Department of Chemistry and Chemical Biology

FRANCIS T. JONES, DIRECTOR

FACULTY*

Professors

Athula Attygalle, Ph.D. (1983), University of Keele, UK
Ajay K. Bose, Sc.D. (1950), Massachusetts Institute of Technology
Francis T. Jones, Ph.D. (1960), Polytechnic Institute of Brooklyn
Marc L. Mansfield, Ph.D. (1981), Dartmouth College
Nicolai S. Panikov, Ph.D. (1976), Moscow State University
Harold J. Raveché, President of Stevens, Ph.D. (1967), University of California at San Diego

Associate Professors

Nuran Kumbaraci, Ph.D. (1977), Columbia University
Sunil K. Saxena, Ph.D. (1988), Nagpur University, India
Svetlana A. Sukhishvili, Ph.D. (1989), Moscow State University

Research Professors

Stanley A. Lang, Ph.D. (1970), Brown University, Director, Infectious Disease Chemistry Research, Wyeth-Ayerst Research
Maghar S. Manhas, Ph.D. (1950), Allahabad University, India
Salvatore S. Stivala, Ph.D. (1960), University of Pennsylvania

Distinguished Service Professor

A.K. Ganguly, Ph.D. (1959), Imperial College, London, formerly Senior Vice President, Chemical Research, Schering-Plough Research Institute

**The list indicates the highest earned degree, year awarded and institution where earned.*

INDUSTRIAL ADVISORY BOARD

Dr. Thomas Salzmann, Vice President, Chemistry, Merck Company

UNDERGRADUATE PROGRAMS

Chemistry

Chemistry is often known as the central science, bridging the gap between the life sciences and physical science, and ranging from the very practical to the highly theoretical. It is the science of matter — its structure, its properties and how it changes.

All around us we see the discoveries of chemistry: synthetic fabrics, aspirin, penicillin and other pharmaceuticals, detergents, better fuels, plastics and more abundant food. Chemists enjoy the excitement and rewards of discovery and creation.

Career opportunities exist in research (creating new knowledge or synthesizing new chemicals) or in quality control (testing and analysis) in pharmaceuticals, petroleum, polymer and plastics, paints and adhesives, electronic materials, waste treatment,

agricultural chemistry, and foods and fragrances, in addition to many other industries. Chemists are employed in hospitals, clinical, environmental control and criminology laboratories. Chemistry also occupies a pivotal role in the high-technology areas of bioinformatics, biotechnology, materials technology, ceramics, polymers and electronic materials. The Stevens program prepares you for employment with companies in these industries, and also meets the admission requirements for graduate programs in chemistry or biochemistry.

The program is based on a solid foundation in the major areas of chemistry and biochemistry. Additional courses in advanced chemistry are available in those areas in which Stevens has unique strengths, such as polymer chemistry, natural products, medicinal chemistry, biochemistry, structural chemistry and instrumental analysis. Research is strongly encouraged due to its importance in preparing for a career in chemistry; it also helps develop independence in solving open-ended problems.

The Stevens chemistry program is certified by the American Chemical Society (ACS). The course sequence for chemistry is as follows:

Freshman Year

Term I					Term II				
		Hrs. Per Wk.					Hrs. Per Wk.		
		Class	Lab	Sem. Cred.			Class	Lab	Sem. Cred
Hu	Humanities	3	0	3	Hu	Humanities	3	0	3
Ch 115	General Chemistry I	3	0	3	Ch 116	General Chemistry II	3	0	3
Ch 117	General Chemistry Lab I	0	3	1	Ch 118	General Chemistry Lab II	0	3	1
CS 115	Intro to Computer Science	2	2	3	Ch 281	Biology and Biotechnology	3	0	3
Ma 115	Math Analysis I	3	0	3	Ma 116	Math Analysis II	3	0	3
PEP 111	Mechanics	3	0	3	PEP 112	Electricity and Magnetism	3	0	3
PE 200	Physical Education I	0	2	1	PE 200	Physical Education II	0	2	1
	TOTAL	**14**	**7**	**17**		**TOTAL**	**15**	**5**	**17**

Sophomore Year

Term III					Term IV				
		Hrs. Per Wk.					Hrs. Per Wk.		
		Class	Lab	Sem. Cred.			Class	Lab	Sem. Cred.
Hu	Humanities	3	0	3	Hu	Humanities	3	0	3
Ma 221	Differential Equations	4	0	4	Mgt 244	Economics	3	0	3
Ch 381	Cell Biology	3	3	4	Ch 321	Thermodynamics	3	0	3
Ch 241	Organic Chemistry I	3	4	4	Ch 242	Organic Chemistry II	3	4	4
PEP 221	Physics Lab I	0	3	1	PEP 222	Physics Lab II	0	3	1
PE 200	Physical Education III	0	2	1	Ma 227	Multivariate Calculus	3	0	3
					PE 200	Physical Education IV	0	2	1
	TOTAL	**13**	**12**	**17**		**TOTAL**	**15**	**9**	**18**

Junior Year

Term V					Term VI				
		Hrs. Per Wk.					Hrs. Per Wk.		
		Class	Lab	Sem. Cred.			Class	Lab	Sem. Cred.
Hu	Humanities	3	0	3	Hu	Humanities	3	0	3
Ma 222	Probability & Statistics	3	0	3	PEP 242	Modern Physics	3	0	3
Ch 421	Chemical Dynamics	3	4	4	Ch 322	Theoretical Chemistry	3	0	3
Ch 362	Instr. Analysis I	3	4	4	Ch 461	Instr. Analysis II	3	4	4
PE 200	Physical Education V	0	2	1		Elective	3	0	3
					PE 200	Physical Education VI	0	2	1
	TOTAL	**12**	**10**	**15**		**TOTAL**	**15**	**6**	**17**

Senior Year

Term VII					Term VIII				
		Hrs. Per Wk.					Hrs. Per Wk.		
		Class	Lab	Sem. Cred.			Class	Lab	Sem. Cred.
Hu	Humanities	3	0	3	Hu	Humanities	3	0	3
Ch 341	Biological Chemistry	3	4	4	Ch 412	Inorganic Chemistry	3	4	4
Ch 360	Spectra & Struct.	3	0	3	Ch 580	Biochemistry I	3	0	3
	Elective	3	0	3	Ch 582	Biophysical Chemistry	3	0	3
Ch 496/8	Project/Research*	0	8	3	Ch 497/9	Project/Research*	0	8	3
	TOTAL	**12**	**12**	**16**		**TOTAL**	**12**	**12**	**16**

* Project/Research can be either a project (Ch 496/7) or thesis (Ch 498/9) and can be done either in the junior/senior year or senior year.

A Minor in Chemistry

A minor in chemistry comprises the following courses: Ch 115, Ch 117 General Chem I + Lab, Ch 116, Ch 118 General Chem II + Lab, Ch 241 Organic Chemistry I, Ch 242 Organic Chemistry II, Ch 421 Chemical Dynamics, Ch 362 Instrumental Analysis I and either Ch 412 Inorganic Chemistry or Ch 580 Biochemistry I. This sequence meets the American Chemical Society guidelines for a minor in chemistry.

Chemical Biology

Chemical biology is the application of exact science, particularly chemistry, to the understanding and utilization of biological phenomena. The scientific approach to understanding living systems ultimately leads to the cell — the basis of all living systems. Modern biology focuses on how cells originate, differentiate, multiply and function, with emphasis on their molecular components, their chemical and physical properties, and their interaction.

Chemical biology includes genetic engineering, the design and modification of genetic material, and molecular biology. It is an exciting field at the very core of biotechnology. Today's biology laboratory is equipped with sophisticated instrumentation to stimulate muscle tissue and measure action potentials; to determine the size, shape and electrical charge of protein molecules; and to follow reactions within the cell. Biologists can study biological phenomena under controlled conditions, to explore the mechanisms governing growth, differentiation, behavior, evolution and aging — knowledge that provides a foundation for modern medicine. The field of medicine relies heavily on modern biology.

The Stevens program in chemical biology provides excellent preparation for you to pursue a career in medicine, and satisfies requirements for admission to professional schools of medicine, dentistry and veterinary medicine. Our program features the study of biology, molecular genetics, cell physiology, biochemistry, biophysical chemistry, organic and physical chemistry, and instrumental analysis. Equipped with this rigorous background — and here is where the Stevens chemical biology program differs from traditional biology and pre-medicine programs — our graduates also find employment in industrial research and pathology laboratories. Many continue their studies at the graduate level in the biological sciences, biochemistry, chemistry or biophysics.

The chemical biology program is certified by the American Chemical Society (ACS), option - biochemistry. The typical course sequence at Stevens is as follows:

Freshman Year

Term I					Term II				
		Hrs. Per Wk. Class	Lab	Sem. Cred.			Hrs. Per Wk. Class	Lab	Sem. Cred
Hu	Humanities	3	0	3	Hu	Humanities	3	0	3
Ch 115	General Chemistry I	3	0	3	Ch 116	General Chemistry II	3	0	3
Ch 117	General Chemistry Lab I	0	3	1	Ch 118	General Chemistry Lab II	0	3	1
CS 115	Intro to Computer Science	2	2	3	Ch 281	Biology and Biotechnology	3	0	3
Ma 115	Math Analysis I	3	0	3	Ma 116	Math Analysis II	3	0	3
PEP 111	Mechanics	3	0	3	PEP 112	Electricity and Magnetism	3	0	3
PE 200	Physical Education I	0	2	1	PE 200	Physical Education II	0	2	1
	TOTAL	**14**	**7**	**17**		**TOTAL**	**15**	**5**	**17**

Sophomore Year

Term III					Term IV				
		Hrs. Per Wk. Class	Lab	Sem. Cred.			Hrs. Per Wk. Class	Lab	Sem. Cred.
Hu	Humanities	3	0	3	Hu	Humanities	3	0	3
Ma 221	Differential Equations	4	0	4	Ch 382	Biological Systems	3	3	4
Ch 381	Cell Biology	3	3	4	Ch 321	Thermodynamics	3	0	3
Ch 241	Organic Chemistry I	3	4	4	Ch 242	Organic Chemistry II	3	4	4
PEP 221	Physics Lab I	0	3	1	PEP 222	Physics Lab II	0	3	1
PE 200	Physical Education III	0	2	1	PE 200	Physical Education IV	0	2	1
	TOTAL	**13**	**12**	**17**		**TOTAL**	**12**	**12**	**16**

Junior Year

Term V					Term VI				
		Hrs. Per Wk. Class	Lab	Sem. Cred.			Hrs. Per Wk. Class	Lab	Sem. Cred.
Hu	Humanities	3	0	3	Hu	Humanities	3	0	3
Ch 484	Intro. to Molecular Genetics	3	3	4	PEP 242	Modern Physics	3	0	3
Ch 421	Chemical Dynamics	3	4	4	Ch 461	Instr. Analysis II	3	4	4
Ch 362	Instr. Analysis I	3	4	4	Ch 580	Biochemistry I	3	0	3
PE 200	Physical Education V	0	2	1		Elective	3	0	3
					PE 200	Physical Education VI	0	2	1
	TOTAL	**12**	**13**	**16**		**TOTAL**	**15**	**6**	**17**

Senior Year

Term VII					Term VIII				
		Hrs. Per Wk. Class	Lab	Sem. Cred.			Hrs. Per Wk. Class	Lab	Sem. Cred.
Hu	Humanities	3	0	3	Hu	Humanities	3	0	3
Ma 222	Probability & Statistics	3	0	3	Mgt 244	Economics	3	0	3
Ch 583	Physiology	3	0	3	Ch 686	Immunology*	3	0	3
Ch 681	Biochemistry II*	3	0	3		Elective**	3	0	3
Ch 496/8	Project/Research*	0	8	3	Ch 582	Biophysical Chemistry	3	0	3
					Ch 497/9	Project/Research*	0	8	3
	TOTAL	**12**	**8**	**15**		**TOTAL**	**15**	**8**	**18**

* With the approval of the advisor

** For American Chemical Society certification, Ch 412 is required

A Minor in Chemical Biology

A minor in chemical biology comprises the following courses: Ch 115, Ch 117 General Chemistry I + Lab, Ch 116, Ch 118 General Chemistry II + Lab, Ch 241 Organic Chemistry I, Ch 242 Organic Chemistry II, Ch 421 Chemical Dynamics, Ch 281 Biology and Biotechnology, Ch 381 Cell Biology, Ch 382 Biological Systems, Ch 580 Biochemistry I, Ch 484 Introduction to Molecular Genetics.

Accelerated Chemical Biology Program

If you are pursuing a special combined degree program in medicine or dentistry, you are enrolled in the Accelerated Chemical Biology program. A heavy course load is required during the three years of the program at Stevens, and completion of the B.S. degree requirements relies on transfer credit from the first year of study at the affiliated medical/dental school. Thus, admission to the accelerated chemical biology program is restricted to students admitted to these special programs.

Freshman Year

Term I					Term II				
		Hrs. Per Wk. Class	Lab	Sem. Cred.			Hrs. Per Wk. Class	Lab	Sem. Cred
Hu	Humanities	3	0	3	Hu	Humanities	3	0	3
Ch 115	General Chemistry I	3	0	3	Ch 116	General Chemistry II	3	0	3
Ch 117	General Chemistry Lab I	0	3	1	Ch 118	General Chemistry Lab II	0	3	1
CS 115	Intro to Computer Science	2	2	3	Ch 281	Biology and Biotechnology	3	0	3
Ma 115	Math Analysis I	3	0	3	Ma 116	Math Analysis II	3	0	3
PEP 111	Mechanics	3	0	3	PEP 112	Electricity and Magnetism	3	0	3
PE 200	Physical Education I	0	2	1	PE 200	Physical Education II	0	2	1
	TOTAL	**14**	**7**	**17**		**TOTAL**	**15**	**5**	**17**

Sophomore Year

Term III					Term IV				
		Hrs. Per Wk. Class	Lab	Sem. Cred.			Hrs. Per Wk. Class	Lab	Sem. Cred.
Hu	Humanities	3	0	3	Hu	Humanities	3	0	3
Ma 221	Differential Equations	4	0	4	Ch 382	Biological Systems	3	3	4
Ch 381	Cell Biology	3	3	4	Ch 321	Thermodynamics	3	0	3
Ch 241	Organic Chemistry I	3	4	4	Ch 242	Organic Chemistry II	3	4	4
PEP 221	Physics Lab I	0	3	1	PEP 222	Physics Lab II	0	3	1
Mgt	Economics	3	0	3	PE 200	Physical Education IV	0	2	1
PE 200	Physical Education III	0	2	1					
	TOTAL	**16**	**12**	**20**		**TOTAL**	**12**	**12**	**16**

Junior Year

Term V					Term VI				
		Hrs. Per Wk. Class	Lab	Sem. Cred.			Hrs. Per Wk. Class	Lab	Sem. Cred.
Hu	Humanities	3	0	3	Hu	Humanities	3	0	3
Hu	Humanities	3	0	3	Hu	Humanities	3	0	3
Ch 484	Intro. to Molecular Genetics	3	3	4	PEP 242	Modern Physics	3	0	3
Ch 421	Chemical Dynamics	3	4	4	Ch 461	Instr. Analysis II	3	4	4
Ch 362	Instr. Analysis I	3	4	4	Ch 580	Biochemistry I	3	0	3
PE 200	Physical Education V	0	2	1	Ch 586	Immunology	3	0	3
					PE 200	Physical Education VI	0	2	1
	TOTAL	**15**	**13**	**19**		**TOTAL**	**18**	**6**	**20**

Two years of Summer Research are expected for participants in this program.
The Senior Year is completed at the Medical/Dental School.

Special Programs

The Accelerated Chemical Biology program gives you the opportunity to earn the B.S. degree at Stevens and the M.D. degree at the University of Medicine and Dentistry of New Jersey (UMDNJ)-New Jersey Medical School, or the D.M.D. degree at UMDNJ-New Jersey Dental School, in a total of seven years.

More information on this program can be found in the Pre-professional and Accelerated Programs section of this catalog. You will also find a discussion of a program called Undergraduate Projects in Technology and Medicine (UPTAM), which is available to specially selected Stevens undergraduates.

Interdisciplinary Program in Computational Science

For students interested in interdisciplinary science and engineering Stevens offers an undergraduate computational science program. Computational science is a new field in which techniques from mathematics and computer science are used to solve scientific and engineering problems. See the description of the Program in Computational Science in the Interdisciplinary Programs section.

GRADUATE PROGRAMS

Chemistry and Chemical Biology

Graduate study in the chemical sciences offers research opportunities of great variety and scope. It offers, too, an unusual receptivity to different kinds of research interests, from the most immediate and practical to the highly theoretical.

The Department of Chemistry and Chemical Biology includes faculty and programs in chemistry as well as in the emerging area of chemical biology. In fact, Stevens pioneered this area with the first undergraduate program in Chemical Biology in the late 1970s. Chemists and biologists share instruments and collaborate on joint educational and research programs. The close proximity of these disciplines encourages cooperation and provides access to equipment and expertise not usually available within a single department.

The degrees Master of Science and Doctor of Philosophy are offered in chemistry or chemical biology with concentrations in physical chemistry, organic chemistry, analytical chemistry, polymer chemistry, chemical biology and bioinformatics. Admission to the graduate program in chemistry requires an undergraduate education in chemistry. Admission to the chemical biology program requires either an undergraduate degree in chemistry with strong biology background or an undergraduate degree in biology with strong chemistry background.

Polymer synthesis and characterization, methods of instrumental analysis, medicinal chemistry and structural chemistry (theoretical as well as experimental) are areas of chemistry in which the department has attained international recognition. Research in chemical biology focuses on enzyme catalysis and biomolecular structure-function relationships. Biotechnology, polymer science and engineering are multidisciplinary research areas in which the department has gained widespread recognition, combining the expertise of chemists, chemical engineers and chemical biologists.

The department is the home for the Center for Mass Spectrometry – one of the best equipped mass spectrometry laboratories anywhere. Included are Electrospray, MALDI, GC/LC MS and other new techniques used in pioneering work in chemistry and biology.

The department is housed in a modern building with well-equipped laboratories for tissue-culture work, protein separation and analysis, and enzyme kinetics. State-of-the-art instrumentation is also available, including rapid scanning stop-flow spectrophotometry, fluorometry, double-beam spectrophotometry, molecular modeling, Fourier-transform infrared, nuclear magnetic resonance, chemical ionization and high resolution mass spectrometry, high-performance liquid chromatography, X-ray scattering and diffractometry, thermal analysis and electron tunneling microscopy.

Periodically, the department invites a preeminent scientist for a sequence of informal talks and formal lectures. Previous lecturers have included Kenneth Pitzer and Herman Mark and the Nobelists William Lipscomb, Sir Derek Barton, Ilya Prigogine, Arthur Kornberg, Rosalyn Yalow, Sidney Altman and George Palade. Periodically, The Stivala Lectures in Chemistry invites an outstanding scientist for a day of lectures and discussions on timely topics in chemistry. Dr. James Cooper, M.D., established this lecture series in memory of his father Charles Cooper, who was a close friend of Professor Salvatore Stivala, a professor of chemistry and chemical engineering at Stevens.

The department believes the vitality of an academic community depends on interaction among its members, and that teaching and learning are essential activities for students and professors alike.

Master's Programs

Thirty graduate credits in an approved plan of study, that include the following core courses, are required for the Master of Science degree. Areas of concentration include analytical chemistry, chemical biology, organic chemistry, physical chemistry and polymer chemistry, and others can be designed. Research may be included in master's degree programs, either as a Special Research Problem (Ch 800) or a master's thesis (Ch 900), and is included in the 30 credits required for the degree. All fellows and teaching or research assistants are expected to complete a thesis.

Core Courses in Chemistry

The first two courses can be waived, depending on the background of the student. In such cases, these must be replaced by electives in order to complete the total of 30 credits.

Ch 520 Advanced Physical Chemistry I (may be required for students with insufficient knowledge of quantum chemistry)
Ch 561 Instrumental Methods of Analysis (may be required for students with insufficient knowledge of instrumental analysis)
Ch 610 Advanced Inorganic and Bioinorganic Chemistry I
Ch 620 Thermodynamics and Kinetics
Ch 640 Advanced Organic and Heterocyclic Chemistry I
Ch 660 Advanced Instrumental Analysis

Core Courses in Chemical Biology

Ch 561 Instrumental Methods of Analysis
Ch 640 Advanced Organic and Heterocyclic Chemistry I
Ch 687 Molecular Genetics
Ch 582 Biophysical Chemistry
Ch 580 Biochemistry I
Ch 668 Computational Biology

Elective Courses

Additional courses are chosen depending on the student's interests and background. The advisor must approve all elective courses.

Doctoral Program

Admission to the doctoral program is based on reasonable evidence that an individual will prove capable of scholarly specialization on a broad intellectual foundation of chemistry or chemical biology. The master's degree is strongly recommended for students entering the doctoral program, and applicants without the master's degree will normally be enrolled in the master's program unless the department is convinced that the student will be able to pass the various doctoral examinations on schedule. Those with a master's degree who wish to transfer those credits toward the Ph.D. must be aware that only one master's degree can be used toward the Ph.D.

The purpose of the doctoral program is to educate scientists who are prepared to carry out independent investigations. While courses provide the tools for independent work, a large part of the doctoral work is done through independent study. This includes preparation for the qualifying and preliminary examinations, the preparation of research proposals and seminars, and familiarity with the current scientific literature in the area of specialization.

Ninety credits of graduate work in an approved program of study are required beyond the bachelor's degree; this may include up to 30 credits obtained in a master's degree program, if the area of the master's degree is relevant to the doctoral program. A doctoral dissertation based on the results of original research, carried out under the guidance of a faculty member and defended in a public examination, is a major component of the doctoral program, and is included in the 90-credit requirement.

Graduate Certificate Programs

In addition to the degree programs, the department currently offers seven Graduate Certificate Programs. The courses may be used towards a master's degree. Each Graduate Certificate Program is a self-contained and highly focused collection of courses carrying 12 or more graduate credits.

Analytical Chemistry

Ch 561 Instrumental Methods of Analysis
Ch 660 Advanced Instrumental Analysis
Ch 662 Separation Methods in Analytical and Organic Chemistry
Ch 665 Chemometrics

Biomedical Chemistry

Ch 642 Synthetic Organic Chemistry
Ch 646 Chemistry of Natural Products
and two of the following courses (with advisor approval):
Ch 647 Chemical Pharmacology of Drugs
Ch 685 Selected Topics in Medicinal Chemistry
Ch 800 Special Research Problems in Chemistry

Polymer Chemistry

Ch 670 Synthetic Polymer Chemistry
Ch 671 Physical Chemistry of Polymers
Ch 672 Macromolecules in Modern Technology
Ch 673 Special Topics in Polymer Chemistry

The above Graduate Certificate Programs are regular graduate courses and are part of the Master of Science program, Chemistry concentration.

Bioinformatics

Ch 681 Biochemistry II
Ch 664 Computer Methods in Chemistry
Ch 668 Computational Biology
Ch 760 Chemoinformatics or CS 580 The Logic of Program Design

Chemical Biology

Ch 580 Biochemistry I
Ch 681 Biochemistry II
Ch 686 Immunology
Ch 687 Molecular Genetics

Chemical Physiology

Ch 580 Biochemistry I
Ch 583 Physiology

Ch 684 Experimental Molecular Biology
and one of the following courses with the approval of your program advisor:
Ch 686 Immunology
Ch 782 Selected Topics in Bioorganic Chemistry
Ch 800 Special Research Problems in Chemistry

Laboratory Methods in Chemical Biology

Ch 561 Instrumental Methods of Analysis
Ch 682 Biochemical Laboratory Techniques
Ch 684 Molecular Biology Laboratory Techniques
Ch 689 Cell Biology Laboratory Techniques

The above Graduate Certificate Programs are regular graduate courses and are part of the Master of Science program, Chemical Biology concentration.

UNDERGRADUATE COURSES

Ch 107 General Chemistry IA (2-0-2)
Elements, compounds, ions, stoichiometry, chemical reactions, solutions, gas laws, partial pressures, effusion, thermochemistry, atomic structure, periodicity, bonding, organic molecules, (nomenclatures), organic chemistry (hybridization, delocalization), polymers. Required course for Engineering students.

Ch 109 General Chemistry IB (1-0-1)
An extension of Ch 107 that includes redox chemistry, balancing chemical equations, nuclear chemistry, the reactions of organic chemistry, polymer chemistry. Prerequisite: Ch 107. Elective course for Engineering students.

Ch 115 General Chemistry I (3-0-3)
Atomic structure and periodic properties, stoichiometry, properties of gases, thermochemistry, chemical bond types, introduction to organic chemistry and biochemistry, transition metals and complexes, nuclear chemistry and radioactivity.

Ch 116 General Chemistry II (3-0-3)
Liquids and solids, phase changes, properties of solutions, kinetics, chemical equilibrium, strong and weak acids and bases, buffer solutions and titrations, solubility, thermodynamics, electrochemistry, properties of the elements. Prerequisite: Ch 107 or Ch 115.

Ch 117 General Chemistry Laboratory I (0-3-1)
Laboratory work to accompany Ch 107 or Ch 115: experiments of atomic spectra, stoichiometric analysis, qualitative analysis, organic and inorganic syntheses.

Corequisite: Ch 107 or Ch 115.

Ch 118 General Chemistry Laboratory II (0-3-1)
Laboratory work to accompany Ch 116: analytical techniques, gases, kinetics, equilibrium, acid-base titrations, oxidation-reduction reactions, electrochemical cells. Corequisite: Ch 116.

Ch 189 Seminar in Chemistry and Biology (1-0-1)
Introduction to chemistry as the "central science" and its impact on other fields,

particularly biology. Areas to be explored include the interaction of radiation with matter, the effect of symmetry on chemical and physical properties of molecules, hyphenated methods of analysis, the chemistry of biological signals, biochemical cycles, the physiology of exercise and chaotic reactions. By invitation only; Corequisite Ch 115/116. Pass/Fail.

Ch 241 Organic Chemistry I
(3-4-4)
Principles of descriptive organic chemistry; structural theory; reactions of aliphatic compounds; stereochemistry. Laboratory includes introduction to organic reaction and separation techniques, reactions of functional groups, synthesis. Prerequisites: Ch 116, 118.

Ch 242 Organic Chemistry II
(3-4-4)
Continuation of Ch 241; reactions of aromatic compounds; infrared and nuclear magnetic resonance spectroscopy; laboratory work in synthesis, spectroscopy and chromatographic separation techniques. Prerequisite: Ch 241.

Ch 281 Biology and Biotechnology
(3-0-3)
Biological principles and their physical and chemical aspects are explored at the cellular and molecular level. Major emphasis is placed on cell structure, the processes of energy conversion by plant and animal cells, genetics and evolution, and applications to biotechnology.

Ch 282 Introductory Biology Laboratory
(0-3-1)
An introductory laboratory illustrating basic techniques and principles of modern biology by means of laboratory experiments and simulated experiments. This laboratory does not satisfy medical school admission requirements. Prerequisite or Corequisite: Ch 281.

Ch 321 Thermodynamics
(3-0-3)
Laws of thermodynamics, thermodynamic functions and the foundations of statistical thermodynamics. The chemical potential is applied to phase equilibria, chemical reaction equilibria and solution theory, for both ideal and real systems. Prerequisites: Ch 116, Ma 116.

Ch 322 Theoretical Chemistry
(3-0-3)
Quantum mechanics of molecular systems are developed. The techniques of approximation methods are employed for molecular binding and spectroscopic transitions. Examples are taken from infrared, visible, ultraviolet, microwave and nuclear magnetic resonance spectroscopy. Prerequisites: Ch 116, Ma 221.

Ch 341 Biological Chemistry
(3-4-4)
Survey of biologically important classes of compounds including fats and lipids, terepenes, steroids, acetogenins, sugars, carbohydrates, peptides, proteins, alkaloids and other natural products. Prerequisite: Ch 242.

Ch 360 Spectra and Structure
(3-0-3)
Interpretation of infrared, ultraviolet, nuclear magnetic resonance and mass spectra. Emphasis is on the use of these spectroscopic methods in identification and structure determination of organic compounds. Prerequisite: Ch 241.

Ch 362 Instrumental Analysis I
(3-4-4)
Experimental approach to spectroscopy. Topics include Fourier Transform infrared spectroscopy, ultraviolet, visible and fluorescence measurements, atomic absorption spectroscopy and nuclear magnetic resonance spectroscopy. Prerequisites: Ch 116, Ch 118 and Ch 241.

Ch 372 Organic Chemistry of Polymers
(3-3-4)
Survey of preparative methods of polymers, including condensation, free radical, ionic, group transfer, ring opening, stereoregular polymerization and copolymerization. Newer techniques stressed. Prerequisites: Ch 241, ChE 270.

Ch 381 Cell Biology
(3-3-4)
The structure and function of the cell and its subcellular organelles is studied. Biological macromolecules, enzymes, biomembranes, biological transport, bioenergetics, DNA replication, protein synthesis and secretion, motility and cancer are covered. Cell biology experiments and interactive computer simulation exercises are conducted in the laboratory. Prerequisite: Ch 281.

Ch 382 Biological Systems
(3-3-4)
Physiochemical principles underlying the coordinated function in multicellular organisms are studied. Electrical properties of biological membranes, characteristics of tissues, nerve-muscle electrophysiology, circulatory, respiratory, endocrine, digestive andexcretory systems are covered. Computer simulation experiments and data acquisition methods to evaluate and monitor human physiological systems are conducted in the laboratory. Prerequisite: Ch 281.

Ch 412 Inorganic Chemistry I
(3-4-4)
Lecture and laboratory; ionic solids, lattice energy and factors determining solubility; thermodynamics in inorganic synthesis and analysis; acid-base equilibria; systematic chemistry of the halogens and other non-metals.

Ch 421 Chemical Dynamics
(3-4-4)
Chemical kinetics, solution theories with applications to separation processes, electrolytes, polyelectrolytes, regular solutions and phase equilibria, and laboratory practice in the measurements of physical properties and rate processes. Prerequisites: Ch 321 or ChE 226 and Ma 221.

Ch 422 Supplemental Topics in Physical Chemistry
(1-0-1)
Additional work in physical chemistry for transfer students to cover topics omitted from physical chemistry courses taken elsewhere. A failure grade is entered on the student's record and the student is required to enroll in Ch 421.

Ch 461 Instrumental Analysis II
(3-4-4)
Theory and practice of analytical chemistry. Topics include sampling techniques, potentiometric and conductometric titrations, chromatographic separations (gas and high-performance liquid chromatography), polarimetry and gas chromatography-mass spectrometry. Prerequisites: Ch 116 and Ch 118.

Ch 484 Introduction to Molecular Genetics (3-3-4)
Introduction to the study of molecular basis of inheritance. Starts with classical Mendelian genetics and proceeds to the study and function of DNA, gene expres-

sion and regulation in prokaryotes and eukaryotes, genome dynamics and the role of genes in development and cancer. All topics include discussions of current research advances. Accompanied by laboratory section that explores the lecture topics in standard wet laboratory experiments and in computer simulations. Prerequisites: Ch 281, 381.

Ch 496-497 Chemical Biology Project I-II
(0-8-3) (0-8-3)
Participation in a small group project, under the guidance of a faculty member, whose prior approval is required. Experimentation, application of chemical knowledge and developmental research leading to the implementation of a working chemical process. Individual or group written report required. Open to juniors and seniors only.

Ch 498-499 Senior Chemical/Biological Research I-II
(0-8-3) (0-8-3)
Individual research project under the guidance of a chemistry faculty member, whose prior approval is required. A written report in acceptable journal format and an oral presentation are required at the end of the project. Senior students only. Ch 498 and 499 cannot be taken simultaneously.

GRADUATE COURSES

All Graduate courses are 3 credits except where noted.

Chemistry and Chemical Biology

Ch 500 Physical Chemistry Review
Review of undergraduate physical chemistry by means of problem solving; atomic spectra; structure of atoms and molecules; thermodynamics; changes of state; solutions; chemical equilibrium; kinetic theory of gases; chemical kinetics and electrochemistry. This course may not be counted toward the master's degree and is not open to undergraduate students.

Ch 520 Advanced Physical Chemistry
The elements of quantum mechanics are developed and applied to chemical systems. Valence bond theory and molecular orbital theory of small molecules; introduction to group theory for molecular symmetry; fundamental aspects of chemical bonding and molecular spectra.

Ch 540-541 Advanced Organic Laboratory I-II*
Your needs and interests will be considered in the assignment of typical advanced preparations, small research problems and special operations. Prerequisite: one year of organic laboratory. Laboratory Fee: $60. Fall and spring semesters.

Ch 561 Instrumental Methods of Analysis
Primarily a laboratory course, with some lecture presenting the principles and applications of contemporary instrumental analytical methods, with a focus on spectroscopy and separations. Laboratory practice explores ultraviolet, visible and infrared spectrophotometry; atomic absorption spectroscopy; nuclear magnetic resonance spectrometry; gas-liquid and high-performance liquid chromatography and mass spectrometry. These instrumental techniques are utilized for quantitative and qualitative analyses of organic, inorganic, biological and environmental samples. Laboratory fee: $60.

Ch 580 Biochemistry I – Cellular Metabolism and Regulation
Discussions include metabolic pathways in biosynthesis and catabolism of biomol-

ecules, including carbohydrates, proteins, lipids and nucleic acids. The hormonal regulation of metabolism as well as vitamin metabolism is presented. Prerequisite: Ch 242 or its equivalent.

Ch 582 Biophysical Chemistry
The relationship of the chemical and physical structure of biological macromolecules to their biological functions as derived from osmotic pressure, viscosity, light and X-ray scatting, diffusion, ultracentrifugation and electrophoresis. The course is subdivided into: 1) properties, functions and interrelations of biological macromolecules, e.g., polysaccharides, proteins and nucleic acids; 2) correlation of physical properties of macromolecules in solution; 3) conformational properties of proteins and nucleic acids and 4) aspects of metal ions in biological systems. Prerequisite: Ch 421 or its equivalent.

Ch 583 Physiology
Fundamentals of control processes governing physiological systems analyzed at the cellular and molecular level. Biological signal transduction and negative feedback control of metabolic processes. Examples from sensory, nervous, cardiovascular and endocrine systems. Deviations that give rise to abnormal states; their detection, the theory behind the imaging and diagnostic techniques such as MRI, PET, SPECT; the design and development of therapeutic drugs. The principles, uses and applications of biomaterials and tissue engineering techniques; problems associated with biocompatibility. Students (or groups of students) are expected to write and present a term project. Prerequisite: Ch 382 or equivalent.

Ch 610 Advanced Inorganic and Bioinorganic Chemistry I
A systematic treatment of the bonding and reactivity of inorganic substances; molecular shape and electron charge distribution of main-group and coordination compounds, including valence- bond theory and a group theoretical approach to molecular orbital theory; organometallic chemistry; the solid state; and the role of inorganic compounds in biological processes and the environment.

Ch 620 Chemical Thermodynamics and Kinetics
Applications of the laws of thermodynamics to solutions, electrolytes and polyelectrolytes, binding and biological systems; statistical thermodynamics is developed and applied to spectroscopy and transition state theory; chemical kinetics of simple and complex reactions, enzyme and heterogeneous catalysis and theories of reaction rates.

Ch 621 Quantum Chemistry*
Theorems and postulates of quantum mechanics; operator relationships; solutions of the Schrödinger equation for model systems; variation and perturbation methods; pure spin states; Hartree-Fock self-consistent field theory; applications to many-electron atoms and molecules. Prerequisite: Ch 520 or equivalent.

Ch 622 Molecular Spectroscopy*
Theoretical foundations of spectroscopic methods and their application to the study of molecular structure and properties. Theory of the absorption and emission of radiation; line spectra of complex atoms; group theory and rotational, vibrational, and electronic spectroscopy of diatomic and polyatomic molecules.

Ch 623 Chemical Kinetics*
A detailed discussion of the kinetics and mechanism of complex reactions in the gaseous and liquid phases. Topics include stationary and nonstationary conditions; chain reactions; photo and radiation-induced reactions; and reaction rate theories.

Ch 624 Statistical Mechanics*
Classical and quantum mechanical preliminaries; derivation of the laws of thermodynamics; applications to monoatomic and polyatomic gases and to gaseous mixtures; systems of dependent particles with applications to the crystalline solid, the imperfect gas and the cooperative phenomena; electric and magnetic fields; degenerate gases. Prerequisite: Ch 620 or equivalent.

Ch 640-641 Advanced Organic and Heterocyclic Chemistry I-II
An advanced course in the chemistry of carbon compounds, with special reference to polyfunctional compounds, heterocycles, techniques of literature survey, stereochemical concepts, physical tools for organic chemists. Fall and spring semester.

Ch 642 Synthetic Organic Chemistry
A survey of important synthetic methods with emphasis on stereochemistry and reaction mechanism. Prerequisite: Ch 640.

Ch 645 Chemistry of Heterocyclic Compounds*
A survey of the more important classes of heterocyclic compounds, their physical and chemical properties, and methods of synthesis. Prerequisite: Ch 241 or equivalent.

Ch 646 Chemistry of Natural Products
Structure, synthesis and biogenesis of antibiotics, alkaloids, hormones and other natural products. Prerequisite: Ch 241 or equivalent.

Ch 647 Chemistry and Pharmacology of Drugs
Discussion at the molecular level of drug receptor interaction, influence of stereochemistry and physiochemical properties on drug action, pharmacological effects of structural features, mechanism of drug action, metabolic rate of drugs in animals and man, drug design. The application of newer physical tools and recent advances in methods for pharmacological studies will be emphasized. Prerequisite: Undergraduate organic chemistry.

Ch 650 Spectra and Structure Determination
An intensive course on the interpretation of spectroscopic data; emphasis is on the use of modern spectroscopic techniques, such as NMR (13C, D, 15N, H), mass (including CI), laser—Raman, ESCA, ORD, CD, IR, UV for structure elucidation. Special attention is given to the application of computer technology in spectral work. A course designed for practicing chemists in analytical, organic, physical and biomedical areas. Extensive problem solving. No laboratory.

Ch 660 Advanced Instrumental Analysis
Advanced treatment of the theory and practice of spectrometric methods (mass spectrometry, nuclear magnetic resonance, etc.) and electroanalytical methods with emphasis on Fourier Transform techniques (FTIR, FTNMR, etc.) and hyphenated methods (gc-ms, etc.), the instrument-sample interaction and signal sampling. A survey of computational methods such as factor analysis and other chemometric methods is also included. Prerequisite: Undergraduate instrumental analysis with laboratory, or Ch 561.

Ch 661 Advanced Instrumental Analysis Laboratory*
Your needs and interests are considered in the assignment of work on one or more of the following: NMR spectrometry, mass spectrometry, electrochemical methods, infrared, ultraviolet and visible spectrophotometry. Laboratory Fee: $60.

Ch 662 Separation Methods in Analytical and Organic Chemistry
An advanced course applying principles and theory to problems in chemical analysis. Theory of separations, including distillation, chromatography and ultracentrifugation; heterogeneity and surface effects; sampling and its problems.

Ch 663 Design of Chemical Instrumentation*

A practical treatment of the mechanical, electronic and optical devices used in the construction of instruments for research and chemical analysis and control; motors, light sources and detectors, servomechanisms, electronic components and test equipment, vacuum and pressure measuring devices, and overall design concepts are among the topics treated. Laboratory fee: $60.

Ch 664 Computer Methods in Chemistry
Discusses computational chemistry topics, including energy minimization, molecular dynamics, solvation mechanics and electronic structure calculations. Applications in drug design and receptors will be discussed. Prerequisite: Ch 321 or its equivalent.

Ch 665 Chemometrics *
Application of chemometric techniques to problems in analytical, physical and organic chemistry, with emphasis on spectroscopic measurements. Includes optimization, analysis of variance, pattern recognition, factor analysis, experimental design, etc.

Ch 666 Modern Mass Spectrometry
A comprehensive hands-on course covering both fundamentals and modern aspects of mass spectrometry with emphasis on biological and biochemical applications. Topics include: contemporary methods of gas phase ion formation, electron ionization (EI), chemical ionization (CI), inductively coupled plasma (ICP), fast atom bombardment (FAB), plasma desorption (PD), electrospray (ESI), atmospheric pressure chemical ionization (APCI), matrix assited laser desorption ionization (MALDI), detection (electron and photomultipliers, array detectors), and mass analysis [magnetic deflection, quadrupole, ion trap, time of flight (TOF), Fourier-transform (FTMS)]. Detailed interpretation of organic mass spectra for structural information with special environmental, biological, pharmacological, forensic, geochemical sciences.

Ch 668 Computational Biology
Topics at the interface of biology and computer technology will be discussed, including molecular sequence analysis, phylogeny generation, biomolecular structure simulation and modeling of site-directed mutagenesis. Prerequisite: Ch 321, Ch 580 or equivalent.

Ch 670 Synthetic Polymer Chemistry
Mechanisms and kinetics of organic and inorganic polymerization reactions; condensation, free radical and ionic addition, stereoregular polymerizations; copolymerizations; the nature of chemical bonds and the resulting physical properties of high polymers.

Ch 671 Physical Chemistry of Polymers
Physio-chemical aspects of polymers, molecular weight distributions, solution characterization and theories, polymer chain configuration, thermodynamics of polymer solutions, the amorphous state, the crystalline state.

Ch 672 Macromolecules in Modern Technology
The course covers recent advances in macromolecular science, including polyelectrolytes and water-soluble polymers, synthetic and biological macromolecules at surfaces, self-assembly of synthetic and biological macromolecules, and polymers for biomedical applications.

Ch 673 Special Topics in Polymer Chemistry*
Recent developments in polymer science will be discussed, e.g., physical measurements, polymer characterization, polymerization kinetics, morphology. Topics will vary from year to year and specialists will participate.

Ch 674 Polymer Functionality
Topics at the interface of polymer chemistry and the uses of polymers, focusing on areas where polymers have made a particularly strong contribution, such as biomedical engineering and pharmaceutical engineering. Synthesis and properties of biopolymers; polymers whose properties change with the environment ("smart polymers"); functional applications in tissue and cell ingineering; biosensors and drug delivery. Prerequisite: Undergraduate organic chemistry.

Ch 678 Experimental Microbiology
Discussions in medical, industrial and environmental microbiology will include bacteriology, virology, mycology, parasitology and infectious diseases. Includes experimental laboratory instruction. Laboratory fee: $60. Prerequisite: Ch 382 or its equivalent.

Ch 681 Biochemistry II – Biomolecular Structure and Function
Discusses the physical and structural chemistry of proteins and nucleotides, as well as the functional role these molecules play in biochemistry. Extensive use of known X-ray structural information will be used to visualize the three- dimensional structure of these biomolecules. This structural information will be used to relate the molecules to known functional information. Prerequisite: Ch 242 or its equivalent.

Ch 682 Biochemical Laboratory Techniques
Students will work actively in small collaborative groups to solve a unique research project that encompasses the purification, analysis of purity, kinetics and structure-function analysis of a novel recombinant protein. Techniques in protein purification, gel electrophoresis, peptide digest separation, ligand binding, steady-state and stopped-flow kinetics, and molecular simulation will be explored. Prerequisite: admission into the graduate Chemical Biology program. Laboratory fee: $60.

Ch 684 Molecular Biology Laboratory Techniques
This laboratory course introduces essential techniques in molecular biology and genetic engineering in a project format. The course includes aseptic technique and the handling of microbes; isolation and purification of nucleic acids; construction, selection and analysis of recombinant DNA molecules; restriction mapping; immobilization and hybridization of nucleic acids; and labeling methods of nucleic acid probes. Laboratory fee: $60. Prerequisite: Ch 484 or its equivalent.

Ch 685 Medicinal Chemistry
A few topics of timely interest will be treated in depth; recent chemical developments will be surveyed in fields such as antibiotics, cancer chemotherapy, CNS agents, chemical control of fertility,

steroids and prostaglandins in therapy, etc. Prerequisite: Ch 242 or equivalent.

Ch 686 Immunology
The cells and molecules of the immune system and their interaction and regulation; the cellular and genetic components of the immune response, the biochemistry of antigens and antibodies, the generation of antibody diversity, cytokines, hypersensitivities and immunodeficiencies (i.e. AIDS); transplants and tumors. Use of antibodies in currently emerging immunodiagnostic techniques such as ELISA, disposable kits, molecular targets, development of vaccines utilizing molecular biological techniques such as recombinant and subunit vaccines. Students (or groups of students) are expected to write and present a term project. Prerequisite: Ch 381 or equivalent.

Ch 687 Molecular Genetics
This course is a modern approach to the study of heredity through molecular biology. Primary emphasis is on nucleic acids, the molecular biology of gene expression, molecular recognition and signal transduction, and bacterial and viral molecular biology. The course will also discuss recombinant DNA technology and its impact on science and medicine. Prerequisite: Ch 484 or its equivalent.

Ch 688 Methods in Chemical Biology
A discussion of the theories underlying various techniques of molecular biology which are used in the biotechnology industry. Topics include all recombinant DNA techniques; DNA isolation and analysis; library construction and screening; cloning; DNA sequencing; hybridization and other detection methods; RNA isolation and analysis; protein isolation and analysis (immunoassay, ELISA, etc.); transgenic and ES cell methods; electrophoresis (agarose, acrylamide, two dimensional and SDS-PAGE); column chromatography; and basic cell culture including transfection and expression systems. Prerequisites: Undergraduate biology, especially cell biology (Ch 381 or equivalent).

Ch 689 Cell Biology Laboratory Techniques
Laboratory practice in modern biological research will be explored. Techniques involving gene and protein cellular probes, ELISA, mammalian cell culturing, cell cycle determination, differential centrifugation, electron microscopy, and fluorescent cellular markets will be addressed. Prerequisite: admission into the graduate Chemical Biology program and Ch 381 or its equivalent. Laboratory fee: $60.

Ch 700 Seminar in Chemistry
Lectures by department faculty, guest speakers and doctoral students on recent research. Enrollment during the entire period of study is required of all doctoral students. .5 credit, pass/fail. Must be taken every semester.

Ch 720-721 Selected Topics in Chemical Physics I-II*
Topics of current interest selected by you are to be investigated from an advanced point of view.

Ch 722 Selected Topics in Physical Chemistry*
Topics selected to coincide with research interests current in the department.

Ch 740 Selected Topics in Organic Chemistry*
Selected topics of current interest in the field of organic chemistry will be treated from an advanced point of view; recent

developments will be surveyed in fields such as reaction mechanisms, physical methods in organic chemistry, natural products chemistry, biogenesis, etc.

Ch 760 Chemoinformatics
This advanced course in computational chemistry builds on the methods developed in Ch 664. Students will analyze and design combinatorial libraries, develop SAR models and generate calculated molecular properties. The hands-on course will use both PC and Silicon Graphics computers. Software such as that from Oxford Molecular, Tripos and Oracle will be used, as will MSI software, such as INSIGHT/DISCOVER, Catalyst and Cerius 2. Prerequisite: Ch 664 or its equivalent.

Ch 780-781 Selected Topics in Biochemistry I-II*
Topics of current interest in biochemical research are discussed, such as: enzyme chemistry, biochemical genetics and development, cellular control mechanism, biochemistry of cell membranes, bioenergetics and microbiology.

Ch 782 Selected Topics in Bioorganic Chemistry*
Topics of timely interest will be treated in an interdisciplinary fashion; recent developments will be surveyed in fields such as biosynthesis, radioactive and stable isotope techniques, genesis of life chemicals, nucleic acids and replication, genetic defects and metabolic errors.

Ch 800 Special Research Problems in Chemistry*
One to six credits. Limit of six credits for the degree of Master of Science.

Ch 801 Special Problems in Chemistry*
One to six credits. Limit of six credits for the degree of Doctor of Philosophy.

Ch 900 Thesis in Chemistry*
For the degree of Master of Science, five to ten credits with departmental approval.

Ch 960 Research in Chemistry*
Original experimental or theoretical research that may serve as the basis for the dissertation required for the degree of Doctor of Philosophy. The work will be carried out under the guidance of a faculty member. Hours and credits to be arranged.

*by request