advisers to teach in additional terms, but would not be required to teach more than five terms over their first five years. All students are required to take CHEM 590, Ethical Conduct and Scientific Research, in the fall term of their first year of study.

MASTER’S DEGREE
M.S. (en route to the Ph.D.) A student must pass at least five graduate-level term courses in the Chemistry department exclusive of seminars and research. In addition, an overall average (exclusive of seminars and research) of High Pass must be maintained in all courses. One full year of residence is required.

Program materials are available upon request to the Director of Graduate Studies, Department of Chemistry, Yale University, PO Box 208107, New Haven CT 06520-8107.

COURSES
CHEM 518a, Advanced Organic Chemistry  William Jorgensen
Concise overview of structure, properties, thermodynamics, kinetics, reactions, and intermolecular interactions for organic molecular systems.
Chemistry

CHEM 521a, Chemical Biology  Sarah Slavoff
A one-term introduction to the origins and emerging frontiers of chemical biology. Discussion of the key molecular building blocks of biological systems and the history of macromolecular research in chemistry.

CHEM 525b, Spectroscopic Methods of Structure Determination  Martin Saunders
The background and use of spectroscopic methods emphasizing NMR in organic chemistry. The course includes the use of programs for simulating spin-spin coupling and rapid rearrangement reactions in NMR. All methods commonly used by organic chemists for determining molecular structures of species in solution, in the gas phase, and in solids are included.

CHEM 526b, Computational Chemistry and Biochemistry  Sharon Hammes-Schiffer and William Jorgensen
An introduction to modern computational methods employed for the study of chemistry and biochemistry, including molecular mechanics, quantum mechanics, statistical mechanics, and molecular dynamics. Special emphasis on the hands-on use of computational packages for current applications ranging from organic reactions to protein-ligand binding and dynamics.

CHEM 527b, Fundamentals of Organic Reaction Mechanisms  Seth Herzon
Introduction to problem-solving techniques in organic chemistry and chemical biology, focusing on fundamental mechanistic paradigms for synthetic and biosynthetic transformations. Course meetings maximize interaction between students and faculty with the goal of providing students with a strong conceptual skill set in preparation for full-time research.

CHEM 529b, Special Topics in Chemical Biology  Sarah Slavoff
Current topics at the interface of chemistry, biology, and medicine with an emphasis on synthetic biology approaches.

CHEM 530a, Statistical Methods and Thermodynamics  Victor Batista
The fundamentals of statistical mechanics developed and used to elucidate gas phase and condensed phase behavior, as well as to establish a microscopic derivation of the postulates of thermodynamics. Topics include ensembles; Fermi, Bose, and Boltzmann statistics; density matrices; mean field theories; phase transitions; chemical reaction dynamics; time-correlation functions; Monte Carlo and molecular dynamics simulations.

CHEM 537a, Chemistry of Isotopes  Martin Saunders
Advanced applications of isotopes to chemical problems and the theory associated with them, including kinetic and equilibrium isotope effects, tracer applications, and dating.

CHEM 540a, Molecules and Radiation I  Kurt Zilm

CHEM 542b, Molecules and Radiation II  Mark Johnson
An extension of the material covered in CHEM 540 to atomic and molecular spectroscopy, including rotational, vibrational, and electronic spectroscopy, as well as an introduction to laser spectroscopy.

CHEM 549a, Materials Chemistry  Hailiang Wang
This course covers fundamental principles in materials chemistry including basic solid-state chemistry; structures, properties, and applications of metals, semiconductors, polymers, and nanomaterials; and material characterization techniques. Special topics at research frontiers of materials chemistry are also covered, including graphene and carbon nanotubes, nanomaterials for batteries, nanomaterials for catalysis, etc. This course aims to serve graduate and senior undergraduate students from various academic departments who are interested in advanced chemistry and nanoscience for materials research.

CHEM 550b, Theoretical and Inorganic Chemistry  Patrick Holland
Elementary group theory, molecular orbitals, states arising from molecular orbitals containing several electrons, ligand field theory, and electronic structure of metal complexes. Introduction to physical methods used in the determination of molecular structure and the bonding of polyatomic molecules.

CHEM 552a, Organometallic Chemistry  Robert Crabtree
A survey of the organometallic chemistry of the transition elements and of homogeneous catalysis.

CHEM 555b, Inorganic Mechanisms  James Mayer
An advanced course studying the mechanisms of important inorganic transformations. Topics such as proton-coupled electron transfer are covered.

CHEM 556b, Biochemical Rates and Mechanisms  J. Patrick Loria
An advanced treatment of enzymology. Topics include transition state theory and derivation of steady-state and pre-steady-state rate equations. The role of entropy and enthalpy in accelerating chemical reactions is considered, along with modern methods for the study of enzyme chemistry. These topics are supplemented with in-depth analysis of the primary literature.

CHEM 557a, Modern Coordination Chemistry  Nilay Hazari
The principles of modern inorganic chemistry. Main group and transition element chemistry: reactions, bonding, structure, and spectra.
CHEM 559a, Biophysics  J. Patrick Loria and Elsa Yan
A discussion of applications of quantitative biophysical methods to biomolecules. Emphasis is placed on interpreting experimental data obtained by various biophysical methods to gain structural and dynamic information to address biological questions at the molecular level. Topics include mainly spectroscopic methods, such as Raman, single-molecule, fluorescence, FTIR, chiroptical, and higher-order optical spectroscopies. Discussions focus on current and classic studies reported in the literature.

CHEM 560La, Advanced Instrumentation Laboratory I  Mark Johnson
A laboratory course introducing physical chemistry tools used in the experimental and theoretical investigation of large and small molecules. Modules include electronics, vacuum technology, optical spectroscopy and lasers, and computer programming.

CHEM 562La or b / PHYS 762a or b, Laboratory in Instrument Design and the Mechanical Arts  Kurt Zilm and David Johnson
Familiarization with modern machine shop practices and techniques. Use of basic metalworking machinery and instruction in techniques of precision measurement and properties of commonly used metals, alloys, and plastics.

CHEM 564La or b, Advanced Mechanical Instrumentation  Kurt Zilm and David Johnson
A course geared for both the arts and sciences that goes beyond the basic introductory shop courses, offering an in-depth foundation study utilizing hands-on instructional techniques that must be learned from experience. Prerequisite: CHEM 562L.

CHEM 565Lb, Introduction to Glass Blowing  Patrick Vaccaro and Daryl Smith
The course provides a basic introduction to the fabrication of scientific apparatus from glass. Topics covered include laboratory setup, the fundamental skills and techniques of glass blowing, the operation of glass fabricating equipment, and requisite safety procedures.

CHEM 570a, Quantum Chemistry  Sharon Hammes-Schiffer
The elements of quantum mechanics developed and illustrated with applications in chemistry and chemical physics.

CHEM 572b, Advanced Quantum Mechanics  Victor Batista
Topics in quantum mechanics that are essential for understanding modern chemistry, physics, and biophysics. Topics include the interaction of radiation with matter and the use of quantized radiation fields and may include time-dependent quantum theory, scattering, semiclassical methods, angular momentum, density matrices, and electronic structure methods.

CHEM 590a, Ethical Conduct and Scientific Research  Jonathan Parr
A survey of ethical questions relevant to the conduct of research in the sciences with particular emphasis on chemistry. A variety of issues, including plagiarism, the falsification of data, and financial malfeasance, are discussed, using as examples recent cases of misconduct by scientists. Enrollment is restricted to graduate students in chemistry. 0 Course cr

CHEM 600a or b, Research Seminar  Staff
Presentation of a student’s research results to the student’s adviser and fellow research group members. Extensive discussion and literature review are normally a part of the series.

CHEM 700a or b, Laboratory Rotation for First-Year Biophysical and Chemical Biology Graduate Students  Staff

CHEM 720a and CHEM 721b, Current Topics in Organic Chemistry  Seth Herzon
A seminar series based on invited speakers in the general area of organic chemistry.

CHEM 730a and CHEM 731b, Molecular Science Seminar  Mark Johnson
A seminar series based on invited speakers in the areas of physical, inorganic, and biological chemistry.

CHEM 740a and CHEM 741b, Seminar in Chemical Biology  Jonathan Ellman

CHEM 750a and CHEM 751b, Biophysical Chemistry Seminar  J. Patrick Loria

CHEM 760a and CHEM 761b, Seminar in Inorganic Chemistry  Nilay Hazari

CHEM 990a or b, Research  Staff
Individual research for Ph.D. degree candidates in the Department of Chemistry, under the direct supervision of one or more faculty members.