Chemistry and Biochemistry

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Introduction

The UCSD Department of Chemistry and Biochemistry was founded in the 1950s by the late Professor Harold Urey and a group of colleagues who strove to create a department that would stress the fundamentals of chemistry and, at the same time, embrace diverse applications of those principles at the frontiers of knowledge.

Degrees offered include:

Biochemistry

B.S. Biochemistry/Chemistry
M.S. Chemistry
Ph.D. Chemistry
Ph.D. Chemistry with specialization in bioinformatics

Chemistry

B.A. Environmental Chemistry
B.S. Biochemistry
B.S. Bioinformatics from the Department of Chemistry and Biochemistry
B.S. Chemical Education
B.S. Chemical Physics
B.S. Chemistry
B.S. Chemistry/Earth Sciences
B.S. Environmental Chemistry
B.S. Molecular Synthesis
B.S. Pharmacological Chemistry
M.S. Chemistry
Ph.D. Chemistry
Ph.D. Chemistry with specialization in bioinformatics

Chemistry–Premedical Majors

Either a biochemistry/chemistry major or a chemistry major with appropriate choice of electives provides a strong background for students intending to pursue careers in the medical sciences.

Premedical students are encouraged to complete the three-quarter general chemistry series (Chem. 6A-B-C or 6AH-6BH-6CH) in their first year. Most medical schools require both a full year of general chemistry, and may not accept Advanced Placement exam scores to satisfy admissions

requirements. Students with Advanced Placement exam scores of 4 or 5 who plan to attend medical school should discuss their academic plan with an academic or career adviser early in their academic career. Students should complete the organic chemistry series (either Chem. 140A-B-C or Chem. 141A-B-C) in their sophomore year.

The lower-division biology (BILD 1-2-3) series or equivalent is also required for most medical schools, along with certain upper-division biology courses, some of which may be counted toward the major requirements in chemistry. Students should meet with the department's undergraduate adviser early in order to plan their courses and discuss their options.

General Chemistry

The General Chemistry Chem. 6 sequence (6A-B-C) is intended for science and engineering majors as well as others who need a quantitative course. It satisfies all preprofessional programs. Chem. 4 is a one-quarter preparation for 6A, which should be taken only by those whose college adviser so recommends. The Honors General Chemistry sequence (6AH-6BH-6CH) is designed for science and engineering majors with strong preparation in science and mathematics. A student intending to major in chemistry can thus begin with 4, 6A, or 6AH depending on the level of preparation. A student intending to major in a discipline other than chemistry should consult his or her adviser in the appropriate department to determine which chemistry course is recommended.

Chem. 11, 12, 13 is a terminal sequence for non-science/non-engineering majors. Chem. 15 is a one-quarter survey course suitable for non-science majors. Students should check with their college adviser to determine applicability toward general-education requirements.

General Information on Undergraduate Major Programs

The minimum passing grade is a D, though students may not graduate with more than one D grade in upper-division required course work and must maintain a minimum of a 2.0 average GPA in the major. All courses for the major, except for independent research (Chem. 199) and chemistry instruction (Chem. 195), must be taken for a letter grade. Chem. 195 and Chem. 199 must be taken on a P/NP basis. All chemistry majors, including transfer students, must complete forty-eight units of upper-division chemistry course work at UCSD and fulfill the campus senior residency requirement.

In addition to the requirements, Math. 20F (required for chemical physics majors) and a course in computer programming are also recommended.

Any departure from the requirements outlined below must be approved by petition. This applies to lower- and upper-division requirements.

The suggested programs following each of the major descriptions are only examples.

All undergraduate degree programs, unless otherwise noted, are certified by the American Chemical Society.

Biochemistry/ Chemistry Major

The Biochemistry/Chemistry major deals with the chemical processes in living organisms, including structure and function of nucleic acids and proteins. It is suitable for those planning to go to graduate school as well as medical, dental, veterinary, and other professional schools. It is also suitable at the bachelor's level for jobs in the biotechnology or pharmaceutical field.

The following courses must be taken for a letter grade:

Lower-Division Requirements

1. General chemistry including laboratory (Chem. 6A-C or 6AH-CH, and 6BL, or equivalent).
2. Calculus (Math. 20A-D, or equivalent).
3. Calculus-based physics including laboratory (Phys. 2A-B and 2D or equivalent, and either 2BL, 2CL or 2DL. Phys. 2CL is recommended and is accessible without Phys. 2C).

Upper-Division Requirements

1. Three quarters of organic chemistry (Chem. 140A-C or 141A-C).
2. Two quarters of physical chemistry (Chem. 126-127 recommended; 131–133 acceptable).
3. One quarter of inorganic chemistry (Chem. 120A).
4. Three quarters of biochemistry (Chem. 114A-C).
5. Six laboratory courses (Chem. 100A, 143AM or 143A, 143B, 105A, either 112A or 112B and one additional chemistry lab from the following: Chem. 100B, 105B, 112A or 112B, 123, 143C, or 143D).
6. Two elective courses from the following list: Chem. 107, 113/213, 114D, 115/215, 124/225, 116/216, 118, 152/252, 154/254, 155/255, 156/256, 157/257.
7. One additional elective course chosen from among all of the upper-division and graduate courses offered by the Department of Chemistry and Biochemistry (except non-letter-graded courses) **or** from the following list of courses offered by the Department of Biology (some biology courses will require additional coursework to fulfill prerequisites): BICD 100, BICD 110, BICD 140, BIMM 114, BIMM 120, BIPN 100, BIPN 102, BIPN 140. Other electives may be arranged by petition.

Suggested Program for Biochemistry/Chemistry B.S. Major

Many courses have enforced prerequisites or are offered once per year.

FALL	WINTER	SPRING
FRESHMAN YEAR		
Chem. 6A	Chem. 6B	Chem. 6C
Math. 20A	Math. 20B	Chem. 6BL
	BILD 1*	Math. 20C
SOPHOMORE YEAR		
Chem. 100A	Chem. 140B	Chem. 140C
Chem. 140A	Chem. 143AM	Chem. 143B
Math. 20D	Phys. 2B	Phys. 2D
Phys. 2A		
JUNIOR YEAR		
Chem. 114A	Chem. 114B	Chem. 105A
Chem. 126	Chem. 127	Chem. 114C
Phys. 2CL		
SENIOR YEAR		
Chem. 120A	Elective Lab**	Elective Lab**
Elective	Elective	Elective

* Recommended, but not required.

** One of these must be Chem. 112A or 112B.

Bioinformatics Major from the Department of Chemistry and Biochemistry

Also see the program information listed under Bioinformatics in the catalog.

The Bioinformatics major offers a rigorous, interdisciplinary training in the new and rapidly evolving field of bioinformatics with a strong focus on chemistry and biochemistry. Bioinformatics is the field of advanced computational and experimental methods that model the flow of information (genetic, metabolic, and regulatory) in living systems to provide an integrated understanding of the systems properties of model organisms. This is a new and rapidly evolving field in which large volumes of both qualitative and quantitative data will accrue at an increasing pace, and the bioinformatician must have a substantial mastery of both the sciences and engineering. This interdisciplinary specialization will be offered jointly with computer science and engineering, bioengineering, and biological sciences, each with its own set of requirements and electives. The program offered by the Department of Chemistry and Biochemistry is aimed at a student interested in applying and developing tools of bioinformatics for the study of chemical processes in biological systems.

Admission to the Bioinformatics Major

There is a fifty-student limit in all combined bioinformatics majors on campus. As a result, admission to the bioinformatics degree is not guaranteed, but is based on a screening process which evaluates potential majors based on academic excellence. Since bioinformatics is an interdisciplinary major, a steering committee involving faculty from the participating departments will select among the best candidates applying and recommended through each department, while insuring active participation of the departments and divisions offering the major. The final decision on admission to the pre-major and major will be made by the bioinformatics steering committee, in consultation with the departments.

Chemistry and Biochemistry candidates for the major should enroll as either chemistry (major code Chem. 25) or biochemistry (major code Chem. 31) majors until they have completed their screening courses in the first two years and have been admitted to the bioinformatics major.

Freshmen

Freshmen may apply to the bioinformatics pre-major after completing the initial screening courses:

- Math. 20B
- Math. 20C
- BILD 1
- Chem. 6A

Once admitted to the pre-major, students may take CSE 11 and 12. On completion of those courses, students may apply for admission to the major. Admission is based on the number of seats available and the applicant's GPA in the six screening courses (Math. 20B-C, BILD 1, Chem. 6A, CSE 11, CSE 12).

Continuing Students

Students who have not declared the bioinformatics pre-major, but who have completed the screening courses, may apply for entry to a bioinformatics program after six quarters (the end of the sophomore year). They will be admitted on a space-available basis, after pre-majors have been screened for admission to the major.

Transfer Students

Effective fall 2003, applicants seeking admission to a bioinformatics major must have completed the following courses with a strong GPA that is competitive with that of UCSD students applying for entry into this specialization:

- a year of calculus (equivalent to Math. 20A-B-C)
- a year of general chemistry, with lab (equivalent to Chem. 6A-B-C, and 6BL)
- the highest level programming course offered at the community college (equivalent to CSE 11 and 12)
- one semester of biology (equivalent to BILD 1 and BILD 2)

Those who have not completed the equivalent courses may be admitted as pre-majors, using the same criteria that apply for UCSD students, and will be allowed a maximum of three quarters to complete pre-major requirements. Transfer students are therefore encouraged to complete these requirements at the community college.

The following courses must be taken for a letter grade:

Lower-Division Requirements

1. Calculus and linear algebra (Math. 20A-C, 20F)
2. General chemistry including laboratory (Chem. 6A-C or 6AH-CH, and 6BL).
3. Physics (Phys. 2A-B)
4. Biology (BILD 1-2)
5. Computer programming (CSE 11-12)
6. Mathematics for algorithm and systems (CSE 21/Math. 15B)
7. Bioinformatics seminar (BILD 94)

The department recommends that students complete an introductory C programming course before taking CSE 11 and CSE 12, either in their first year or during the summer between their first and second years.

Upper-Division Requirements

1. Two quarters of organic chemistry (Chem. 140A-B)
2. Organic chemistry (Chem. 140C) or structural biochemistry (Chem. 114A)
3. Metabolic biochemistry (Chem. 114B)
4. Physical chemistry (Chem. 127 accepted, Chem. 131 *and* 132 recommended)
5. Molecular and cellular biochemistry (Chem. 114D)
6. Two quarters of biochemistry laboratory (Chem. 112A-112B)
7. Genetics (BICD 100)
8. Cell biology (BICD 110)
9. Two computer science courses (CSE 100 *or* Math. 176; and CSE 101 *or* Math. 188)
10. Two additional upper-division electives offered by the Department of Chemistry and Biochemistry (each course must be at least four units) with only one quarter of credit allowed for any given course. Recommended courses are: Chem. 100A, 115, 118, and 143A.

The bioinformatics series comprising the following courses:

11. Molecular sequence analysis (BIMM 181 or CSE 181 or BENG 181)
12. Biological databases (Chem. 182 or BIMM 182 or CSE 182 or BENG 182)
13. Applied genomic technologies (BENG 183)
14. Computational molecular biology (BIMM 184 or CSE 184 or BENG 184)
15. Bioinformatics lab (BIMM 185)
16. Probability and statistics (Math. 186)

Suggested Program for the Bioinformatics B.S. from the Department of Chemistry and Biochemistry

Many courses have enforced prerequisites or are offered once per year.

FALL	WINTER	SPRING
FRESHMAN YEAR		
Chem. 6A	Chem. 6B	Chem. 6C
Math. 20A	BILD 1	Chem. 6BL
	Math. 20B	Math. 20C
		BILD 94
SOPHOMORE YEAR		
CSE 11	Chem. 140A	Chem. 112B*
BILD 2	CSE 12	Chem. 140B
Phys. 2A	Phys. 2B	CSE 21/ Math. 15B
JUNIOR YEAR		
Chem. 114A/140C	Chem. 114B*	Elective
BICD 100	Chem. 114D*	BIMM 181/ BENG 181/ CSE 181
CSE 100/Math 176*	Math. 186	
Math. 20F	CSE 101/ Math. 188	BICD 110
SENIOR YEAR		
Chem. 182/ BIMM 182/ BENG182/CSE 182	Chem. 112A* Chem. 127* BIMM 184/ BENG 184/CSE184	BIMM 185 Elective
BENG 183		

* Certain prerequisite courses are waived for the bioinformatics majors. See the department adviser for details.

Chemical Education Major

The Chemical Education major offers an excellent preparation for teaching physical science in secondary schools, including chemistry, physics, earth science, biology, and mathematics.

The chemical education program is sufficiently intensive that students with this degree should be admissible as graduate students in chemistry, biochemistry, and teacher education programs at most universities. This program is also excellent preparation for students interested in a career in science writing.

The program is basically a chemistry major with earth science and biochemistry as electives, combined with three courses in the Teacher Education Program.

If you are interested in earning a California teaching credential through UCSD, contact the Teacher Education Program for information about the prerequisite and professional preparation requirements. It is recommended that you contact TEP as early as possible in your academic career.

The following courses must be taken for a letter grade:

Lower-Division Requirements

1. General chemistry including laboratory (Chem. 6A-C or 6AH-CH, and 6BL, or equivalent).
2. Calculus (Math. 20A-D, or equivalent).
3. Calculus-based physics including laboratory (Phys. 2A-B and 2D or equivalent, and either 2BL, 2CL or 2DL. Phys. 2CL is recommended and is accessible without Phys. 2C).
4. Biology (BILD 1).

Upper-Division Requirements

1. Three quarters of organic chemistry (Chem. 140A-C or 141A-C).
2. Two quarters of physical chemistry (Chem. 126-127 recommended; 131-133 acceptable).
3. One quarter of inorganic chemistry (Chem. 120A).
4. One quarter of biochemistry (Chem. 114A).
5. Six laboratory courses (Chem. 100A, 143AM or 143A, 143B, 105A, and two of the following: 100B, 105B, 112A-112B, 123, 143C, or 143D).
6. One additional elective course chosen from among all of the upper-division and graduate courses offered by the Department of Chemistry and Biochemistry (except non-letter graded courses).
7. Two earth science courses (Erth. 101 and Erth. 102 or 103). Other biology or chemistry courses may be arranged by petition.
8. Chem. 195, or 196, or 199. Chem. 195 is recommended.
9. TEP 129A-B-C.

Suggested Program for Chemical Education B.S. Major

Many courses have enforced prerequisites or are offered once per year.

FALL	WINTER	SPRING
FRESHMAN YEAR		
Chem. 6A	Chem. 6B	Chem. 6C
Math. 20A	BILD 1	Chem. 6BL
	Math. 20B	Math. 20C
SOPHOMORE YEAR		
Chem. 100A	Chem. 140B	Chem. 140C
Chem. 140A	Chem. 143AM	Chem. 143B
Math. 20D	Phys. 2B	Phys. 2D
Phys. 2A		
JUNIOR YEAR		
Chem. 126	Chem. 127	Phys. 2CL
Erth. 101	Elective Lab	Elective
	Erth. 102/103	
SENIOR YEAR		
Chem. 114A	Chem. 105A	Elective Lab
Chem. 120A	Chem. 195/196/199	
TEP 129A	TEP 129B	TEP 129C

Chemical Physics Major

The Chemical Physics major applies the concepts and quantitative methods of physics to the descriptions of atoms and molecules, analyzes matter as a statistical assembly of molecular building blocks, and develops and exploits physical (largely spectroscopic) experimental tools with which to test and refine such theories.

The chemical physics major is designed as a preparation for graduate work in chemistry, physics, or other interdisciplinary areas.

The following courses must be taken for a letter grade:

Lower-Division Requirements

1. General chemistry including laboratory (Chem. 6A-C or 6AH-CH, and 6BL, or equivalent).
2. Calculus and linear algebra (Math. 20A-F, or equivalent).
3. Calculus-based physics including laboratory (Phys. 2A-D or equivalent, and either 2BL, 2CL or 2DL. Phys. 2CL is recommended).

It is recommended that the above requirements be completed by the end of the sophomore year.

Upper-Division Requirements

1. Two quarters of organic chemistry (Chem. 140A-B or 141A-B).
2. One year of physical chemistry (Chem. 131-133).
3. Two quarters of inorganic chemistry (Chem. 120A-B). Chem. 114A can substitute for Chem. 120B.
4. Six upper-division chemistry labs: Chem. 100A-B, 143AM or 143A, 143B or 143C,

105A and one of the following: 105B, 112A, 112B, 123, 143B, 143C, or 143D.

5. Molecular spectroscopy (Chem. 135).
6. Partial differential equations (Math. 110).
7. Two quarters of physics (Phys. 110A-B, or Phys. 100A-B).
8. One additional course in physical chemistry or related areas as approved by the department. Chem. 199 may be petitioned.

Suggested Program for Chemical Physics B.S. Major

Many courses have enforced prerequisites or are offered once per year.

FALL	WINTER	SPRING
FRESHMAN YEAR		
Chem. 6A	Chem. 6B	Chem. 6C
Math. 20A	Math. 20B	Chem. 6BL
		Math. 20C
		Phys. 2A
SOPHOMORE YEAR		
Chem. 140A	Chem. 140B	Chem. 100A
Math. 20D	Chem. 143AM	Math. 20F
Phys. 2B	Math. 20E	Phys. 2D
	Phys. 2C	
JUNIOR YEAR		
Chem. 131	Chem. 132	Chem. 100B
Chem. 143C	Phys. 2CL	Chem. 133
Phys. 110A/100A	Phys. 110B/100B	Math. 110
SENIOR YEAR		
Chem. 105A	Elective Lab	Chem. 135
Chem. 120A	Chem. 120B*	Elective

* Chem. 114A (fall quarter) may be substituted.

Chemistry Major

The Chemistry major provides a broad introduction for the biochemistry, organic, physical, or inorganic student as well as those who prefer not to specialize. This major will enable a student to pursue further studies in chemistry or in related fields of science, medicine, or engineering.

The following courses must be taken for a letter grade:

Lower-Division Requirements

1. General chemistry including laboratory (Chem. 6A-C or 6AH-CH, and 6BL, or equivalent).
2. Calculus (Math. 20A-D, or equivalent).
3. Calculus-based physics including laboratory (Phys. 2A-B and 2D or equivalent, and either 2BL, 2CL or 2DL. Phys. 2CL is recommended and is accessible without Phys. 2C).

Upper-Division Requirements

1. Three quarters of organic chemistry (Chem. 140A-C or 141A-C).
2. Three quarters of physical chemistry (Chem. 131–133).
3. Two quarters of inorganic chemistry (120A-B).
4. One quarter of biochemistry (Chem. 114A).
5. Six laboratory courses (Chem. 100A, 143AM or 143A, 143B, 105A and two of the following: Chem. 100B, 105B, 112A, 112B, 123, 143C, or 143D).
6. Three additional four-unit upper-division or graduate courses in chemistry and biochemistry or related areas. One of Chem. 195 or 199 may be petitioned.

Suggested Program for Chemistry B.S. Major

Many courses have enforced prerequisites or are offered once per year.

FALL	WINTER	SPRING
FRESHMAN YEAR		
Chem. 6A	Chem. 6B	Chem. 6C
Math. 20A	Math. 20B	Chem. 6BL
		Math. 20C
SOPHOMORE YEAR		
Chem. 100A	Chem. 140B	Chem. 140C
Chem. 140A	Chem. 143AM	Chem. 143B
Math. 20D	Phys. 2A	Phys. 2B
JUNIOR YEAR		
Chem. 120A	Chem. 120B	Chem. 105A
Chem. 131	Chem. 132	Chem. 133
Phys. 2D	Phys. 2CL	
SENIOR YEAR		
Chem. 114A	Elective Lab	Elective
Elective Lab	Elective	Elective

Chemistry/Earth Sciences Major

The Chemistry/Earth Sciences major is available in cooperation with UCSD's Scripps Institution of Oceanography. It requires course work for a major in chemistry, plus additional courses in geology. It will appeal to students who plan to go on to graduate school in related fields, or to those students who plan to go into professional geologic work with their undergraduate degree.

The following courses must be taken for a letter grade:

Lower-Division Requirements

1. General chemistry including laboratory (Chem. 6A-C or 6AH-CH, and 6BL, or equivalent).
2. Calculus (Math. 20A-D, or equivalent).
3. Calculus-based physics including laboratory (Phys. 2A-B and 2D or equivalent, and either 2BL, 2CL or 2DL. Phys. 2CL is recommended and is accessible without Phys. 2C). Phys. 2C is recommended as preparation for the upper-division Earth Sciences sequence, but it is not required for the major.

Upper-Division Requirements

1. Two quarters of organic chemistry (Chem. 140A-B or 141A-B).
2. Three quarters of physical chemistry (Chem. 131-133).
3. Two quarters of inorganic chemistry (Chem. 120A-B). Chem. 114A can substitute for Chem. 120B.
4. Six upper-division labs: Chem. 100A-B, 143AM or 143A, 105A, Erth. 162L, and one of the following: Chem. 105B, 112A, 112B, 123, 143B-143C or 143D.
5. Five Earth Sciences courses (Erth. 101-103, 120 and 162A).
6. One additional course from the following list: SIO 252, 253, 259, 260, 261, Chem. 149A-149B, 170, 171, 173. Petrology is essential for geology students. SIO 253 should be taken by students planning to go on to graduate school or to do professional geologic work with their undergraduate degrees. Students are encouraged to take at least one quarter of Chem. 199.

Suggested Program for Chemistry/ Earth Sciences B.S. Major

Many courses have enforced prerequisites or are offered once per year.

FALL	WINTER	SPRING
FRESHMAN YEAR		
Chem. 6A	Chem. 6B	Chem. 6C
Math. 20A	Math. 20B	Chem. 6BL
		Math. 20C

SOPHOMORE YEAR		
Chem. 100A	Chem. 140B	Chem. 100B
Chem. 140A	Chem. 143AM	Phys. 2B
Math. 20D	Phys. 2A	Phys. 2CL
JUNIOR YEAR		
Chem. 131	Chem. 132	Chem. 105A
Earth. 101	Earth. 102	Chem. 133
Phys. 2D	Earth. 120	Earth. 103
SENIOR YEAR		
Chem. 114A*	Earth. 162A	Elective
Chem. 120A	Earth. 162L	Elective Lab

* Chem. 120B (winter quarter) may be substituted.

Environmental Chemistry Major

Students have the option of earning the B.A. or the B.S. in the Environmental Chemistry major. The B.S. is ACS certified and is recommended for those who intend to apply to graduate school.

The Environmental Chemistry major requires a strong chemistry background, but also includes breadth courses from other disciplines related to environmental concerns. The elective courses allow specialization in a secondary area of interest, such as economics, political science, biology, earth sciences, or additional chemistry.

The program is designed to prepare students to enter the industrial, governmental, or legal workforce, or to continue studies in the environmental sciences. Students fulfilling their elective requirements with chemistry and biochemistry courses would be prepared to attend most graduate schools in chemical sciences.

The following courses must be taken for a letter grade:

Lower-Division Requirements

1. General chemistry including laboratory (Chem. 6A-C or 6AH-CH, and 6BL, or equivalent).
2. Calculus (Math. 20A-D, or equivalent).
3. Calculus-based physics (Phys. 2A-B and 2D or equivalent). Phys. 2CL (or Phys. 2BL or 2DL) is required for a B.S. degree.

Upper-Division Requirements

1. Two quarters of organic chemistry (Chem. 140A-B or 141A-B).
2. Two quarters of physical chemistry (Chem. 126-127 recommended; 131-133 acceptable).
3. One quarter of inorganic chemistry (Chem. 120A) or a third quarter of organic chemistry (Chem. 140C or 141C).
4. One quarter of biochemistry (Chem. 114A).
5. Three laboratory courses (Chem. 100A-B, and 143AM or 143A).
6. Two quarters of environmental chemistry (Chem. 149A-B).
7. Atmospheric chemistry (Chem. 173).

Elective Requirements

1. Four non-science elective courses chosen from the following list (at least one course must be upper-division): Econ. 1, Econ. 3, Econ. 131, Econ. 132, HIUS 154, Phil. 148, Phil. 164, Poli. SCI 160AA, Poli. SCI 160AB, Poli. SCI 162, Soc. 185, USP 2, USP 124, USP 144, USP 171. Environmental chemistry students must complete their elective requirements through coursework and cannot substitute examination scores such as Advanced Placement examinations for these courses.
2. Three science elective courses chosen from the following list (at least two courses must be upper-division): Chem. 105A, Chem. 105B, Chem. 112A, Chem. 112B, Chem. 114B, Chem. 114C, Chem. 120A, Chem. 120B, Chem. 123, Chem. 140C or 141C, Chem. 143B, Chem. 143C, Chem 143D, Chem. 170, Chem. 171, Chem. 199, Erth. 40, Erth. 101, Erth. 102, Erth. 103, BILD 1, BILD 2, BILD 3, BIEB 120, BIEB 121, BIEB 176, BIEB 178, BIEB 179, MAE 118A-B.
3. Students desiring an ACS certified B.S. Degree must take three laboratory courses: Chem. 105A, 143B or 143C, and one from the following list: Chem. 105B, 112A, 112B, 123, 143B, 143C or 143D. These courses may be used to satisfy number 2 above.

Suggested Program for Environmental Chemistry B.A. or B.S. Major (B.S. and ACS certification require additional courses)

Many courses have enforced prerequisites or are offered once per year.

FALL	WINTER	SPRING
FRESHMAN YEAR		
Chem. 6A	Chem. 6B	Chem. 6C
Math. 20A	Math. 20B	Chem. 6BL
	Phys. 2A	Math. 20C
SOPHOMORE YEAR		
Chem. 100A	Chem. 140B	Chem. 100B
Chem. 140A	Chem. 143AM	Phys. 2D
Math. 20D	Phys. 2B	
JUNIOR YEAR		
Chem. 126	Chem. 127	Chem. 173
Chem. 149A	Chem. 149B	Elective
Elective	Elective	Elective
SENIOR YEAR		
Chem. 114A	Elective	Elective
Chem. 120A*		Elective

*Chem. 140C may be substituted.

Molecular Synthesis Major

The Molecular Synthesis major offers a thorough training in all aspects of the molecular synthesis of organic, inorganic, and biological substances, and with a fundamental understanding of their structure and reactivity. This major provides an excellent preparation for employment in biotechnology, diagnostic, electronic, and pharmaceutical enterprises as well as for graduate programs in organic, bioorganic, and inorganic chemistry.

The following courses must be taken for a letter grade:

Lower-Division Requirements

1. General chemistry including laboratory (Chem. 6A-C or 6AH-CH, and 6BL, or equivalent).
2. Calculus (Math. 20A-D, or equivalent).
3. Calculus-based physics including laboratory (Phys. 2A-B and 2D or equivalent, and either 2BL, 2CL or 2DL. Phys. 2CL is recommended and is accessible without Phys. 2C).

Upper-Division Requirements

1. Three quarters of organic chemistry (Chem. 140A-C or 141A-C)
2. Three quarters of physical chemistry (Chem. 131-133)
3. Two quarters of inorganic chemistry (Chem. 120A-120B)
4. One quarter of biochemistry (Chem. 114A)
5. Six laboratory courses (Chem. 100A, 143A or 143AM, 143B-143C, 105A, and 123)

6. Synthetic methods (Chem. 152)
7. Structural or mechanistic organic chemistry (Chem. 154 or 156)
8. Polymer, bioorganic, or bioinorganic chemistry (Chem. 107 or 124 or 157)
9. One additional course from the following: Chem. 114B, 114C, 155, 185, or 199

Suggested Program for Molecular Synthesis B.S. Major

Many courses have enforced prerequisites or are offered once per year.

FALL	WINTER	SPRING
FRESHMAN YEAR		
Chem. 6A	Chem. 6B	Chem. 6C
Math. 20A	Math. 20B	Chem. 6BL
		Math. 20C
SOPHOMORE YEAR		
Chem. 100A	Chem. 141B	Chem. 141C
Chem. 141A	Chem. 143AM	Chem. 143B
Math. 20D	Phys. 2B	Phys. 2CL
Phys. 2A		Phys. 2D
JUNIOR YEAR		
Chem. 120A	Chem. 120B	Chem. 105A
Chem. 131	Chem. 123	Chem. 133
Chem. 143C	Chem. 132	
SENIOR YEAR		
Chem. 114A	Chem. 154/156	Chem. 107/
Chem. 152	Elective	124/157

Pharmacological Chemistry Major

The Pharmacological Chemistry major provides a strong background in chemistry and includes most courses required by California pharmacy schools. The major is intended primarily to prepare students for pharmacy school (Pharm.D.). Students fulfilling their elective requirements with appropriate courses would be prepared for graduate school to obtain a Ph.D. in pharmacology, biochemistry, or other areas of science. Degree recipients would also be prepared for most jobs in the biotechnology and chemical industries.

Pharmacological chemistry students are strongly encouraged to complete a full year of general chemistry and a full year of lower-division biology. As with some medical programs, some pharmacy programs may require a full year of these courses and may not accept tests such as the Advanced Placement exam to satisfy these requirements.

The following courses must be taken for a letter grade:

Lower-Division Requirements

1 Biology (BILD 1, 2 and 3, and either BICD 101, 111, 131, or BIPN 105 or BIMM 121). Alternatively, a year of biology with laboratory at a community college may be petitioned.
2. General chemistry including laboratory (Chem. 6A-C or 6AH-CH , and Chem. 6BL, or equivalent).
3. Calculus-based physics including laboratory. (Phys. 2A-B and 2D or equivalent, and either 2BL, 2CL, or 2DL. Phys. 2CL is recommended and is usually the course required by pharmacy schools. It is accessible without Phys. 2C).
4. Calculus (Math. 20A–D, or equivalent).
5. Economics (Econ. 1 or 3 or equivalent).
6. Pharmacology seminar (Chem. 92).

Most California pharmacy schools require a course in public speaking for admission to the school. Students planning to apply to these programs should take Introduction to Speech, Theatre THGE 25, or an appropriate course at a community college.

Upper-Division Requirements

1. Two quarters of physical chemistry (Chem. 126-127 recommended; 131–133 acceptable).
2. Three quarters of organic chemistry (Chem. 140A-C or 141A-C).
3. Three quarters of biochemistry (Chem. 114A-B-C).
4. Four laboratory courses (Chem. 100A, 143AM or 143A, 143B and either 112A, 112B or 143C).
5. One quarter of pharmacology and toxicology (Chem. 118).
6. One chemistry elective course chosen from among all the upper-division and graduate courses offered by the Department of Chemistry and Biochemistry (except non-letter graded courses).

If ACS certification is desired, Chem. 120A, plus two additional laboratory courses (Chem. 105A and a lab chosen from Chem. 100B, 105B, 123, or 143C/112A/112B, if not already taken), are required. Any of these courses would satisfy #6. above.

Suggested Program for Pharmacological Chemistry B.S. Major (ACS certification requires additional courses)

Many courses have enforced prerequisites or are offered once per year.

FALL	WINTER	SPRING
FRESHMAN YEAR		
Chem. 6A	Chem. 6B	Chem. 6C
Math. 20A	Math. 20B	Chem. 6BL
	BILD 1	Chem. 92
		Math. 20C
SOPHOMORE YEAR		
Chem. 100A	Chem. 140B	Chem. 140C
Chem. 140A	Chem. 143AM	Chem. 143B
Math. 20D	Phys. 2A	Phys. 2B
JUNIOR YEAR		
Chem. 114A	Chem. 114B	Chem. 114C
Chem. 143C*	Econ. 1/3	BILD 3
Phys. 2D	BILD 2	Phys. 2CL
SENIOR YEAR		
Chem. 126	Chem. 127	Chem. 118
Elective	Bio. lab**	

* Chem. 112A or 112B may be substituted.

** BICD 101, 111, 131, or BIPN 105 or BIMM 121 (some have prerequisites that must be taken in an earlier quarter).

Honors Program

The Department of Chemistry and Biochemistry offers an Honors Program to those students who have demonstrated excellence in any of the nine majors. Students are eligible for Departmental Honors at graduation when they have:

1. Achieved a GPA of 3.2 overall and 3.4 in chemistry courses.
2. Completed a minimum of eight units of Chem. 199, distributed over at least two quarters. A student who registers for 199 and subsequently fails to complete the Honors Program may apply up to four units to any major that normally allows 199 as elective credit. A student who has successfully petitioned to use a Chem 199 course to fulfill elective credit may not use that course to fulfill honors requirements as well.
3. Submitted a final honors research report to three UCSD faculty members, including their research adviser, for approval.

4. Presented an oral report about their research before a group of at least three faculty. This can be at an undergraduate research conference or at a seminar involving honors students and faculty.

Students who are interested in the Honors Program should contact the Undergraduate Coordinator in 4010 York Hall, and are invited to do so at any time.

Education Abroad

Majors are encouraged to explore the programs that allow students to study abroad or at other U.S. universities for a term or longer. See an adviser for details.

Minor Program in Chemistry and Biochemistry

A typical minor in chemistry consists of three lower-division lecture courses and at least one laboratory course, followed by a minimum of five upper-division courses, including at least one laboratory course, focused in physical, inorganic, organic, environmental chemistry, or biochemistry. Lower-division course requirements may not be satisfied by advanced placement credit, though transfer units may be used to satisfy lower-division minor requirements. Upper-division courses required by a student's major may not be applied toward a minor.

Upper-division courses for the minor must be taken at UCSD in the Department of Chemistry and Biochemistry, and must be taken for a letter grade. The minimum overall GPA requirement for the minor is a 2.0.

The Graduate Programs

Graduate students are accepted to the Department of Chemistry and Biochemistry for study toward Plan I (Thesis) and the Plan II (Comprehensive Examination) M.S. in chemistry, the Ph.D. in chemistry and the Ph.D. in chemistry with specialization in bioinformatics. Students interested in the bioinformatics specialization should contact the Student Affairs Office for more information.

Master's of Science

A Plan I (Thesis) M.S. in chemistry and a Plan II (Comprehensive Examination) M.S. in chemistry are offered.

Admissions: UCSD students are admitted for fall, winter, and spring quarter entrance; non-UCSD students are admitted for fall entrance only. Eligibility requirements for admission include a solid training in the chemical sciences based on the undergraduate record, a 3.0 GPA in chemistry courses completed, and a 3.0 overall GPA.

The GRE general test is required of all applicants. Foreign applicants must submit a TOEFL score; TWE scores are strongly recommended. Those who wish to apply to the Thesis Plan must have a letter of support from the proposed thesis adviser.

Residency and Time to Degree: Master's students must register at UCSD for a minimum of three quarters, and complete at least twenty units per academic year. Full-time Comprehensive Examination Plan students can complete the degree in three quarters. Thesis Plan students typically take eighteen to twenty-four months to graduate.

Relationship to Doctoral Program: Master's students who wish to continue their studies as doctoral students in chemistry and biochemistry must request to transfer to that program. Application materials are due mid-January and include current letters of recommendation, current UCSD transcript, and statement of purpose. Transfer is for fall quarter only.

PLAN I (THESIS)

Purpose: To prepare students for research careers or for doctoral or professional studies; the emphasis is on research.

Advancement to Candidacy: A minimum of thirty-six units with an overall GPA of 3.0 must be completed. The majority of units taken are for thesis research (Chem. 299). At least eight units of graduate level chemistry courses must be completed for a letter grade. Four units of teaching apprenticeship are required (Chem. 500; see Doctoral Program, Teaching and Language Requirement sections). Contact the Student Affairs Office for full information.

Thesis: Students must give an oral presentation and defense of their thesis project to a Thesis Committee. A student graduates after the thesis has been defended and the written dissertation approved by his or her committee, department, and OGSR, and filed with the University Archivist. The Thesis Committee consists of at least three faculty: (1) the thesis adviser, (2) a faculty member from the Department of Chemistry and Biochemistry familiar with the student's research area, and (3) a faculty member from either this or another department whose research is in an area different from that of the thesis.

PLAN II (COMPREHENSIVE EXAM)

Purpose: To prepare students for doctoral or professional studies; the emphasis is on course work.

Advancement to Candidacy: A minimum of thirty-six units with an overall GPA of 3.0 must be completed. The majority of units taken are in letter-graded graduate chemistry courses. Four units of teaching apprenticeship are required (Chem. 500; see Doctoral Program, Teaching and Language Requirement sections). Four units of nonthesis research (Chem. 297) are allowed. Contact the Student Affairs Office for full information.

Comprehensive Examination: The purpose of this requirement is to confirm that students have achieved an advanced understanding of, and a comprehensive training in, the chemical sciences. The tests cover a wide range of material, so that students will have a chance to show what they have learned. For master's students, the department administers the standardized American Chemical Society exams in biochemistry and in analytical, inorganic, organic, and physical chemistry. Students must pass three of the five exams in order to graduate. For doctoral students earning the M.S. on the way to the Ph.D., the Departmental Examination fulfills this requirement.

Doctoral Program

The goal of the Ph.D. in chemistry is to prepare students for careers in science by expanding their knowledge of chemistry while developing their ability for critical analysis, creativity, and independent study. The program is designed to encourage initiative and to stimulate enjoyment and development of the student's area of research expertise as well as the broader aspects of scientific inquiry and enlightenment.

Research

Students choose their research concentration from programs in biochemistry, biophysics, bioinformatics, inorganic, organic, physical, analytical, and theoretical chemistry, surface and materials chemistry, and atmospheric and environmental

chemistry. Opportunities for scientific discovery are also abundant through the department's extensive collaborations with investigators in the physical, biological, and engineering sciences. This includes on-campus collaborations with faculty in the Materials Science Program, School of Medicine, School of Pharmacy and Pharmaceutical Sciences, and Scripps Institution of Oceanography. There are also off-campus interactions with scientists at nearby research facilities such as the Salk Institute and The Scripps Research Institute. Excellent state-of-the-art facilities and equipment support all the research programs. The department's Industrial Relations Program interfaces with national and local chemical, biotechnology, and pharmaceutical industries to encourage technology transfer and to assist postgraduates interested in industrial careers.

Research Adviser

A first-year faculty adviser guides students until a research adviser is chosen. Most of a student's efforts in graduate school are directed toward research for the doctoral dissertation, and selection of a research adviser is of utmost importance. To assist students with this critical decision, all chemistry and biochemistry faculty present research seminars in the fall quarter. Students then rotate in laboratories or consult with faculty to discuss research opportunities. Although students have until the end of the first year to join a laboratory, most start their research studies by mid-year.

Placement Examinations and Course Work

Entering students take written placement examinations in analytical, biochemistry, inorganic, organic, and physical chemistry. The purposes of these exams are to assist with advising and to assure that students have the breadth and level of competence needed for graduate studies. Deficiencies must be remedied in the first year. Three of five exams must be passed, including the one in the student's research area.

First-year students normally take at least six of the graduate courses listed below based on the results of their placement examinations, their research programs, and their specialized interests. Chem. 250 and Chem. 500 are required. Undergraduate courses and courses offered through other departments may also be taken, depending on the student's research area. By the second year, the emphasis is on thesis research, and a lighter load of courses is taken, although participation in seminars and informal study groups continues.

Departmental Examination

In the winter quarter of the second year, a student's progress in research and graduate studies is evaluated through the departmental examination, which includes presentation and critical discussion of a recent research article. Students are also evaluated on their general knowledge of their particular field of study. Students may also be asked about progress on their dissertation.

Qualifying Examination

By the end of the third year, students defend the topic, preliminary findings, and future research plans of their dissertation. Passing this defense qualifies the student to advance to candidacy for the dissertation. A dissertation committee composed of five faculty, one of whom is the research adviser, provides consultation and evaluation for the dissertation project.

Dissertation

The dissertation is normally completed in the fourth or fifth year. This body of research is expected to make an innovative contribution to the field of chemistry. Ph.D. candidates present a seminar summarizing their research accomplishments and defend their thesis in an oral examination before their dissertation committee.

Teaching

Experience in teaching is a vital and integral part of every graduate student's training, and all students participate in the instructional activities of the undergraduate curriculum. Course credit for the teaching apprenticeship is earned by enrolling in Chem. 500. Excellence in teaching is stressed, and the department provides a thorough training program covering the fundamentals of teaching as well as other useful information and techniques for effective instruction. Further training is provided by the campus's Center for Teaching Development. Faculty and the students taught evaluate the performance of teaching assistants every quarter and awards are bestowed annually for outstanding performance as a teaching assistant.

Language Requirement

Students whose native language is not English must demonstrate a mastery of English adequate to complete the teaching requirement. Deficiencies must be remedied by the end of the first year of academic residency. For native English speakers, there is no foreign-language requirement.

Time Limits

In accordance with UCSD policy, students must advance to candidacy by the end of four years. Total university support cannot exceed six and one-third years. Total registered time at UCSD cannot exceed seven and one-third years.

Seminars

Seminars by researchers from other universities, national laboratories, and industry are another basic and important aspect of the graduate curriculum. Seminars are presented weekly in biochemistry, inorganic, organic, and physical chemistry. Department colloquia are given on topics of general interest to the department. Seminars are also sponsored by many other departments and institutes.

Financial Support

The department supports all first-year students in good academic standing from a variety of sources, including teaching and research assistantships, training grants, fellowships, and awards. A stipend is paid in addition to fees and, if applicable, tuition. Continuing students who do not have fellowships or awards are normally supported on training grants or on research assistantships by their thesis advisers.

Admissions

The department seeks bright, motivated doctoral students and welcomes all such applications. To make admissions decisions, the department considers an applicant's statement of purpose and research interests, GRE scores on the general test plus either the advanced chemistry or advanced biochemistry test, undergraduate record, quality of the undergraduate university, letters of recommendation, and research experience and publica-

tions. Applicants whose native language is not English must also submit TOEFL scores; TWE scores are strongly recommended. Admissions to the doctoral program is for fall quarter. Applications received by mid-January receive priority consideration.

Students who have a master's degree with strong course records and with research experience are encouraged to apply. They normally pass the Qualifying Examination and graduate at an accelerated pace.

Joint Doctoral Program with San Diego State University

The Department of Chemistry and Biochemistry at UCSD and the Department of Chemistry at San Diego State University offer a joint program of graduate study leading to the Ph.D. degree in chemistry. More information is available in the current edition of the *Bulletin of the Graduate Division* of San Diego State University.

COURSES

LOWER-DIVISION

4. Basic Chemistry (4)
Chemistry 4 is a one-quarter course for science majors with insufficient preparation to start the Chem. 6 sequence. Emphasis is on learning how to solve quantitative problems. Topics include nomenclature, stoichiometry, and the periodic table. Includes a combined laboratory and discussion-recitation each week. *Prerequisite: Math. 4C. Cannot be taken for credit after any other chemistry course.* Intended for science majors. (F)

6A. General Chemistry I (4)
First quarter of a three-quarter sequence intended for science and engineering majors. Topics include: stoichiometry, gas laws, bonding, atomic theory, quantum theory, and thermochemistry. Three hours lecture, one hour recitation. *Prerequisites: proficiency in high school chemistry or physics, Math. 10A or 20A or a higher course in the Math. 10 or 20 sequence (may be taken concurrently).* (F,W,S)

6AH. Honors General Chemistry I (4)
First quarter of a three-quarter honors sequence intended for well-prepared science and engineering majors. Topics include: stoichiometry, gas laws, bonding, atomic theory, quantum theory, and thermochemistry. Three hours lecture and one hour recitation. Students may not receive credit for both Chem. 6AH and Chem. 6A. *Prerequisites: proficiency in high school chemistry, physics and mathematics. Math. 10A or 20A or a higher course in the Math. 10 or 20 sequence. Concurrent enrollment in Math. 20A or higher level calculus required.* (F)

6B. General Chemistry II (4)
Second quarter of a three-quarter sequence intended for science and engineering majors. Topics include: molecular geometry, condensed phases and solutions, chemical equilibrium, acids and bases and thermodynamics. Three hours lecture and one hour recitation. *Prerequisites: Chem. 6A, Math. 10A or 20A or a higher course in the Math. 10 or 20 sequence.* (F,W,S)

6BH. Honors General Chemistry II (4)
Second quarter of a three-quarter honors sequence intended for well-prepared science and engineering majors. Topics include: molecular geometry, condensed phases and solutions, chemical equilibrium, acids and bases and thermodynamics. Students may not receive credit for both Chem. 6BH and Chem. 6B. Three hours lecture and one hour recitation. *Prerequisites: Chem. 6AH, Math. 10A or 20A or a higher course in the Math. 10 or 20 sequence.* (W)

6BL. Introductory Inorganic Chemistry Laboratory (3)
Introduction to experimental procedures used in synthetic, inorganic, analytical, and physical chemistry. *Prerequisites: Chem. 6A, 6B. If 6BL is a requirement for your major, it should be taken concurrently with 6C.* A materials fee is required for this course. (F,W,S)

6C. General Chemistry III (4)
Third quarter of a three-quarter sequence intended for science and engineering majors. Topics include: electrochemistry, kinetics, coordination chemistry, nuclear chemistry, and an introduction to organic and biochemistry. Three hours lecture and one hour recitation. *Prerequisite: Chem. 6B, Chem. 6BL may be taken concurrently.* (F,W,S)

6CH. Honors General Chemistry III (4)
Third quarter of a three-quarter honors sequence intended for well-prepared science and engineering majors. Topics include: electrochemistry, kinetics, coordination chemistry, nuclear chemistry, and an introduction to organic and biochemistry. Three hours lecture and one hour recitation. Students may not receive credit for both Chem. 6CH or Chem. 6C. *Prerequisites: Chem. 6BH, Math. 20B; Chem. 6BL may be taken concurrently.* (S)

11. The Periodic Table (4)
Introduction to the material world of atoms and small inorganic molecules. Intended for nonscience majors. Can be skipped by students with a good knowledge of high school chemistry. Cannot be taken for credit after any other general chemistry course. (F)

12. Molecules and Reactions (4)
Introduction to molecular bonding and structure and chemical reactions, including organic molecules and synthetic polymers. Intended for nonscience majors. *Prerequisite: Chem. 11 or good knowledge of high school chemistry.* Cannot be taken for credit after any organic chemistry course. (W)

13. Chemistry of Life (4)
Introduction to biochemistry for nonscience majors. *Prerequisite: Chem. 12.* Cannot be taken for credit after any biochemistry course. (S)

15. Chemistry of the Universe (4)
This is a one-quarter, nonmathematical chemistry course for nonscience majors covering the origin of the universe, the elements, and the formation of the solar system. The evolution of the Earth's atmosphere, hydrosphere, geosphere, and biosphere will be covered, as well as contemporary problems in environmental chemistry. Cannot be taken for credit after any other chemistry course.

87. Freshman Seminar in Chemistry and Biochemistry (1)
This seminar will present topics in chemistry at a level appropriate for first-year students.

90. Undergraduate Seminar (1)
The seminar will focus on a variety of issues and special areas in the field of chemistry.

91. Undergraduate Honors Seminar (1)
A seminar intended for exposing undergraduate students, especially freshmen and sophomores, to exciting research programs conducted by the faculty. Enrollment is limited.

92. Undergraduate Pharmacology Seminar (1)
Selected topics in pharmacology and toxicology.

99. Independent Study (2-4)
Independent literature or laboratory research by arrangement with and under the direction of a member of the Department of Chemistry and Biochemistry faculty. Students must register on a P/NP basis. *Prerequisites: lower-division standing, 3.0 minimum UCSD GPA, consent of instructor and department, completion of 30 units of undergraduate study at UCSD, completed and approved special studies form.*

UPPER-DIVISION

100A. Analytical Chemistry Laboratory (4)
Laboratory course emphasizing classical quantitative chemical analysis techniques, including separation and gravimetric methods, as well as an introduction to instrumental analysis. *Prerequisites: Chem. 6C or 6CH or equivalent, and Chem. 6BL or equivalent; Phys. 2CL or 2BL recommended.* A materials fee is required for this course.

100B. Instrumental Analysis Laboratory (4)
Laboratory course covering fundamental principles of operation, capabilities, applications, and limitations of modern analytical instrumentation. Techniques include gas chromatography, mass spectrometry, high performance liquid chromatography, ion chromatography, atomic absorption spectroscopy, fluorescence, and infrared spectrometry. *Prerequisites: Chem. 100A, and Phys.2A-B-D or equivalent; Phys.2CL or 2BL recommended.* A materials fee is required for this course.

105A. Physical Chemistry Laboratory (5)
Laboratory course in experimental physical chemistry. *Prerequisites: Chem. 100A (formerly 6CL) and Phys. 2CL or equivalent, Chem. 126 or 127 or 131 or 133.* A materials fee is required for this course. (F,W,S)

105B. Physical Chemistry Laboratory (4)
Laboratory course in experimental physical chemistry. *Prerequisite: Chem. 105A.* A materials fee is required for this course. (F,W,S)

107. Synthetic Macromolecules (4)
The chemistry of high polymers with emphasis on synthesis, structure, characterization, and properties. Polymers as materials are important as films, fibers, and elastomers. They play an ever-increasing role in science, technology, and medicine. *Prerequisites: Chem. 140AB or 141AB.* (May not be offered every year.)

112A. Molecular Biochemistry Laboratory (6)
The application of techniques to study protein structure and function, including electrophoresis, protein purification, column chromatography, enzyme kinetics, and immunochemistry. *Prerequisites: Chem. 140A-*

B-C, 143A-B, 114A-B. (Some of these courses may be taken concurrently.) (**Note**: Students may not receive credit for both Chem. 112A and BIBC 103.) A materials fee is required for this course. (W)

112B. Molecular Biochemistry Laboratory (6)
This laboratory will introduce the students to the tools of molecular biology and will involve experiments with recombinant DNA techniques. *Prerequisites: Chem. 114A-B, Chem. 114C (may be taken concurrently); Chem. 143A and 143B.* (**Note**: Students may not receive credit for both Chem. 112B and BIMM 101.) A materials fee is required for this course. (S)

113. Chemistry of Biological Macromolecules (4)
A discussion of the structural principles governing biological macromolecules, the techniques used in their study, and how their functional properties depend on three-dimensional structure. *Prerequisites: elementary organic and physical chemistry.* (May not be offered every year.)

114A. Biochemical Structure and Function (4)
Introduction to biochemistry from a structural and functional viewpoint. *Prerequisite: elementary organic chemistry (Chem. 140A or equivalent).* (**Note**: Students may not receive credit for both Chem. 114A and BIBC 100.) (F)

114B. Biochemical Energetics and Metabolism (4)
This course is an introduction to the metabolic reactions in the cell which produce and utilize energy. The course material will include energy-producing pathways: glycolysis, Krebs cycle, oxidative phosphorylation, fatty-acid oxidation. Biosynthesis of amino acids, lipids, carbohydrates, purines, pyrimidines, proteins, nucleic acids. *Prerequisite: Chem. 114A or BIBC 100.* (**Note**: Students may not receive credit for both Chem. 114B and BIBC 102.) (W)

114C. Biosynthesis of Macromolecules (4)
This course is a continuation of the introduction to biochemistry courses (114A and 114B). This quarter reviews the mechanisms of biosynthesis of macromolecules–particularly proteins and nucleic acids. Emphasis will be placed on how these processes are controlled and integrated with the metabolism of the cell. *Prerequisite: Chem. 114B or BIBC 102.* (**Note**: Students may not receive credit for both Chem. 114C and BIMM 100.) (S)

114D. Molecular and Cellular Biochemistry (4)
This course represents a continuation of 114C, or an introductory course for first- and second-year graduate students, and covers topics in molecular and cellular biochemistry. Emphasis will be placed on contemporary approaches to the isolation and characterization of mammalian genes and proteins, and molecular genetic approaches to understanding eukaryotic development and human disease. *Prerequisites: Chem. 114A-C or consent of instructor.* (May not be offered every year.)

115. Modeling Biological Macromolecules (4)
Use of computer graphics and modeling methods in the study of biological macromolecules. The course will cover basic methods and techniques. The objective is to provide a good working knowledge of the critical features of the methods and to provide a foundation for further study for those who wish to pursue these methods as research topics. *Prerequisite: Chem. 114A or equivalent.* (May not be offered every year.)

116. Chemistry of Enzyme Catalyzed Reactions (4)
A discussion of the chemistry of representative enzyme catalyzed reactions is presented. Enzyme reaction mechanisms and their relation to enzyme structure are emphasized. *Prerequisites: Chem. 140A-C, 114A, and 126 or 131.* (May not be offered every year.)

118. Pharmacology and Toxicology (4)
A survey of the biochemical action of drugs and toxins as well as their absorption and excretion. *Prerequisites: Chem. 140C or 141C; and Chem. 114C, or consent of instructor. Priorities will be given to PharmChem majors.*

120A. Inorganic Chemistry I (4)
The chemistry of the main group elements in terms of atomic structure, ionic and covalent bonding. Structural theory involving s, p, and unfilled d orbitals. Thermodynamic and spectroscopic criteria for structure and stability of compounds and chemical reactions of main group elements in terms of molecular structure and reactivity. *Prerequisite: a general chemistry course. Chem. 140A or 141A or equivalent course is recommended.* (F)

120B. Inorganic Chemistry II (4)
A continuation of the discussion of structure, bonding, and reactivity with emphasis on transition metals and other elements using filled d orbitals to form bonds. Coordination chemistry in terms of valence bond, crystal field, and molecular orbital theory. The properties and reactivities of transition metal complexes including organometallic compounds. *Prerequisite: Chem. 120A.* (W)

123. Advanced Inorganic Chemistry Laboratory (4)
Synthesis, analysis, and physical characterization of inorganic chemical compounds. A materials fee is required for this course. *Prerequisites: Chem. 120A, 143AM or 143A, and 143B. Chem. 120B and 143B may be taken concurrently.* (W,S)

124. Bioinorganic Chemistry (4)
The role of metal ions in biological systems, with emphasis on transition metal ions in enzymes that transfer electrons, bind oxygen, and fix nitrogen. Also included are metal complexes in medicine, toxicity, and metal ion storage and transport. *Prerequisites: Chem. 6C or 6CH, 114A, and 120A recommended.* (May not be offered every year.)

126. Physical Chemistry (4)
An introduction to physical chemistry with emphasis on biochemical and environmental applications. Quantum mechanics and molecular structure, spectroscopy. *Prerequisites: Phys. 2D and Math. 20D or 21D; or consent of instructor.* (F)

127. Physical Chemistry (4)
An introduction to physical chemistry with emphasis on biochemical and environmental applications. Thermodynamics, first and second laws, thermochemistry, chemical equilibrium, solutions, kinetic theory, reaction kinetics. *Prerequisite: Chem. 126 or consent of instructor.* (W)

131. Physical Chemistry (4)
Thermodynamics, chemical equilibrium, phase equilibrium, chemistry of solutions. *Prerequisites: Math. 20C or 21C, and Phys. 2B. Recommended: Math. 20D or 21D, and Phys. 2D.* (F)

132. Physical Chemistry (4)
Chemical statistics, kinetic theory, reaction kinetics. *Prerequisites: Math. 20D or 21D, and Phys. 2B. Recommended: Phys. 2D.* (W)

133. Physical Chemistry (4)
Quantum mechanics, atomic and molecular spectroscopy, molecular structure. *Prerequisites: Chem. 132 and Phys. 2D; or Chem. 6C, Math. 20D or 21D, Math. 20F, and Phys. 2AB; or consent of instructor.* (S)

134. Computer Programming in Chemistry (4)
Use of computer programming in the analysis and presentation of chemical data (statistical analysis, least squares fitting procedures, titration curve interpretation, analysis of radioactive decay series, chemical kinetics, organic synthesis, etc.) *Prerequisites: Math. 20A and 20B or equivalent.* (**Note**: Students may not receive credit for both Chem. 134 and BIBC 115.) (May not be offered every year.)

135. Molecular Spectroscopy (4)
Time-dependent behavior of systems; interaction of matter with light; selection rule. Radiative and nonradiative processes, coherent phenomena, and the density matrices. Instrumentation, measurement, and interpretation. *Prerequisites: Chem. 133 or equivalent. Math. 20D or 21D, or Chem. 190/290.* (May not be offered every year.)

140A. Organic Chemistry I (4)
Introduction to organic chemistry, with applications to biochemistry. Bonding theory, isomerism, stereochemistry, chemical and physical properties. Introduction to substitution, addition, and elimination reactions. Students may not receive credit for both Chem. 140A and Chem. 141A. *Prerequisite: Chem. 6C or equivalent course in general chemistry. (F,W,S)*

140B. Organic Chemistry II (4)
Continuation of Organic Chemistry I, 140A. Methods of analysis, chemistry of hydrocarbons, chemistry of the carbonyl group. Introduction to the reactions of biologically important molecules. Students may not receive credit for both Chem. 141B and Chem. 140B. *Prerequisite: Chem. 140A (a grade of C or higher in Chem. 140A is strongly recommended).* (F,W,S)

140C. Organic Chemistry III (4)
Continuation of Organic Chemistry I (140A) and Organic Chemistry II (140B). Organic chemistry of biologically important molecules: carboxylic acids, carbohydrates, proteins, fatty acids, biopolymers, natural products. Students may not receive credit for both Chem. 140C and Chem. 141C. *Prerequisite: Chem. 140B (a grade of C or higher in Chem. 140B is strongly recommended).* (F,W,S)

141A. Organic Chemistry (4)
Chem. 141A introduces theoretical and experimental studies of structure and properties of covalent molecules. Both resonance and simple molecular orbital descriptions of organic compounds are introduced and spectroscopic methods for determining electronic and molecular structure are discussed. Organic reactions are introduced with synthetic and mechanistic examples. *Prerequisites: Chem. 6C (6C may be taken concurrently by good students). Prior or concurrent physics recommended.* (**Note**: Students may not receive credit for both Chem. 141A and Chem. 140A.) (F)

141B. Organic Chemistry (4)
A continuation of Chem. 141A, this course applies the structure-reactivity, spectroscopy, and electronic theories introduced in Chem. 141A to organic reactions. *Prerequisite: Chem. 141A or consent of instructor.* (**Note**: Students may not receive credit for both Chem. 141B and Chem. 140B.) (W)

141C. Organic Chemistry (4)
A continuation of Chem. 141A-B, this course treats selected topics such as carbon-metal bonds, organometallic chemistry, electrophilic reactions, free radical reactions, alkane chemistry, polymerization, molecular orbital theory and electrocyclic reactions, photochemistry, unstable intermediates such as carbenes, benzyne, etc., and metal oxidation reactions, and an introduction to carbohydrate and protein chemistry. *Prerequisite: Chem. 141B or consent of instructor.* (**Note**: Students may not receive credit for both Chem. 141C and Chem. 140C.) (S)

143A. Organic Chemistry Laboratory (4)
Introduction to laboratory techniques needed in organic chemistry. Stresses physical methods including separation and purification, spectroscopy, product analysis and effects of reaction conditions. *Prerequisites: Chem. 6BL and Chem. 140A or Chem. 141A.* (**Note**: Students may not receive credit for both Chem. 143A and Chem. 143AM.) A materials fee is required for this course. (F,W,S)

143AM. Advanced Organic Chemistry Laboratory (4)
An organic chemistry laboratory intended for chemistry majors only. It is similar to Chem. 143A, but with emphasis on instrumental methods of product identification, separation, and analysis. *Prerequisites: Chem. 6BL, Chem. 140A or Chem. 141A. (**Note**: Students may not receive credit for both Chem. 143AM and Chem. 143A.) This course is restricted to majors only*. A materials fee is required for this course. (W)

143B. Organic Chemistry Laboratory (4)
Continuation of Chem. 143AM or 143A, emphasizing synthetic methods of organic chemistry. *Prerequisites: Chem. 143AM or 143A, Chem. 140B (may be taken concurrently). Enrollment is limited to majors in the Department of Chemistry and Biochemistry, unless space is available.* A materials fee is required for this course. (W,S)

143C. Organic Chemistry Laboratory (5)
Identification of unknown organic compounds by a combination of chemical and physical techniques. This course is intended for chemistry majors only. *Prerequisites: Chem. 6CL and 143 AM or 143A or equivalent (may be taken concurrently); 143B recommended.* A materials fee is required for this course. (F)

143D. Molecular Design and Synthesis (4)
Advanced organic synthesis. Relationships between molecular structure and reactivity using modern synthetic methods and advanced instrumentation. Stresses importance of molecular design, optimized reaction conditions for development of practically useful synthesis, and problem-solving skills. *Prerequisites: Chem. 140C and Chem. 143B.* A materials fee is required for this course. (S)

149A. Environmental Chemistry (4)
The chemical basis of air and water pollution, chlorofluorocarbons and the ozone hole, the environmental impact of radioactive waste disposal, mineral resource usage, and nuclear energy. *Prerequisites: Chem. 6C or 6CH or equivalent.* (F)

149B. Environmental Chemistry (4)
Agricultural productivity, biological impact on the environment, deforestation, environmental disasters (fires, nuclear winter, and volcanoes), and organic waste handling. *Prerequisite: Chem. 149A.* (W)

152. Synthetic Methods in Organic Chemistry (4)
(Formerly Chem. 148) A survey of reactions of particular utility in the organic laboratory. Emphasis is on methods of preparation of carbon-carbon bonds and oxidation reduction sequences. *Prerequisites: Chem. 140C or Chem. 141C or consent of instructor.*

154. Mechanisms of Organic Reactions (4)
(Formerly Chem. 147) A qualitative approach to the mechanisms of various organic reactions; substitutions, additions, eliminations, condensations, rearrangements, oxidations, reductions, free-radical reactions, and photochemistry. Includes considerations of molecular structure and reactivity, synthetic methods, spectroscopic tools, and stereochemistry. The topics emphasized will vary from year to year. This is the first quarter of the advanced organic chemistry sequence. *Prerequisites: Chem. 140C or 141C.*

155. Synthesis of Complex Molecules (4)
(Formerly Chem. 144) This course discusses planning economic routes for the synthesis of complex organic molecules. The uses of specific reagents and protecting groups will be outlined as well as the control of stereochemistry during a synthesis. Examples will be selected from the recent literature. (May not be offered every year.) *Prerequisites: Chem. 152 or 252 or consent of instructor.*

156. Structure and Properties of Organic Molecules (4)
(Formerly Chem. 145) Introduction to the measurement and theoretical correlation of the physical properties of organic molecules. Topics covered include molecular geometry, molecular-orbital theory, orbital hybridization, aromaticity, chemical reactivity, stereochemistry, infrared and electronic spectra, photochemistry, and nuclear magnetic resonance. *Prerequisites: Chem. 140A-B-C or 141A-B-C or the equivalent.*

157. Bioorganic and Natural Products Chemistry (4)
(Formerly Chem. 142) A comprehensive survey of modern bioorganic and natural products chemistry. Topics will include biosynthesis of natural products, molecular recognition, and small molecule-biomolecule interactions. *Prerequisites: Chem. 140C or 141C or 254 or consent of the instructor.*

161. Supramolecular Coordination Chemistry (4)
An introduction and survey of modern coordination chemistry. Topics will include structure and bonding of alkali, transition, lanthanide and actinide metals, with emphasis on the first row transition metals; stereochemistry, coordination clusters, molecular solids and nanoparticles. *Prerequisites: Chem. 120A and 120B or equivalent.*

166. Environmental and Molecular Toxicology
Molecular and cellular mechanisms underlie the actions of environmental toxicants. This course will investigate approaches to study the impact of environmental toxicants on human health. Other modern approaches that are being implemented to detect and remediate environmental toxicants will also be examined. *Prerequisites: Chem. 114A-B.*

168. Bioenergetics (4)
Chemiosmotic processes in mitochondria and photosynthetic organelles, structure-function relationships of membrane protein apoptosis, a refined view of mitochondrial structure deduced from electron tomography, and the role of proteins encoded by mitochondrial DNA in oxidative phosphorylation. *Prerequisites: Chem. 114 A and Chem. 114B (or equivalents.)*

170. Cosmochemistry (4)
Composition of stars, of planets, of meteorites, and the earth. Nuclear stability rules and isotopic composition of the elements. Chemical properties of solar matter. Origin of the elements and of the solar system *Prerequisite: general chemistry sequence.*

171. Nuclear and Radiochemistry (4)
Radioactive decay, stability systematics, neutron activation, nuclear reactions. Szilard-Chalmers reactions, hot-atom chemistry, radiation chemistry, effects of ionizing radiation. *Prerequisite: general chemistry sequence.*

173. Atmospheric Chemistry (4)
Chemical principles applied to the study of atmospheres. Atmospheric photochemistry, radical reactions, chemical lifetime determinations, acid rain, greenhouse effects, ozone cycle, and evolution are discussed. *Prerequisites: Chem. 6A-6C or 6AH, 6BH, and 6CH, or equivalent.* (S)

182. Biological Databases (4)
This course provides an introduction to the features of biological data, how those data are organized efficiently in databases, and how existing data resources can be utilized to solve a variety of biological problems. Object oriented databases, data modeling, and description. Survey of current biological database with respect to above, implementation of database on a biological topic. *Prerequisite: CSE 100 or Math. 176. Bioinformatics majors only.*

184. Computational Molecular Biology (4)
This advanced course covers the application of machine learning and modeling techniques to biological systems. Topics include gene structure, recognition of DNA and protein sequence patterns, classification, and protein structure prediction. Pattern discovery, Kidden Markov models/support vector machines/ neural network/profiles, protein structure prediction, functional characterization or proteins, functional genomics/proteomics, metabolic pathways/gene networks. *Prerequisites: BIMM 181 or BENG 181 or CSE 181; BIMM 182 or BENG 182 or CSE 182 or CHEM 182. Bioinformatics majors only.*

185. Introduction to Computational Chemistry (4)
Course in computational methods building on a background in mathematics and physical chemistry. Brief introduction and background in computational theory, molecular mechanics, semi-empirical methods, and ab initio-based methods of increasing elaboration. Emphasis on applications and reliability. *Prere-quisites: Chem. 126 or 133 and Math. 20C or 21C.* (May not be offered every year.)

190. Mathematical Methods in Chemistry I (4)
Applied mathematics useful in kinetics, spectroscopy, thermodynamics, statistical mechanics and quantum mechanics; ordinary and partial differential equations, vector spaces, operators, linear algebra, numerical analysis. *Prerequisites: general chemistry, calculus.* (May not be offered every year.)

195. Methods of Teaching Chemistry (4)
An introduction to teaching chemistry. Students are required to attend a weekly class on methods of teaching chemistry, and will teach a discussion section of one of the lower-division chemistry courses. Attendance at lecture of the lower-division course in which the student is participating is required. (P/NP grades only.) *Prerequisite: consent of instructor.* (F,W,S)

196. Reading and Research in Chemical Education (2 or 4)
Independent literature or classroom research by arrangement with, and under the direction of, a member of the Department of Chemistry and Biochemistry

faculty. Students must register on a P/NP basis. *Prerequisites: upper-division standing, 2.5 minimum GPA, consent of instructor and department.* (F,W,S)

199. Reading and Research (2 or 4)
Independent literature or laboratory research by arrangement with, and under the direction of, a member of the Department of Chemistry and Biochemistry faculty. Students must register on a P/NP basis. *Prerequisites: upper-division standing, 2.5 minimum GPA, consent of instructor and department.* (F,W,S)

GRADUATE

207. Modern NMR Methods (4)
Treats varied pulse sequences, one- and two-dimensional methods, interpretation of relaxation rates, spin-decoupling, multiple quantum filtering, and solvent suppression with application to liquid crystals, membranes, small molecules, proteins, and nucleic acids. *Prerequisite: does not require extensive mathematics, but Chem. 130 recommended.* (May not be offered every year.)

209. Macromolecular Recognition (4)
Structures and functions of nucleic acids, folding and catalysis of nucleic acids, motifs and domains of proteins, principles of protein-protein interactions, chemistry of protein/DNA and protein/RNA interfaces, conformational changes in macromolecular recognition. *Prere-quisites: biochemistry background and graduate standing, or approval of instructor.*

211. Metabolic Biochemistry (4)
A comprehensive course in biochemistry emphasizing metabolic and human biochemistry. *Prerequisites: physical and organic chemistry; graduate standing.* (F)

213. Chemistry of Biological Macromolecules (4)
A discussion of the structural principles governing biological macromolecules, the techniques used in their study, and how their functional properties depend on three-dimensional structure. Chem. 213 students will be required to complete additional coursework beyond that expected of students in Chem. 113. *Prerequisites: elementary physical and organic chemistry.* (May not be offered every year.)

214. Molecular and Cellular Biochemistry (4)
This course represents a continuation of 114C, or an introductory course for first- and second-year graduate students, and covers topics in molecular and cellular biochemistry. Emphasis will be placed on contemporary approaches to the isolation and characterization of mammalian genes and proteins, and molecular genetic approaches to understanding eukaryotic development and human disease. Chem. 214 students will be required to complete additional coursework beyond that expected of students in Chem. 114D. *Prerequisite: Chem. 114A-C or consent of instructor.* (May not be offered every year.)

215. Modeling Biological Macromolecules (4)
Use of computer graphics and modeling methods in the study of biological macromolecules. The course will cover basic methods and techniques. The objective is to provide a good working knowledge of the critical features of the methods and to provide a foundation for further study for those who wish to pursue these methods as research topics. Chem. 215 students will be required to complete additional coursework beyond that expected of students in Chem. 115. *Prerequisite: Chem. 114A or equivalent.* (May not be offered every year.)

216. Chemistry of Enzyme Catalyzed Reactions (4)
A discussion of the chemistry of representative enzyme catalyzed reactions is presented. Enzyme reaction mechanisms and their relation to enzyme structure are emphasized. Chem. 216 students will be required to complete additional coursework beyond that expected of students in Chem. 116. *Prerequisites: Chem. 140A-B-C, 114A and 126 or 131.* (May not be offered every year.)

218. Macromolecular Biochemistry (4)
A comprehensive course in biochemistry emphasizing structural biochemistry. *Prerequisites: physical and organic chemistry; graduate-student standing.* (F)

219A-B-C. Special Topics in Biochemistry (4-4-4)
This special topics course is designed for first-year graduate students in biochemistry. Topics presented in recent years have included protein processing, the chemical modification of proteins, the biosynthesis and function of glycoproteins, lipid biochemistry and membrane structure, and bioenergetics. *Prerequisites: undergraduate courses in biochemistry. Chem. 114A or equivalent.* (May not be offered every year.)

221. Signal Transduction (4)
The aim of this course is to develop an appreciation for a variety of topics in signal transduction. We will discuss several historical developments while the focus will be on current issues. Both experimental approaches and results will be included in our discussions. Topics may vary from year to year. *Prerequisites: biochemistry and molecular biology.* (May not be offered every year.)

222. Structure and Analysis of Solids (4)
Key concepts in the atomic structure and bonding of solids such as metals, ceramics, and semiconductors. Symmetry operations, point groups, lattice types, space groups, simple and complex inorganic compounds, structure/property comparisons, structure determination with X-ray diffraction. Ionic, covalent, metallic bonding compared with physical properties. Atomic and molecular orbitals, bands versus bonds, free electron theory.

223. Organometallic Chemistry (4)
A survey of this field from a synthetic and mechanistic viewpoint. Reactivity patterns for both main group and transition element organometallic compounds will be discussed and organized according to periodic trends. (May not be offered every year.)

224. Spectroscopic Techniques (4)
Application of physical techniques to the elucidation of the structure of inorganic complex ions and organometallic compounds. Topics covered include group theory, and its application to vibrational, magnetic resonance and Raman spectroscopy. (May not be offered every year.)

225. Bioinorganic Chemistry (4)
The role of metal ions in biological systems, with emphasis on transition metal ions in enzymes that transfer electrons, bind oxygen, and fix nitrogen. Also included are metal complexes in medicine, toxicity, and metal ion storage and transport. Chem. 225 students will be required to complete an additional paper and/or exam beyond that expected of students in Chem. 124. *Prerequisites: Chem. 6C or 6CH. Chem. 114A and 120A recommended.* (May not be offered every year.)

227. Seminar in Inorganic Chemistry (2)
Seminars presented by faculty and students on topics of current interest in inorganic chemistry, including areas such as bioinorganic, organometallic and physical-inorganic chemistry. The course is designed to promote a critical evaluation of the available data in specialized areas of inorganic chemistry. Each quarter three or four different topics will be discussed. *Prerequisite: graduate standing or consent of instructor.* (S/U grades only.)

228. Solid State Chemistry (4)
Survey of the chemistry of semiconductors, superconductors, molecular magnetic materials, zeolites, fast ion conductors, electronically conducting polymers and ceramics. Synethetic techniques such as molecular precursor design, the sol-gel process, electrosynthesis, and high-temperature thermolysis will be covered. (May not be offered every year.)

229. Special Topics in Inorganic Chemistry (2-4)
Selection of topics of current interest. May be repeated for credit when topics vary. (May not be offered every year.)

230. Quantum Mechanics (4)
Concepts and mathematical formalism that are useful for problems of chemical interest: states, representations, operators, eigenvalues and eigenfunctions, time evolution, observables, and measurements. Time-independent perturbation theory. *Prerequisites: Chem. 133 or equivalent; Math. 20D or equivalent; Chem. 190 may be taken concurrently.* (May not be offered every year.)

231. Chemical Kinetics and Molecular Reaction Dynamics (4)
Classical kinetics, transition state theory, unimolecular decomposition, potential energy surfaces; scattering processes and photodissociation processes. *Prerequisite: Chem. 230.* (May not be offered ever year.)

232. Statistical Mechanics of Chemical Systems (4)
Equilibrium statistical mechanics, distribution functions, and partition functions. Boltzman, Bose, and Fermi statistics. The different ensembles; ensemble averages and QM expectation values; derivation of thermodynamic properties of simple systems. *Prerequisites: Chem. 131, 132 and 133, or equivalent.* (May not be offered every year.)

235. Molecular Spectroscopy (4)
Time-dependent behavior of systems; interaction of matter with light; selection rule. Radiative and nonradiative processes, coherent phenomena and the density matrices. Instrumentation, measurement, and interpretation. Chem. 235 students will be required to complete additional coursework beyond that expected of students in Chem. 135. *Prerequisites: Chem. 133 or equivalent; Math. 20D or 21D; or Chem. 190/290.* (May not be offered every year.)

236. Atherosclerosis (2 or 4)
Multidisciplinary course integrating topics concerning the pathogenesis of arteriosclerosis, with emphasis on cholesterol and lipoprotein metabolism, and the cellular and biochemical mechanisms of lesion development. Topics include relationship of coronary heart disease to hyperlipoproteinemias, management of risk factors, and therapeutic approaches. Two-hour lectures. Same as Medicine 236. *Prerequisite: biochemistry.* (May not be offered every year.)

237. Essentials of Glycobiology (4)
Advanced elective for graduate/medical students who have had core courses in cell biology or biochemistry. Expert faculty will present a coordinated overview of the field of glycobiology, which explores the structure,

synthesis, and functions of sugar chains in biological systems. (May not be offered every year.)

239. Special Topics in Chemical Physics (2-4)
Topics of special interest will be presented. Examples include NMR, solid-state chemistry, phase transitions, stochastic processes, scattering theory, nonequilibrium processes, tensor transformations, and advanced topics in statistical mechanics, thermodynamics, and chemical kinetics. (May not be offered every year.)

240. Electrochemistry (4)
Application of electrochemical techniques to chemistry research. Basic electrochemical theory and instrumentation: the diffusion equations, controlled potential, and current methods. Electro-chemical kinetics, Butler-Volmer, Marcus-Hush theories, preparative electrochemistry, analytical electrochemistry, solid and polymer electrolytes, semiconductor photoelectrochemistry. (May not be offered every year.)

246. Kinetics and Mechanism (4)
Methodology of mechanistic organic chemistry: integration of rate expressions, determination of rate constants, transition state theory; catalysis, kinetic orders, isotope effects, substituent effects, solvent effects, linear free energy relationship; product studies, stereochemistry; reactive intermediates; rapid reactions. (May not be offered every year.)

250. Seminar in Chemistry (2)
Regularly scheduled seminars by first-year graduate students provide opportunities for practice in seminar delivery and for the exploration of topics of general interest. (S/U grades only.) (S)

251. Research Conference (2)
Group discussion of research activities and progress of the group members. *Prerequisite: consent of instructor.* (S/U grades only.) (F,W,S)

252. Synthetic Methods in Organic Chemistry (4)
(Formerly Chem. 248) A survey of reactions of particular utility in the organic laboratory. Emphasis is on methods of preparation of carbon-carbon bonds and oxidation reduction sequences. Chem. 252 students will be required to complete additional coursework beyond that expected of students in Chem. 152. *Prerequisite: Chem. 140C or 141C or consent of instructor.*

254. Mechanisms of Organic Reactions (4)
(Formerly Chem. 247) A qualitative approach to the mechanisms of various organic reactions; substitutions, additions, eliminations, condensations, rearrangements, oxidations, reductions, free-radical reactions, and photochemistry. Includes considerations of molecular structure and reactivity, synthetic methods, spectroscopic tools, and stereochemistry. The topics emphasized will vary from year to year. This is the first quarter of the advanced organic chemistry sequence. Chem. 254 students will be required to complete an additional paper and/or exam beyond that expected of students in Chem. 154. *Prerequisites: Chem. 140C or 141C or graduate standing.*

255. Synthesis of Complex Molecules (4)
(Formerly Chem. 244) This course discusses planning economic routes for the synthesis of complex organic molecules. The uses of specific reagents and protecting groups will be outlined as well as the control of stereochemistry during a synthesis. Examples will be selected from the recent literature. Chem. 255 students will be required to complete an additional paper and/or exam beyond that expected of students in Chem. 155. (May not be offered every year.) *Prerequisites: Chem. 152 or 252 or consent of instructor.*

256. Structure and Properties of Organic Molecules (4)
(Formerly Chem. 245) Introduction to the measurement and theoretical correlation of the physical properties of organic molecules. Topics covered include molecular geometry, molecular-orbital theory, orbital hybridization, aromaticity, chemical reactivity, stereochemistry, infrared and electronic spectra, photochemistry, and nuclear magnetic resonance. Chem. 256 students will be required to complete an additional paper and/or exam beyond that expected of students in Chem. 156. *Prerequisites: Chem. 140ABC or 141ABC or the equivalent.*

257. Biorganic and Natural Products Chemistry (4)
(Formerly Chem. 242) A comprehensive survey of modern bioorganic and natural products chemistry. Topics include biosynthesis of natural products, molecular recognition, and small molecule-biomolecule interactions. Chem. 257 students will be required to complete additional coursework beyond that expected of students in Chem. 157. *Prerequisites: Chem. 140C or 141C, 254 or consent of instructor.*

258. Applied Spectroscopy (4)
Intensive coverage of modern spectroscopic techniques used to determine the structure of organic molecules. Problem solving and interpretation of spectra will be strongly emphasized. *Prerequisites: Chem. 254 or consent of instructor.*

259. Special Topics in Organic Chemistry (2-4)
(Formerly Chem. 249) Various advanced topics in organic chemistry. Includes but is not limited to: advanced kinetics, advanced spectroscopy, computational chemistry, heterocyclic chemistry, medicinal chemistry, organotransition metal chemistry, polymers, solid-phase synthesis/combinatorial chemistry, stereochemistry, and total synthesis classics.

261. Supramolecular Coordination Chemistry (4)
An introduction and survey of modern coordination chemistry. Topics will include structure and bonding of alkali, transition, lanthanide, and actinide metals, with emphasis on the first row transition metals; stereochemistry, coordination clusters, molecular solids and nanoparticles. Chem. 261 students will be required to complete additional coursework beyond that expected of students in Chem. 161. *Prerequisites: Chem. 120A, 120B or equivalent; or graduate standing.*

262. Inorganic Chemistry and NMR (4)
A survey of inorganic chemistry to prepare for graduate research in the field, including a detailed introduction to nuclear magnetic resonance (NMR), followed by applications of NMR to structural and mechanistic problems in inorganic chemistry.

266. Environmental and Molecular Toxicology
Molecular and cellular mechanisms underlie the actions of environmental toxicants. This course will investigate approaches to study the impact of environmental toxicants on human health. Other modern approaches that are being implemented to detect and remediate environmental toxicants will also be examined.

268. Bioenergetics (4)
Chemiosmotic processes in mitochondria and photosynthetic organelles, structure-function relationships of membrane protein apoptosis, a refined view of mitochondrial structure deduced from electron tomography and the role of proteins encoded by mitochondrial DNA in oxidative phosphorylation. Chem. 268 students will be required to complete additional coursework beyond that expected of students in Chem. 168. *Prerequisites: Chem. 114 A and Chem. 114B (or equivalents.)*

270A-B-C. Current Topics in Environmental Chemistry (2-2-2)
Seminar series on the current topics in the field of environmental chemistry. Emphasis is on current research topics in atmospheric, oceanic, and geological environments. *Prerequisite: consent of instructor.* (S/U grades only.) (May not be offered every year.)

273. Atmospheric Chemistry
Chemical principles applied to the study of atmospheres. Atmospheric photochemistry, radical reactions, chemical lifetime determinations, acid rain, greenhouse effects, ozone cycle, and evolution are discussed. Chem. 273 students will be required to complete additional coursework beyond that expected of students in Chem. 173. *Prerequisites: Chem. 6A-B-C, or Chem. 6AH, 6BH and 6CH, or equivalent, or graduate standing.* (S)

285. Introduction to Computational Chemistry (4)
Course in computational methods building on a background in mathematics and physical chemistry. Brief introduction and background in computational theory, molecular mechanics, semi-empirical methods, and ab initio-based methods of increasing elaboration. Emphasis on applications and reliability. Chem. 285 students will be required to complete an additional paper and/or exam beyond that expected of students in Chem. 185. *Prerequisites: Chem. 126 or 133 and Math. 20C or 21C.* (May not be offered every year.)

290. Mathematical Methods in Chemistry I (4)
Applied mathematics useful in kinetics, spectroscopy, thermodynamics, statistical mechanics, and quantum mechanics; ordinary and partial differential equations, vector spaces, operators, linear algebra, numerical analysis. Chem. 290 students will be required to complete additional coursework beyond that expected of students in Chem. 190. *Prerequisites: general chemistry, calculus.* (May not be offered every year.)

293. Cosmochemistry Seminar (2)
Formal seminars or informal sessions on topics of current interest in cosmochemistry as presented by visiting lecturers, local researchers, or students. *Prerequisite: advanced graduate-student standing.* (S/U grades only.)

294. Organic Chemistry Seminar (2)
Formal seminars or informal puzzle sessions on topics of current interest in organic chemistry, as presented by visiting lecturers, local researchers, or students. *Prerequisite: advanced graduate-student standing.* (S/U grades only.) (F,W,S)

295. Biochemistry Seminar (2)
Formal seminars or informal puzzle sessions on topics of current interest in biochemistry, as presented by visiting lecturers, local researchers, or students. *Prerequisite: graduate-student standing.* (S/U grades only.)

296. Chemical Physics Seminar (2)
Formal seminars or informal sessions on topics of current interest in chemical physics as presented by visiting lecturers, local researchers, or students. *Prerequisite: advanced graduate-student standing.* (S/U grades only.) (F,W,S)

297. Experimental Methods in Chemistry (4)
Experimental methods and techniques involved in chemical research are introduced. Hands-on experience provides training for careers in industrial research and for future thesis research. *Prerequisite: graduate standing.*

298. Special Study in Chemistry (1-4)
Reading and laboratory study of special topics for first-year graduate students under the direction of a faculty member. Exact subject matter to be arranged in individual cases. (S/U grades only.) *Prerequisite: first-year graduate student standing*. (F,W,S)

299. Research in Chemistry (1-12)
Prerequisites: graduate standing and consent of instructor. (S/U grades only.) (F,W,S)

500. Teaching in Chemistry (4)
A doctoral student in chemistry is required to assist in teaching undergraduate chemistry courses. One meeting per week with instructor, one or more meetings per week with assigned class sections or laboratories, and attendance at the lecture of the undergraduate course in which he or she is participating. *Prerequisites: graduate standing and consent of instructor.* (S/U grades only.) (F,W,S)