Chemistry and Biochemistry

Faculty and Fields of Interest

Bates, Alan H Professor of Chemistry and Biochemistry (1971), BS 1965 Allegheny College, AM 1966, PhD 1970 Harvard University. *Specializations:* Inorganic chemistry: organosilicon and organogerma-nium chemistry.

Boerth, Donald W Chancellor Professor of Chemistry and Bio-chemistry and Marine Science and Technology (1978), BS 1969 North Dakota State University, PhD 1974 University of Minnesota. *Specializations:* Organic chemistry: theoretical and physical organic chemistry, interactions of nucleic acids with mutagens, modeling in drug and agrochemical design, theoretical studies of acidity and isotope exchange in nucleic acid components, allylic nucleophilic displacements, halogen oxidation of oxopurines—kinetics and mechanism.

Dills, Jr., William L (Department Chairperson) Chancellor Professor of Chemistry and Biochemistry (1982), BS 1967 Juniata College, PhD 1973 University of Vermont. *Specializations:* Biochemistry: metabolism of xylitol, chemistry and biochemistry of carbohydrate analogs, biosynthesis of polysaccharides such as cellulose, chitin, and glycogen, hands-on science exercises for K-12 classrooms.

Golen, James A Professor of Chemistry and Biochemistry (1976), BS 1965 Southeastern Massachusetts University (UMass Dartmouth), PhD 1970 University of Massachusetts Amherst. *Specialization:* Physical inorganic chemistry: synthesis and molecular spectroscopy of inorganic compounds.

Goodson, David Z Assistant Professor of Chemistry (2002), BA 1980 Pomona College, PhD 1987 Harvard University. *Specializations:* Physical chemistry: theoretical and computational chemical physics, atomic and molecular physics, quantum chemistry methods development, chemical reaction rate theory, quantum molecular dynamics simulation of hydrogen in combustion chemistry and materials science.

Hammond, Gerald B Professor of Chemistry and Biochemistry (1990), BS 1975 Universidad Catolica del Peru, MS 1979 University of British Columbia, PhD 1984 University of Birmingham, England. *Specializations:* Organic chemistry: design and synthesis of fluorinated building blocks; selective incorporation of fluorine in organic molecules; fluorinated allenes and fluoro-phosphonates capable of mimicking biologically active centers, "green fluorination"—the synthesis of fluorinated compounds in predominantly aqueous media; ethnomedicinal chemistry of Peruvian rain forest plants, isolation and structure elucidation of bioactive compounds with wound healing, antineoplasic and antioxidant activities.

Mandrioli, Michele I Professor of Chemistry and Biochemistry (1978), AB 1971, MA 1974, PhD 1977 Clark University. *Specializations:* Inorganic chemistry: transition metal chemistry, magnetic resonance, software development for chemistry education, computer science education in chemistry.

Neto, Catherine C Assistant Professor of Chemistry and Biochemistry (1995), BS 1983 Southeastern Massachusetts University (UMass Dartmouth), PhD 1987 Brown University. *Specializations:* Antioxidants, anticancer, and antimicrobial agents in cranberries and other plant sources, bioactivity, purification and structure elucidation of natural products, food science, chemical education in the organic laboratory, K-12 science outreach.

Nevalainen, Vesa Assistant Professor of Chemistry (2002) BSc 1982, MSc 1983, PhLic 1985, PhD 1988 University of Joensuu. *Specializations:* Catalytic reactions and enantioselective organic synthesis, reaction mechanisms, synthesis of new chiral diols and amino alcohols, new reactions for organic synthesis, tandem reactions; terpene-based chiral ligands, boron, aluminum and zinc in organic synthetic chemistry, Lewis acids and bases in synthetic chemistry, molecular interactions, computational and computer-assisted organic chemistry.

Ojadi, Emmanuel C A Associate Professor of Chemistry and Biochemistry (1988), BSc 1979 University of Ife, MA 1982, PhD 1986 Brandeis University. *Specializations:* Physical chemistry: chemical physics, synthesis, photophysics, and photochemistry of porphyrins and other biologically important molecules and their analogs, electron and energy transfer processes in the excited states; porphyrimers and laser spectroscopy.

Singh, Bal-Ram Professor of Chemistry and Biochemistry and Marine Science and Technology (1990), BSc 1977 Kamla Nehru Institute of Science and Technology, MSc 1979, MPhil 1982 Jawaharlal Nehru University, PhD 1987 Texas Tech University. *Specializations:* Physical biochemistry: structure-function relationship of biological macromolecules, spectroscopy of proteins and membranes, protein-membrane interactions, mode of action of botulinum and tetanus neurotoxins, enzymatic activity in non-aqueous solvents, light signal reception and signal transduction by a biosensor, phytochrome for anthocyanin biosynthesis, molecular mechanism of phytophthora root rot in cranberry plants, guatathione-s-tranferases of quahog xenobiotic metabolism.

Su, Timothy C K (Graduate Program Director) Chancellor Professor of Chemistry and Biochemistry (1975), BA 1967 Hope College, PhD 1971 Wayne State University. *Specializations:* Physical chemistry, trajectory calculations of ion-molecule interactions, fuel chemistry, mass spectrometry, chemistry of the atmosphere, computational chemistry.

Vukomanovic, Dragic Assistant Professor of Chemistry (2000), BSc 1981 Nish University, Yugoslavia, MSc 1990, PhD 1995 Queen's University. *Specializations:* Analytical chemistry, electroanalytical chemistry (voltammetry), mass spectrometry (electrospray ionization) study of bioactive molecules and their metal and/or cyclodextrin complexes; redox biochemistry: drug design and phytochemistry of plants used in traditional medicine, bacterial pigments produced by Pseudomonas aeruginosa.

Zuo, Yuegang Assistant Professor of Chemistry and Marine Science and Technology (1999), BS 1982 Wuhan University, China, MS 1984 Chinese Academy of Science, PhD 1992 Swiss Federal Institute of Technology. *Specializations:* Analytical chemistry: separation, identification, and utilization of naturally occuring antioxidants and biopolymers; environmental chemistry, marine chemistry, and photochemistry.

Graduate Chemistry at UMass Dartmouth

Department of Chemistry and Biochemistry
College of Arts and Sciences

The Department of Chemistry and Biochemistry at the University of Massachusetts Dartmouth offers a graduate program leading to the degree of Master of Science with specialization in analytical chemistry, biochemistry, inorganic chemistry, organic chemistry, polymer chemistry, physical chemistry or computational chemistry. Several options leading to the degree in chemistry are available which are tailored to the needs of individual students.

The Research Thesis option (Plan A) is designed for full-time students who wish to continue their graduate education at a PhD granting institution or who want to pursue a career in teaching, research or industry with the Master of Science degree. The Research Project (Plan B) and the Library Research Project (Plan C) are non-thesis options which are intended primarily for working students who wish to earn the Master of Science degree on a part-time basis.

A Doctor of Philosophy degree in chemistry may be obtained through our new joint PhD program with the Department of Chemistry at the University of Massachusetts Lowell. Through this program students enroll in courses and conduct their research on either the Dartmouth or Lowell campus. We also offer a cooperative PhD program with the Department of Chemistry and Biochemistry at the University of Massachusetts Amherst. Through this program, qualified students who complete the UMass Dartmouth MS degree in chemistry and who enroll as degree-seeking students at UMass Amherst may continue their research at UMass Dartmouth and may apply to receive UMass Dartmouth research assistantship support. Details are given below.

Research Facilities

Research is conducted in fifteen research laboratories and six instrument rooms. These facilities are housed in the Group II and Violette Research Buildings.

Modernization of instrumentation is a high priority in the Department of Chemistry and Biochemistry. The departmental instrumentation includes NMR spectrometers, gas chromatograph, mass spectrometers, infrared, UV-visible, fluorescence, atomic absorption spectrometers, preparative and analytical gas and liquid chromatographs, a capillary gas chromatograph, scintillation counter, isothermal titration Calorimeter, ultracentrifuge, electrophosesis systems, spectropolarimeter, optical fiber-based biosensor, microtiter plate reader and washer, dialyzer/protein concentrator, DNA sequencer, Parr hydrogenation apparatus, electroanalytical instrumentation, and related apparatus for chemical and biochemical research. An electronics shop and electron microscope facilities are shared with other science departments.

The department, like the university, has a heavy computer emphasis. The department maintains a variety of computers and accessories, including several IBM and Macintosh microcomputers, a multicolor digital plotter, terminals, laser writers, and printers. The university maintains ALPHA mainframes for research and instructional use. In addition, Computer Clusters with terminals, IBM, PC, Macintosh microcomputers, and a Silicon Graphics workstation are available for use by graduate students and faculty. The Clusters are also equipped with laser printers and scanners.

Admissions Requirements

Undergraduate training in chemistry or biochemistry is the usual background of graduate students in the Department of Chemistry and Biochemistry. However, students from other disciplines (physics, biology, etc.) with a strong emphasis in chemistry are encouraged to apply.

Applicants must submit the required application materials to the Graduate Office, with the following additional considerations:

- The Graduate Record Examination (GRE) scores are not required for admission. However, an applicant may strengthen the application by submitting scores for Verbal, Quantitative, Analytical and Advanced (Chemistry) parts of the GRE.
- Two confidential letters of recommendation are required, from chemistry professors (a third letter is recommended).
- For those submitting TOEFL scores, a minimum score of 550 is required for admission and a teaching assistantship.
- Please submit a separate list of all chemistry courses taken at the college or university level.

While there is no formal application deadline, applicants are encouraged to submit and complete their applications early to place themselves in the best position for consideration for assistantships. Applications from international students for the fall semester will only be considered if they have been completed by May 1 (November 1 for spring semester). International applications completed after those dates will be considered for the following semester.

Financial Assistance

For qualified students, the Department of Chemistry and Biochemistry provides competitive teaching and research assistantships for the academic year (includes waiver of tuition). The number of teaching assistantships, however, are limited. Therefore, persons interested in such support are encouraged to apply early.

A student holding an assistantship must be registered for at least 9 credits per semester. An additional summer research or teaching assistantship has usually been awarded to students in good standing working on thesis research. Students may be supported by research assistantships by faculty members holding research grants from various external agencies.

Other assistance, such as loans or work study, may be available to you. Please consult the chapter on "Expenses and Financial Assistance."

Contacts

Dr. Timothy C. K. Su
Graduate Program Director
Chemistry
508 999-8238
tsu@umassd.edu

Dr. Bal Ram Singh
UMass Dartmouth/Lowell Joint
Doctoral Program, Chemistry
508 999-8588
bsingh@umassd.edu

University of Massachusetts Dartmouth
285 Old Westport Road
North Dartmouth, MA 02747-2300

Degree Requirements (MS degree)

The student must decide on a particular plan before acquiring 12 credits. The time limitation on credit for courses, established by the Graduate School, will apply to all Plans.

Plan A. **Master of Science with Thesis Research** (mandatory for students holding research assistantships):

A total of 30 credits (18 credits course work and 12 credits thesis research). A minimum of 18 credits in formal courses are required, of which at least 12 credits must be in graduate courses numbered 500 and above. The remaining 6 credits may be in advanced undergraduate courses. Courses at the 400 level in chemistry and in related disciplines (biology, mathematics, physics, computer science) qualify as advanced undergraduate courses. A maximum of 6 credits may be taken in courses other than chemistry. In addition, the student is required to register for the graduate seminar course for each semester in residence.

A student's particular program of study must be approved by the Thesis Committee by the end of the first semester in residence. A thesis is required for the Master of Science degree in Chemistry (Plan A). The subject and scope of the thesis will be outlined by the student in consultation with his or her research director. As soon as practicable, a formal outline of the research project will be submitted to the student's Thesis Committee which is composed of the research director and three additional members of the Chemistry Department Research Faculty. The thesis must reveal independent investigation and a knowledge of the methods of original research. Draft copies of the completed thesis will be submitted to the Thesis Committee, whose members are responsible for reading and approving the thesis. The student's Thesis Committee shall constitute the oral examination board.

Plan B. **Master of Science with Laboratory Research Project**

A total of 35 credits (30 credits course work and 5 credits directed research) is required. A written progress report on the research project is required. Laboratory research may be performed days, evenings, weekends, or summers by arrangement with the individual research director. The course work (30 credits) must involve at least 21 credits in chemistry. Up to 9 credits may be taken in a related discipline. At least 24 credits of the course work must be at the 500 level or above. The remaining 6 credits may be in advanced undergraduate courses. Courses at the 400 level in chemistry and in related disciplines (biology, mathematics, physics, computer science) qualify as advanced undergraduate courses. In addition, the student is required to register for the graduate seminar course for each semester in residence. The student is also required to present two seminars.

Plan C. **Master of Science with Library Research Project**

Total of 35 credits (30 credits course work and 5 credits Library Research). A written report on the Library Research Project is required. Course requirements are the same as for Plan B above.

Comprehensive Examination Option
Students in plans B and C may elect to substitute a comprehensive examination for project work. Successful passage of this examination will satisfy the 5-credit requirement.

Seminar Requirement
Each graduate student is required to attend departmental seminars and register for the graduate seminar course for each semester in residence. The student must present two formal seminars. The first seminar is presented before the end of the third semester in residence. The second seminar is presented as part of the oral thesis defense process.

PhD Opportunities through Joint and Cooperative Programs

Joint UMass Dartmouth/ UMass Lowell PhD Program

Two campuses of the University of Massachusetts, UMass Dartmouth and UMass Lowell, offer together a joint doctoral program in Chemistry. This program combines the outstanding resources of the graduate chemistry programs at Lowell and Dartmouth in a new partnership in excellence. The combined areas of research and professional interest on the two campuses offer a rich range of opportunities to their advanced students.

The advanced chemistry program at UMass Lowell offers particular strengths in the following fields:

- Polymer Science
- Polymer Science/Plastics Engineering
- Biochemistry — Biochemistry/Biomaterials; Biotechnology/Bioprocessing; Cellular Biology/Molecular Biology; Clinical Chemistry/Medicinal Chemistry.

The Dartmouth graduate program brings special strengths in:

- Marine Chemistry
- Inorganic Chemistry
- Organic Chemistry
- Physical Chemistry

Both programs have strength in the fields of:

- Analytical/Environmental Chemistry.
- Biochemistry

The joint program features active research collaborations and shared resources from the two campuses. Doctoral students in the Joint Dartmouth/Lowell Chemistry PhD program may conduct their research on either or both campuses. They complete a program of studies totaling 45 credits capped off by a doctoral dissertation.

Current UMass Dartmouth master's students may be considered for the program upon the recommendation of the Chemistry Graduate Programs Committee. New applicants may also be considered directly for admission to this program.

After completing studies at Dartmouth equivalent to a MS degree, Dartmouth Joint Chemistry PhD students will apply for official admission to the PhD program at UMass Lowell, and thenceforward will maintain concurrent enrollment status at both institutions (paying tuition and fees at only one). Their progress toward the degree is monitored

officially at the Lowell campus. Currently, the degree is issued by UMass Lowell, identified as granted for completion of this special joint program.

Dartmouth Joint Chemistry PhD students are supported by a research assistantship from UMass Dartmouth, pursue their principal research with UMass Dartmouth faculty, and take the preponderance of their courses at UMass Dartmouth.

Cooperative PhD Program with UMass Amherst

The Department participates cooperatively in a doctoral program with the University of Massachusetts Amherst. The Chemistry Graduate Programs Committee recommends one or two outstanding students who are completing the master's degree for this program. These students then apply for admission to the UMass Amherst PhD program in Chemistry. Before beginning the application process, the student must have successfully passed all four proficiency examinations. This requirement satisfies a similar requirement at UMass Amherst and allows the student to enter at a level above that of the general new graduate student in chemistry at Amherst. Cooperative Dartmouth/Amherst Chemistry PhD students are supported by a research assistantship from UMass Dartmouth and pursue their principal research with UMass Dartmouth faculty while they are matriculated degree students of UMass Amherst.

Once admitted to the program, the student must follow the regulations for degree completion established at Amherst. There is a one year residency (two semester) requirement at Amherst. Students will, therefore, be expected to spend considerable time in Amherst for this period, during which the student will take courses and pass the required doctoral examinations. Normally a student fulfills this requirement by spending the first semester at Amherst and the second semester largely at Dartmouth with registration at Amherst. Research will continue as feasible at the Dartmouth campus. The student's graduate committee will consist of two faculty members from UMass Dartmouth and two from UMass Amherst.

CHM 431 three credits
Principles of Inorganic Chemistry
Prerequisite: One year of physical chemistry
The application of physico-chemical principles to inorganic systems. Discussion of chemistry of the representative elements utilizing thermodynamic principles and the modern theories of bonding and structure. Introduction to coordination chemistry.

CHM 432 four credits
Organic Analysis
Prerequisites: Organic and analytical chemistry
Quantitative elemental and group determination on a microscale followed by a study of the systematic identification of organic compounds. Extensive laboratory work on unknowns is required.

CHM 433 one credit
Inorganic Chemistry Laboratory
Prerequisite: CHM 316; corequisite: CHM 431
Synthetic and instrumental techniques currently used by inorganic chemists, including electrolytic, inert atmosphere, tube furnace and organometallic syntheses; ultraviolet-visible, nuclear magnetic resonance, infrared and mass spectrometry, magnetic susceptibility determination, as applied to a range of inorganic materials.

CHM 510 three credits
Advanced Organic Chemistry
Prerequisites: One year of physical chemistry and CHM 521
A study of mechanisms and stereo-chemical aspects of chemical reactions including considerations of chemical kinetics and reactivity in terms of modern bonding theory and structural concepts.

CHM 511 three credits
Biochemistry I
Prerequisite: One year of organic chemistry; recommended, cell biology or equivalent
A comprehensive study of biochemistry including amino acid and protein chemistry, enzymology, enzyme kinetics, bioenergetics, metabolism of carbohydrates, lipids, amino acids, nucleotides; biosynthesis of nucleic acids and proteins.

CHM 512 three credits
Biochemistry II
Prerequisite: CHM 511
A continuation of CHM 511.

CHM 514 three credits
Biochemistry Laboratory
1 hour lecture, 6 hours laboratory
Basic biochemical techniques and methods including spectrophotometry, electrophoresis, chromatography, ultracentrifugation and radioisotopic techniques and their application to amino acids and proteins, lipids and membranes, enzymes and nucleic acids.

CHM 520 three credits
Advanced Inorganic Chemistry
Prerequisites: CHM 316 and CHM 431
Selected topics in modern inorganic chemistry.

CHM 521 three credits
Organic Mechanisms
Prerequisite: CHM 252. Prerequisite or Corequisite: One semester of physical chemistry
The first part of the course provides a background in the various areas of physical organic chemistry such as thermodynamics, kinetics, acid-base theory, structure-reactivity relationships and dipole moments. This is followed by a systematic study of reaction mechanisms.

CHM 522 three credits
Computer and Mathematical Methods in Physical Science
Prerequisites: One semester physical chemistry; two semesters college physics; three semesters calculus; or permission of instructor. Recommended Pre or Corequisite: CHM 316
Selected topics in applied mathematics and computer science with applications to physical chemistry, organic chemistry, and bioinformatics. Includes introduction to differential equations, linear algebra, computer programing, curve and surface fitting, numerical integration, trajectory calculations, molecular modeling, quantum chemistry, computational molecular biology, and biological data analysis.

CHM 523 three credits
Chemistry of Mind
Prerequisite: CHM 315, or equivalent
Exploration of the states of matter as understood by mind, by considering reductionist and holistic approaches. Fundamental assumptions in developing scientific principles are examined with examples of kinetic theory of gases, ideal gas equation, and laws of thermodynamics. Application of thermodynamic laws to biological systems to model mind and brain activities. Structure, evolution, and functioning of the nervous system and neurological and metaphysical understanding of mind and consciousness are examined.

CHM 525 three credits
Theoretical Organic Chemistry
Prerequisites or Corequisites: One year each of organic and physical chemistry
Molecular orbital theory of organic molecules; applications of molecular orbital theory;

reactivity, ESR, Carbon-13 NMR, photoelectron spectroscopy, etc.; orbital symmetry in electrocyclic reactions, cycloadditions, and sigmatropic reactions.

CHM 526 four credits
Polymer Synthesis and Characterization
Prerequisites: CHM 252, CHM 315, TEC 410
Laboratory synthesis of polymers and copolymers by different methods with an emphasis on the practical aspects of polymer synthesis. A discussion of various techniques of polymer characterization in terms of basic principles, experimental procedure, and interpretation of results. A selected number of experiments will be conducted on a class-project basis.

CHM 527 three credits
Electronic Structure of Atoms and Molecules
Prerequisite: One year of physical chemistry
Fundamental quantum mechanical principles of electronic structure. Angular momentum, the hydrogen atom problem, helium ground and excited states, electron spin and antisymmetrization, many electron atoms, bonding theory, valence bond and molecular orbital theory of diatomic and polyatomic molecules, applications of group theory to molecular orbital calculations, the self-consistent field method.

CHM 529 three credits
Physical Biochemistry
Prerequisite: One year each of physical chemistry and biochemistry
Physico-chemical principles governing structures of biological macromolecules. Topics include energetics and kinetics of biochemical processes, including binding, catalysis, diffusion/transport, and folding/unfolding; behavior of macromolecules in aqueous medium; and application of spectroscopic methods in biochemistry.

CHM 531 three credits
Chemical Kinetics
Prerequisite: One year of physical chemistry
Principles and selected topics, including analysis of reaction rates, kinetic and transition state theories, reactions in gas and liquid phases, unimolecular reactions, fast reactions, trajectory calculations, ion-molecule reactions, enzyme kinetics, and polymer kinetics.

CHM 533 three credits
Statistical Methods
Prerequisite: One year of physical chemistry
Introduction to the principles and methods of statistical mechanics. Classical and quantum partition functions applied to the calculation of thermodynamic properties.

CHM 542 three credits
Quantum Chemistry
Prerequisite: One year of physical chemistry
Fundamental concepts of quantum mechanics; wave properties, Schrodinger equation, and operators. Basic application to free particles, harmonic oscillator, hydrogen atom. Perturbation theory and variation method. Applications to many-electron systems and time-dependent problems.

CHM 544 three credits
Applied Spectroscopy
Prerequisites: One year each of organic and physical chemistry
A study of spectroscopic methods of determination of structure of organic compounds, especially infrared, ultraviolet, visible, nuclear magnetic resonance, and mass spectrometry, with extensive applications to individual cases.

CHM 549 three credits
Theory and Applications of One- and Two-Dimensional FT-NMR
Prerequisites: CHM 251/252 and 315, or equivalent
Fundamentals of Fourier Transform Nuclear Magnetic Resonance (FT-NMR) spectroscopy, including one- and two-dimensional techniques discussed from the perspective of structural determination. Generation of NMR signals and parameter optimization using a 300 MHz FT-NMR spectrometer will complement the analysis of NMR signals generated in situ.

CHM 550 three credits
Special Topics in Chemistry
Prerequisite: Permission of instructor
An advanced treatment of special topics in chemistry with an emphasis on recent developments. The subject matter varies from year to year.

CHM 551 four credits
Electroanalytical Chemistry
Prerequisite: One year of physical chemistry
The development of the fundamental mathematical relationships upon which electrochemical methods are based. The interpretation of the kinetics of electrode reactions and the transfer of material to and from electrodes under various conditions. The interpretation of data of direct analytical significance generated by the methods and techniques of modern electrochemistry.

CHM 552 three credits
Instrumental Methods of Analysis
Prerequisites: Quantitative analysis and one year of physical chemistry
The theory and practice of modern analysis utilizing optical and electrochemical instrumentation in the solution of chemical problems. Topics discussed include ultraviolet, visible, and infrared spectrophotometry, fluorimetry, flame emission and atomic absorption spectroscopy, plasma emission spectroscopy, potentiometry utilizing ion specific electrodes, radiochemistry, thermoanalytical methods, voltammetry including polarography, amperometry, and coulometry; liquid chromatography, electron spectroscopy, x-ray fluorescence analysis, and neutron activation analysis.

CHM 553 three credits
Nuclear and Radiochemistry
Prerequisite: One year of physical chemistry
Application of nuclear and radiochemical methods. Topics include fundamentals of radioactive decay, radiation safety, interaction of radiation with matter, instrument design and function, radiotracers, radioanalytical methods, and related non-destructive methods for quantative analysis.

CHM 554 three credits
Group Theory and Spectroscopy
Prerequisite: One year of physical chemistry with grades of C- or better, CHM 272, or equivalent
Introduction to theory and its applications in MO theory, spectroscopy, ligand field theory, and molecular structure.

CHM 555 three credits
Methods of Chemical Separation
Prerequisites: Analytical and physical chemistry
A survey and practice of modern separation methods. Topics include liquid, gas, thin layer and ion exchange chromatography; electrophoresis; sample preparation and extraction.

CHM 556 three credits
Theory of Magnetic Resonance Spectroscopy
Prerequisite: One year of physical chemistry; quantum mechanics
Introduction to the theory of electron paramagnetic resonance and nuclear magnetic resonance; applications in the study of molecular structure.

CHM 560 three credits
New Synthetic Methods
Prerequisite: One year of organic chemistry
Survey of preparative methods in organic chemistry and their application to the synthesis of complex molecules.

CHM 562 three credits
Natural Products
Prerequisite: One year of organic chemistry with grades of C- or better; some biochemistry recommended

Isolation, structure elucidation, total synthesis, biosynthetic pathways, metabolism, and physiological importance and pharmacological uses of natural products.

CHM 595 three credits
Graduate Independent Study
Prerequisites: Graduate standing; permission of instructor, graduate director, and college dean
Study under the supervision of a faculty member in an area not otherwise part of the discipline's course offerings. Terms and hours to be arranged.

CHM 596 three credits
Graduate Directed Study
Prerequisites: Graduate standing; permission of instructor, graduate director, and college dean
Study under the supervision of a faculty member in an area covered in a regular course not currently being offered. Terms and hours to be arranged. Terms and hours to be arranged.

CHM 600 three to nine credits per term
Thesis Research
Prerequisite: Departmental permission
Original chemical research and preparation of thesis. Required for Plan A master's degree. Graded P/F.

CHM 610 two to five credits per term
Project Research
Prerequisite: Departmental permission
Original chemical research, required for Plan B master's degree. Written project report required. Graded P/F.

CHM 620 two to five credits per term
Library Research
Prerequisite: Departmental permission
Survey of a particular topic in the chemical literature. Written final summary report required. Graded P/F.

CHM 650 one credit
Graduate Seminar
Lectures on current topics in chemistry from guest lecturers and students. The graduate student will present a total of two seminars, one of which will be the thesis seminar. Each graduate student is required to enroll in this course for each semester in residence. This course will not count toward the 30 credits of course work and research required for the degree.