Department of Chemistry

ARTHUR J. STIPANOVIC, Chair
118 Jahn Laboratory, 315-470-6855; FAX 315-470-6856
www.esf.edu/chemistry

The academic programs in chemistry emphasize fundamental chemical phenomena as well as links from chemistry to the biological and applied sciences. Programs include courses in traditional areas of chemistry, with advanced study in fields pertaining to environmental, life and materials sciences. Emphasis on the investigative function of chemical science is manifest in the wide array of ongoing research projects within the department. Chemistry classes and labs are held in Edwin C. Jahn Laboratory (1997), a modern facility well-equipped with instruments necessary for teaching and research.

Bachelor of Science in Chemistry

The Department of Chemistry offers three options leading to the bachelor of science degree: biochemistry and organic chemistry of natural products, environmental chemistry, and natural and synthetic polymer chemistry. Each option offers an advanced core of studies beyond the basic courses of the classical undergraduate chemistry curriculum. All options are excellent grounding for professional work at the B.S. level or for advanced graduate study. Recent graduates have careers as biochemists, chemical and marketing representatives, environmental chemists, pharmaceutical chemists, materials chemists, research chemists, toxicologists and quality control chemists. Other graduates have pursued careers in medicine and law.

Biochemistry and Organic Chemistry of Natural Products

Participating Faculty: BOYER (Plant and Algal Biochemistry), GINER (Organic and Natural Products Chemistry), NOMURA (Biochemistry and Biotechnology), WEBSTER (Organic Chemistry, Chemical Ecology), WINTER (Polymer Biochemistry)

Biochemistry and organic chemistry of natural products stresses a chemical approach to problems in the life and health sciences. After obtaining a strong foundation in analytical, physical and organic chemistry, these studies are supplemented by advanced courses in natural products chemistry, natural biopolymers, spectroscopy, and biochemistry. Professional electives in botany, chemical ecology, genetics and molecular biology provide the background for interactions in the life and health sciences. Research areas include the elucidation of chemical signals by which organisms communicate with each other, the role of trace metals in the growth of microorganisms, and the origin and function of biologically active natural compounds.

Environmental Chemistry

Participating Faculty: ABRAMS (Inorganic Chemistry, Chemistry Education Laboratory), BOYER (Environmental Biochemistry), DIBBLE (Environmental Chemistry), DONAGHY (Inorganic Chemistry), J.P.HASSETT (Environmental Chemistry), JOHNSON (Environmental Chemistry), KIEBER (Environmental Chemistry, Oceanography), TEECE (Environmental Chemistry, Biogeochemistry)

Environmental chemistry stresses applications of fundamental chemical principles to describe and predict behavior of chemicals in the environment. Courses in air and water chemistry are supplemented by advanced courses in analytical, physical, or organic chemistry. A wide variety of courses in biology, engineering, geology, and environmental policy are also available. Research areas include phase-partitioning of organic compounds in water, characterization of particles in air and water, atmospheric and smog chemistry, aqueous photo-chemistry, sampling methods for trace contaminants in air and water, biological alkylation of metals, analysis of organic particles in water, characterization of natural organic matter in soil and water, behavior of major ions and nutrients in water, and global change.

Natural and Synthetic Polymer Chemistry

Participating Faculty: CABASSO (Polymer Chemistry and Membrane Science, Applied Electrochemistry), CALUWE (Organic Chemistry, Synthetic Polymer Chemistry), A. CHATTERJEE (Polymer Physical Chemistry), DONAGHY (Inorganic Chemistry), GITSOV (Organic and Physical Polymer Chemistry), NOMURA (Biosynthesis and Biopolymer Chemistry), STIPANOVIC (Physical Chemistry of Biopolymers), WINTER (Physical and Biopolymer Chemistry)

Undergraduates in the natural and synthetic polymer option take advanced courses in mechanisms of polymerization and polymer synthesis, in the physical properties and characterization of polymers, and in the laboratory techniques of polymer synthesis and characterization. Special topics courses in contemporary polymer and material science are available as electives. In addition, courses in carbohydrate chemistry provide a solid background for chemists planning careers in paper, plastic, high-tech, energy, membranes, and related areas. Biochemistry is an appropriate elective for students interested in the growth of bio-technologies while environmental chemistry complements this program for students interested in working on problems of biodegradation. The program offers an excellent background both for direct entry into industrial chemistry and graduate study in areas such as chemistry, biotechnology or polymer science.

Students may enter the bachelor of science program as first-year students or as transfer students. Students who are preparing to transfer to ESF as juniors must have earned at least 60 credits of college coursework in courses comparable to the lower-division course requirements noted below.

Undergraduate Program Requirements

Lower Division Required Courses (47 credits):

Courses			Credits	
CLL	190	Writing and the Environment *Meets the requirements for general education skills and knowledge area. A complete listing of ESF or Syracuse University courses that meet the general education standards established by SUNY is listed on page 8.*	G	3
CLL	290	Writing, Humanities and the Environment	G	3
EFB	101/ 102	General Biology I and Laboratory		4
EFB	103/ 104	General Biology II and Laboratory		4
FCH	132	Orientation Seminar: Chemistry Required of all students regardless of entry level		1

FCH	150/ 151	General Chemistry I and Laboratory	G	4
FCH	152/ 153	General Chemistry II and Laboratory		4
FCH	221/ 222	Organic Chemistry I and Laboratory		4
FCH	223/ 224	Organic Chemistry II and Laboratory		4
MAT	295	Calculus I	G	4
MAT	296	Calculus II		4
PHY	211/ 221	General Physics I and Laboratory		4
PHY	212/ 222	General Physics II and Laboratory		4

Upper Division Electives (16 credits):

Math Elective		4
Computing Elective		3
General Education Course	G	3
General Education Course	G	3
General Education Course	G	3

Upper Division Required Courses (32 credits):

CLL	405	Writing for Science Professionals	3
ESF	200	Information Literacy	1
FCH	325	Organic Chemistry III	3
FCH	360	Physical Chemistry I	3
FCH	361	Physical Chemistry II	3
FCH	380	Analytical Chemistry I	4
FCH	381	Analytical Chemistry II	3
FCH	384	Spectrometric Identification of Organic Compounds	2
FCH	410	Inorganic Chemistry	3
FCH	495	Introduction to Professional Chemistry	1
FCH	497	Undergraduate Seminar	1
FCH	498	Introduction to Research *Students may replace this requirement to allow time for special interest, by petition to the department.*	5

Electives (minimum of 17 credits);

Elective		3
General Education Course	G	3
General Education Course	G	3
Professional Electives *Students should complete a two-semester set of professional electives chosen from a list of courses available in the Department of Chemistry office. The courses provide a wide range of study including biology, chemistry, ecology, forestry, environmental law, mathematics, geology, physics, biophysics, and various engineering disciplines. Students in the biochemistry and natural products chemistry option are advised to take FCH 524 Topics in Natural Products Chemistry.*		8-9

Option Courses (9 credits)

Biochemistry and Natural Products Option

FCH	530	Biochemistry I	3
FCH	531	Biochemistry Laboratory	3
FCH	532	Biochemistry II	3

Environmental Chemistry Option

FCH	510	Environmental Chemistry I	3
FCH	511	Environmental Chemistry II	3
FCH	515	Methods of Environmental Chemical Analysis	3

Natural and Synthetic Polymer Chemistry Option

FCH	550	Polymer Science: Synthesis and Mechanisms	3
FCH	551	Polymer Techniques	3
FCH	552	Polymer Science: Properties and Technology	3

Total minimum credits for the degree: 121 credits

Graduate Programs

Graduate degrees require an appropriate program of courses at ESF and at Syracuse University. Master of Science and doctoral students must complete a minimum of 18 credit hours and 30 credit hours of graduate level coursework, respectively. Please see Graduate Academic Policies for complete information on coursework requirements. In addition, doctoral students must pass two preliminary examinations and a doctoral candidacy examination.

Requirements for a Master of Science or Doctor of Philosophy degree also include FCH 997 and a research thesis or dissertation. Current research projects encompass polymer chemistry, membrane science, and carbohydrate chemistry;

biochemistry and microbiology; organic chemistry of natural products and chemical ecology; environmental chemistry of the air, water, and soils.

The Master of Professional Studies (M.P.S.) degree requires a total of 33 credits (minimum) in the following configuration:

Area	Credit hours
Chemistry, including at least 9 credits distributed among 3 of the areas of Biochemistry, Environmental Chemistry, Natural Products Chemistry or Polymer Chemistry.	15
Other sciences, engineering and mathematics	6
Seminars	3
Integrative experience (internship or independent study)	3
Elective coursework, seminars, internships or research experience	6
Total (minimum)	33

15 credits of advanced chemistry courses, including three credits of coursework in three of the four subject areas of Biochemistry, Environmental Chemistry, Natural Products/Organic Chemistry and Polymer Chemistry. ESF courses currently available in these subject areas are listed below. The Biochemistry, Environmental Chemistry and Polymer Chemistry areas each have a core sequence of three classes (FCH 530/531/532, 510/511/515 and 550/551/552; respectively). A student interested in specializing in one of these areas would normally take the core sequence in that area, although this is not strictly required. Students who have taken any of these courses [as undergraduates at ESF] may not repeat them for graduate credit.

Biochemistry courses:

FCH 530. Biochemistry I
FCH 531. Biochemistry Laboratory
FCH 532. Biochemistry II
FCH 650 Plant Biochemistry

Environmental Chemistry courses:

FCH 510 Environmental Chemistry I
FCH 511 Environmental Chemistry II
FCH 515 Methods of Environmental Chemical Analysis

Natural Products/Organic Chemistry courses:

FCH 524 Topics in Natural Products Chemistry
FCH 540 Carbohydrates I: Structure, Reactions and Analysis
FCH 571 Wood Chemistry I: General Wood Chemistry
CHE 575 Organic Spectroscopy

Polymer Chemistry courses:

FCH 550 Polymer Science: Synthesis and Mechanisms
FCH 551 Polymer Techniques
FCH 552 Polymer Science: Properties and Technology
FCH 650 Statistical Physics and Chemistry of Macromolecules

Additional graduate chemistry courses are available at ESF and Syracuse University.

6 credits of graduate coursework in Science, Mathematics or Engineering. These may include graduate courses offered at ESF or Syracuse University in physical or biological sciences, mathematics (including statistical analysis), or any area of engineering. Courses must be approved by the student's steering committee.

3 credits of seminar
FCH 997 Seminar (all students)
FCH 797 Graduate Seminar

Either of above, one-credit courses may be repeated, or students may choose seminars offered in other departments with approval of the advisor.

3 credits for an integrative experience in FCH 796-Special Topics in Chemistry or FCH 798-Research in Chemistry.

6 credits of additional graduate coursework:

The remaining six credits may be drawn from additional graduate level coursework, seminars, internships and research experience as approved by the student's steering committee.

Biochemistry (M.P.S., M.S., Ph.D.)

Graduate studies in biochemistry reflect the College's interests in microbial, insect, bio-based fuel, and plant biochemistry. After completing a one-year sequence in general biochemistry, students select advanced courses from a range of offerings in chemistry, organismal biology and molecular biology. Advanced courses in biochemistry are available both at ESF and Syracuse University.

A wide variety of research topics are available ranging from plant physiology to biotechnology. Selective research topics include microbial and algal production of biologically active natural products and their importance in cell biology (BOYER, GINER); chemical communication and recognition between organisms (WEBSTER); marine algal toxins (BOYER); trace metal/nitrogen physiology of symbiotic plants and algae (BOYER); the structure/function of natural biopolymers (NOMURA, WINTER); metabolic and protein engineering (NOMURA); and global gene expression studies of biopolymer-producing bacteria (NOMURA). Also, the use of microorganisms for the production of specialty chemicals including polysaccharide interconversions, and the application of bacterial and fungal enzymes and peptides in the bioremediation of environmental problems are explored.

Environmental Chemistry (M.P.S., M.S., Ph.D.)

Research for graduate students in environmental chemistry is central to their program and includes both experimental and theoretical considerations. Frequently, the problems to be addressed are transdisciplinary in nature. Thus, coursework is carefully selected from areas of chemistry, biology, geology, engineering, mathematics and computer science in order to support the student's particular research needs in conjunction with fieldwork and laboratory experiments. Special topics in analytical, environmental chemistry, or for methods development are often arranged.

Environmental chemistry faculty members currently have active research interests in both aquatic and atmospheric systems. These include the thermodynamics and kinetics of binding hydrophobic organic compounds by dissolved humic substances in water, the development of techniques for measuring the extent to this binding in both laboratory and field environments, and the characterization of poorly understood humic substances by techniques such as NMR (J.P. HASSETT); the study of chlorinated hydrocarbons in the Niagara River-Lake Ontario-St. Lawrence

River system, and their interaction with sediments, dissolved substances and organisms (J.P. HASSETT); the exchange of chlorinated hydrocarbons and other trace organics between aqueous and atmospheric phases in the environment (DIBBLE, J.P. HASSETT, KIEBER); understanding the role of organic matter in a variety of atmospheric, aquatic and sedimentary processes (DIBBLE, J.P. HASSETT, JOHNSON, KIEBER, TEECE); the development of probe systems to study free radical processes and photochemical transformations of dissolved organic matter in natural waters (KIEBER); understanding the dynamics of the oceanic carbon and sulfur cycles and the importance of sunlight-driven photo-chemical transformations of organic matter in natural waters (KIEBER); the application of computer-assisted SEM/EDXA to individual particle analysis in atmospheric, aquatic and suspended sediment samples (JOHNSON); the dynamics of calcium carbonate precipitation in hard water lakes (JOHNSON); the study of the presence and fate of pharmaceuticals in local streams and the synthesis of novel inorganic materials for use as solid state indicators in aqueous environments (DONAGHY); the bio-methylation of As, Sn, and Hg in soil/plant systems (JOHNSON); the study of spatial and temporal patterns in childhood lead poisoning (JOHNSON); the kinetics of elementary reactions that control the degradation of volatile organic compounds and the resulting yields of ozone, aerosols, and air toxics (DIBBLE); the identification of novel intermediates formed in the degradation of aromatic compounds in the atmosphere (DIBBLE); the application of laser spectroscopy and high-level quantum chemical calculations to atmospheric chemistry (DIBBLE); chemical studies of coral reefs (TEECE); application of stable isotope techniques to trophic relationships in reef-building corals (TEECE); the synthesis of oxynitride photovoltaic materials for water splitting (ABRAMS); and bio-based fuels and protein engineering (NOMURA).

Organic Chemistry of Natural Products (M.P.S., M.S., Ph.D.)

Graduate students in organic chemistry of natural products take a one-year course sequence in mechanistic organic chemistry and another in synthetic organic chemistry. Additionally, one-semester courses are required in advanced physical chemistry and the organic chemistry of natural products. Courses in biochemistry, inorganic chemistry, statistics and specialized courses in chemistry or biology may be arranged and selected by the student in consultation with faculty.

Research in the field of organic chemistry of natural products takes three paths. These paths are the isolation and characterization of new natural substances; the synthesis of new or improved syntheses of better-known natural substances; and the study of the relation of molecular structure to biological response. Chemical research in each of these areas is coupled with biological testing. Research involving isolation and synthetic chemistry requires the student to develop expertise in separation techniques, such as the several methods of chromatography, and spectrometric identification of molecules. Successful investigation in structure/activity relationships requires the student to become familiar with statistical methods of analysis. Current topics of interest to the natural products faculty are the following: structure and function of natural metal chelators (BOYER); marine and freshwater algal toxins (BOYER); synthesis and bio-synthesis of biologically active natural products (GINER); analysis and structure determination of sterodial compounds (GINER); isolation and identification of insect and mammalian pheromones and other semiochemicals such as alleomones and kairomones (WEBSTER); and synthesis of new natural products (semiochemicals) with particular emphasis on stereochemistry (WEBSTER).

Polymer Chemistry (M.P.S., M.S., Ph.D.)

Graduate students in polymer chemistry select their courses from a range of offerings in chemistry, chemical engineering, mathematics, physics, and other appropriate areas. These courses will include a one-year sequence in either physical or organic chemistry of polymers and such additional courses as the student and advisor consider necessary. Special topics in a broad spectrum of polymer fields are offered or can be arranged in consultation with the faculty.

Research is an essential component of any graduate degree program in polymer chemistry. Current topics of research interest within the polymer faculty include the following: preparation, modification and technology of polymeric membranes (CABASSO); preparation, properties and applications of radiopaque polymers (CABASSO); inorganic polymers (CABASSO); applied electro-chemistry, fuel cells, electrodes and electrosynthesis (CABASSO); novel methods of cellulose and cellulosic modification (CALUWE); clustering and percolation in polymer mixtures (A. CHATTERJEE); flow-induced effects on polymer miscibility (A. CHATTERJEE); synthesis of boron hyride containing polymers and the chemical functionalization of nanomaterials for polymer incorporation for hydrogen storage (DONAGHY); synthesis and characterization of polymers with novel architectures that incorporate dendritic, hyper-branched, star-like or cyclic fragments; amphiphilic copolymers; self-assembly and supramolecular chemistry (GITSOV); biomass conversion to biodegradable polyesters (NOMURA); biopolymer polymer rheology and stimuli responsive fluids (STIPANOVIC); controlled release applications of environmentally benign polymer gels (STIPANOVIC); diffraction methods, NMR, and dynamic molecular modeling approaches to polymer structure determination and prediction (WINTER); biomass conversion to industrial polysaccharides (WINTER).

Chemical Ecology (M.S., M.P.S., Ph.D.)

Participating Faculty: BOYER (Environmental Biochemistry), GINER (Natural Insecticides), NAKAS (Microbial Ecology), NAKATSUGAWA (Xenobiotic Plant-Animal Interactions), TEALE (Insect Pheromones), TEECE (Chemical-Thermal Relationships), WEBSTER (Pheromone Chemistry)

The area of study in chemical ecology is offered through collaboration between the Department of Environmental and Forest Biology and the Department of Chemistry. Interested students should apply to the department of major interest, which will have prime responsibility for setting requirements. Faculty from both areas contribute to the development of a plan of study enabling a student to acquire sophisticated skills in either chemistry or biology and an ample understanding of the other field to grapple with problems requiring an understanding of both.

As a relatively new interdisciplinary endeavor, scientists in this field attempt to understand organismal interactions, both intra- and interspecific, mediated by chemical substances such as hormones, pheromones, kairomones and phytoalexins. These interactions occur at all taxonomic levels: between uni- and multicellular organisms, microbes and plants, plants and plants, plants and animals, microbes and animals and various species of animals. Study of such interactions has accelerated in recent years through joint efforts of biologists and chemists in basic and applied research in the laboratory and field.

Research Facilities

Graduate research laboratories are located in Edwin C. Jahn Laboratory, a state-of-the-art, 70,000-square-foot research facility opened in 1997. These labs are well-equipped for chemical, polymer, and biochemical research. Available instrumentation includes: ICP-OES, ICP-MS, FTIR, GC/MS, high resolution MS, stable isotope mass spectrometer, UV/VIS, fluorescence, LC/MS, liquid and solid-state multinuclear NMR (300 and 600 MHz), and a complete thermal analysis suite (TGA, DSC, DMA). Ultra-structure study facilities include X-ray diffraction equipment, an atomic force microscope, and electron microscopes. Chromato-graphic equipment includes instrumentation for analytical and preparative liquid and gas chromatography. Jahn Laboratory is equipped for the use of radioisotopes in research including a separate radioisotope laboratory. Liquid and solid scintillation counters, and a multichannel analyzer are available. Other facilities include excimer pumped dye laser, torsion pendulum, membrane and vapor phase osmometry, solution and solid-state light-scattering photometers, dynamic oscillatory viscometer, tensile/compression test unit, and network access to Syracuse University and the Internet. Field equipment includes a 17’ boat with low emissions engine, water and sediment samplers, in-situ sensors for major chemical and physical parameters, fixed wavelength radiometers and spectroradiometers.