Department of Biological, Chemical and Physical Sciences

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Chair:
John Zasadzinski

Associate Chairs:
Howard A. Rubin, Physics
Benjamin C. Stark, Biology
Rong Wang, Chemisty

The Department of Biological, Chemical and Physical Sciences offers B.S., M.S. and Ph.D. degrees in the fields of chemistry, biology, physics, and molecular biochemistry and biophysics. Within the department, there are many opportunities for interdisciplinary education and research experiences; students in any of the disciplines have easy access to the expertise that the full faculty brings. In addition, the department offers several professional masters degrees and related certificate programs for part-time students, both on campus and through distance learning.

Degrees Offered

Master of Biology
Master of Science in Biology with specialization in:
- Biochemistry
- Biotechnology
- Cell and Molecular Biology
- Microbiology

Master of Science in Molecular Biochemistry and Biophysics
Master of Chemistry
Master of Chemistry in Analytical Chemistry
Master of Chemistry in Materials and Chemical Synthesis
Master of Science in Chemistry
Master of Health Physics
Master of Science in Physics
Doctor of Philosophy in Biology
Doctor of Philosophy in Chemistry
Doctor of Philosophy in Molecular Biochemistry and Biophysics
Doctor of Philosophy in Physics

Certificate Programs

Analytical Methods Development
Analytical Spectroscopy
Characterization of Inorganic and Organic Materials
Chromatography
Radiological Physics
Synthesis and Characterization of Inorganic Materials
Synthesis and Characterization of Organic Materials

Research Centers

Center for Synchrotron Radiation Research and Instrumentation

Center for Accelerator and Particle Physics

Research Facilities

The department has state-of-the-art computer and laboratory equipment and conducts research in the areas of biochemistry, biotechnology, cell and molecular biology, microbiology, molecular biophysics and biochemistry; analytical chemistry, inorganic chemistry, solid-state and materials chemistry, organic chemistry, polymer chemistry, surface chemistry, physical chemistry and theoretical chemistry; and high-energy physics, accelerator and plasma physics, condensed-matter physics, biological physics, x-ray optics, x-ray imaging and quantum theory. The department constructs and operates facilities for x-ray scattering, spectroscopy and imaging at the Advanced Photon Source at Argonne National Laboratory. Additional research facilities include on-campus x-ray diffraction facilities, thin-film growth facilities, a high-field nuclear magnetic resonance facility, state-of-the-art inorganic-, organic- and polymer synthesis and characterization laboratories, Fourier transform infrared spectrometers, atomic force microscope, mass spectrometers, and facilities for high-pressure liquid chromatography and gas chromatography. Laboratories for experimental research in biophysics, low-temperature, solid-state physics and particle physics are active. Collaborative programs are carried on with Fermi National Accelerator Laboratory, Argonne National Laboratory, and the Advanced Photon Source. The department hosts the Center for Accelerator and Particle Physics (CAPP) and the Center for Synchrotron Radiation Research and Instrumentation (CSRRI).

Faculty

Biology

Martin Cole, Research Professor and Director of the National Center for Food Safety and Technology. B.S., Manchester Metropolitan University; Ph.D., University of East Anglia (England). Studies of issues related to food safety technologies and policies.

Douglas J. Cork, Professor. B.S., M.S., Ph.D., University of Arizona. Biotechnology and bioremediation, microbial metabolism of xenobiotics, informatics.

Michael Cummings, Research Professor. B.S., St. Mary's University; Ph.D., Northwestern University. Research on human chromosome organization and the development of innovative methods for teaching biology.

Andrew Howard, Associate Professor and Director of the Health Physics Program. B.A., Pomona College; Ph.D., University of California, San Diego. Structure and function of immune system proteins, macromolecular crystallography.

Thomas C. Irving, Professor and Director of the Biophysics Collaborative Access Team. B.Sc., M.Sc., Ph.D., University of Guelph (Canada). Structure and biophysics of macromolecular systems, muscle structure and physiology, synchrotron radiation instrumentation.

David L. McCormick, Professor, and Senior Vice President and Director of the IIT Research Institute B.A., Middlebury College; Ph.D., New York University. Preclinical development of drugs for the prevention and therapy of cancer.

Rajendra Mehta, Professor and Assistant Vice President of the IIT Research Institute. B.Sc., Gujurat Univeristy; Ph.D., University of Nebraska-Lincoln. Efficacy and mechanism of action of chemopreventive agents in experimental carcinogenesis of breast, colon, lung and prostate.

Nick Menhart, Assistant Professor. B.Sc., Ph.D., University of Waterloo (Canada). Spectroscopic techniques for the study of multi-domain proteins.

Joseph Orgel, Assistant Professor. B.Sc., Ph.D., University of Stirling (Scotland). Study of fundamental structural biochemistry problems that have direct links to the understanding and treatment of disease, primarily of the extra cellular matrix of mammals.

Sadhana Ravishankar, Research Associate Professor. B.S., M.S., Tamilnadu Agricultural University; Ph.D., University of Georgia. Stress tolerance responses of foodborne pathogens, control of foodborne pathogens by non-thermal technology, biofilm formation and control, natural antimicrobials, control of foodborne pathogens by multiple hurdle approach.

Peter Slade, Research Associate Professor. B.S., University of Leeds; Ph.D., University of Guelph (Canada). Antimicrobial treatments applied to seeds, vegetable sprouts, and ready-to-eat meat products, novel processing technologies, development of rapid methods for the detection of food borne pathogens, hygienic design of food processing facilities and equipment.

Kathryn M. Spink, Senior Lecturer. B.S., Michigan Technological University; Ph.D., Michigan State University. Molecular genetics of mammalian viruses.

Benjamin C. Stark, Professor, Associate Chair of the Department, and Director of the Master of Biology Program. B.S., University of Michigan; M.Ph., Ph.D., Yale University. Biochemistry and molecular biology of bacterial respiration, fermentation, bioremediation.

Cynthia Stewart, Research Assistant Professor. B.S., University of Delaware; PhD, Rutgers University. High pressure and other nonthermal technologies, such as cold pasteurization or commercial sterilization processes, to improve the quality and safety of foods.

Stuart Taylor, Research Professor. B.A., Cornell University; Ph.D., New York University. Optical and biophysical methods to study how contractile function follows molecular form.

Dale A. Webster, Emeritus and Research Professor. B.S., University of Michigan; Ph.D., University of California, Berkeley. Biochemistry and molecular biology of bacterial respiration, biotechnology and bioremediation.

Jialing Xiang, Assistant Professor. M.D., Xuzhou Medical College; Ph.D. University of Alabama, Birmingham. Molecular mechanisms of cancer and cancer gene therapy.

Chunbo Zhang, Assisitant Professor. B.S., Ningbo Univeristy; Ph.D., University of Manitoba (Canada). Use of molecular genetics, biophysics, immunohistochemistry, pharmacology, and behavior to study olfactory transduction in the mouse.

Wei Zhang, Assistant Professor. B.S., Huazhong Agricultural University; Ph.D., Pennsylvania State University. Molecular detection, genotyping, epidemiology, virulence and pathogenesis of foodborne bacteria.

Yu-Zhu Zhang, Assistant Professor, B.S. Zhengzhou University; Ph.D., University of Pennsylvania. Structure and function of biomolecular processes involved in cell cycle control, dim1 protein structure.

Department of Biological, Chemical and Physical Sciences

Chemistry

Sandra Whaley Bishnoi, Assistant Professor of Chemistry. B.S., Ph.D., University of Texas at Austin. Synthesis and analysis of inorganic nanoparticles, biomolecular recognition, surface science, analytical chemistry, nanobiotechnology, development of nanoparticle delivery methods, and surface enhanced Raman scattering.

William Buttner, Research Professor of Chemistry. B.S., Loyola University of Chicago; Ph.D., Michigan State University. Basic and applied research in analytical chemistry, environmental chemistry, and electrochemistry; understanding and developing chemical sensors and sensor array instrumental devices with novel structures and new materials for industrial and medical applications.

Hyun-soon Chong, Assistant Professor. B.S., M.S. Kyung Hee University; Ph.D. University of North Texas. Synthetic and mechanistic organic chemistry, macrocyclic chemistry, cancer therapeutics and diagnostics, medicinal chemistry, bioorganic and bioinorganic chemistry, biologically active synthetic and natural products, heterocyclic chemistry, molecular recognition studies, nanobiotechnology.

Walter C. Eisenberg, Emeritus Professor of Chemistry and Director of the Analytical Chemistry Program. B.S. University of Toronto (Canada); M.S., Rochester Institute of Technology; Ph.D., University of Buffalo. Organic-, oxidant- and single oxygen chemistry, biochemistry, air pollution, polycyclic aromatic hydrocarbon transformation, analytical methods development, professional graduate education.

Mohamed El-Maazawi, Senior Lecturer of Chemistry. B.S., University of Alexandria; Ph.D., Pennsylvania State University.

Robert Filler, Emeritus Professor of Chemistry, Senior Research Fellow. B.S., City College of New York; Ph.D., University of Iowa. Heterocyclic compounds, effects of fluorine in fluorine-containing compounds.

Peter Y. Johnson, Professor of Chemistry. B.S., University of Illinois, Urbana-Champaign; Ph.D., Massachusetts Institute of Technology. Syntheses of penicillin related compounds; photochemical and/or transannular reactions.

M. Ishaque Khan, Professor of Chemistry, Associate Dean of the College of Science and Letters, and Director of the Materials and Chemical Synthesis Program. Ph.D., Indian Institute of Technology (India). Synthesis, characterization and properties of inorganic and organic-inorganic hybrid materials of current technological, environmental and fundamental interest. Fabrication of nanostructured materials with desirable catalytic, electronic, magnetic and conducting properties that could be controlled and rationalized at the molecular level. Spectroscopy, x-ray crystallography and synchrotron radiation-based methods.

Peter Lykos, Professor of Chemistry. B.S., Northwestern University; Ph.D., Carnegie Institute of Technology. Physical chemistry, standards for undergraduate chemistry and chemistry curricula, combination theoretical (Hartree Fock) and experimental (synchrotron radiation) determination of correlation energy, semi-empirical methods in quantum chemistry, computer applications in chemistry.

Braja K. Mandal, Professor of Chemistry. B.Sc., University of Calucutta (India); M.Sc., M.Tech., Ph.D., Indian Institute of Technology (India). Polymer science and engineering, electroactive materials, phthalocyanines and porphyrins, solid polymer electrolytes, lithium battery materials.

Kenneth Schug, Professor of Chemistry. B.S., Stanford University; Ph.D., University of Southern California. Chemical education, coordination compounds of transition metals emphasizing chemical reactivity of ligands, enhancement programs for K–12 teachers, minority medical students programs, research opportunities for high school students.

Kenneth W. Stagliano, Associate Professor of Chemistry. B.S., Ph.D., Temple University. Organic chemistry, development of new chemical reactions for solving regiochemical and stereochemical problems for the total synthesis of biologically active natural products, medicinal chemistry, chemistry of the quinonoid compounds, new synthetic methods.

Joseph R. Stetter, Research Professor of Chemistry. B.S., Ph.D., State University of New York, Buffalo. Electroanalytical chemistry, environmental analytical chemistry, chemical sensors, detectors, development of new analytical methods.

Rong Wang, Associate Professor of Chemistry. B.S., Julin University; Ph.D., University of Tokyo (Japan). Examination of biological systems (living cells, e.g., neural cells, stem cells; bacterial spores; cancer tissues) in natural environments on the nanometer scale using molecular characterization methods such as probe scanning microscopy, surface engineering with new bio-conjugate chemistry, and molecular manipulation via photochemistry and nano-processing; fabrication of nanoscale devices via nano-manipulation.

Physics

Grant Bunker, Professor. B.A., Evergreen State College; Ph.D., University of Washington. X-ray absorption spectroscopy, biophysics, synchrotron radiation research, computational physics/chemistry.

Ray A. Burnstein, Emeritus and Research Professor. B.S., University of Chicago; M.S., University of Washington; Ph.D., University of Michigan. Experimental elementary particle physics, interactive teaching and technology.

Liam Coffey, Associate Professor. B.A., Trinity College (Ireland). Ph.D., University of Chicago. Condensed matter theory.

Thomas Erber, Distinguished Professor. B.S., Massachusetts Institute of Technology; M.S., Ph.D., University of Chicago. Electrodynamics, magnetism, fatigue, complex systems.

Laurence Friedman, Senior Lecturer and co-Director of the Health Physics program. B.S., University of Wisconsin; Ph.D. Rensselaer Polytechnic Institute. Health Physics, regulatory affairs.

Porter W. Johnson, Professor. B.S., Case Institute of Technology; M.A., Ph.D., Princeton University. Elementary particle theory, science education.

Daniel Kaplan, Professor and Director of the Center for Accelerator and Particle Physics. B.A., Haverford College; Ph.D., State University of New York, Stony Brook. Experimental high-energy physics, especially symmetry violation and rare decays of hyperons and charm and beauty hadrons, electronics for high-speed triggering and data acquisition.

Leon Lederman, Pritzker Professor of Physics, 1988 Nobel Laureate in Physics; Fermilab Director Emeritus. B.A., City College of New York; Ph.D., Columbia University. Experimental elementary particle physics.

James Longworth, Associate Professor. B.S., Ph.D., Sheffield University.

Timothy Morrison, Professor, Director of the Center for Synchrotron Radiation Research and Instrumentation. B.A., Western Michigan University; Ph.D., University of Illinois, Urbana-Champaign. Solid-state physics, catalysts, x-ray absorption, x-ray optics.

Ivan Nesch, Research Associate Professor, M.S., Sofia University; Ph.D., Moscow State University (Russia).

Howard A. Rubin, Professor, Associate Chair of the Department, and Director of Graduate Affairs. B.S., Massachusetts Institute of Technology; Ph.D., University of Maryland. Experimental elementary particle physics.

H. Larry Scott, Professor of Physics. B.S., Purdue University; Ph.D., Purdue University. Theoretical modeling and computer simulation of lipid bilayers and model biological membranes.

Carlo U. Segre, Professor, Associate Dean of Special Projects for the Graduate College, and Associate Director of the Materials Research Collaborative Access Team. B.S. in Physics, B.S. in Chemistry, University of Illinois, Urbana-Champaign; M.S., Ph.D., University of California, San Diego. Experimental condensed-matter physics, superconductivity, x-ray structural studies of complex materials.

Harold N. Spector, Emeritus Professor. B.A., M.S., Ph.D., University of Chicago. Solid-state theory, electronic and optical processes and semi-conducting nanostructures.

Linda Klamp Spentzouris, Assistant Professor. B.A., Colorado College; Ph.D., Northwestern University. Accelerator physics.

Jeff Terry, Assistant Professor. B.S., University of Chicago; Ph.D., Stanford University. Synchroton raditation techniques.

Christopher White, Associate Professor. B.S., University of Illinois, Urbana-Champaign; Ph.D., University of Minnesota. Experimental elementary particle physics.

John Zasadzinski, Professor and Chair of the Department. B.S., Illinois Benedictine College; Ph.D., Iowa State University. Solid state physics.

Earl Zwicker, Emeritus Professor of Physics. B.S., University of Wisconsin; Ph.D., Illinois Institute of Technology. Physics education.

Admission Requirements

Cumulative undergraduate GPA minimum: 3.0/4.0

TOEFL minimum: 550/213*

The Graduate Record Examination (GRE) is required for M.S., Ph.D., and all international applicants. The GRE is also required for all domestic applicants with an undergraduate GPA below 3.0. The GRE minimum scores are:

For tests taken prior to Oct. 1, 2002: 1200 (combined)
For tests taken on or after Oct. 1, 2002, Ph.D.:
1200 (quantitative + verbal), 3.0 (analytical writing)
For tests taken on or after Oct. 1, 2002, M.S.:
1100 (quantitative + verbal), 2.5 (analytical writing)
For tests taken on or after Oct. 1, 2002, MAS and MCH:
900 (quantitative + verbal), 2.5 (analytical writing)

Applicants to the doctoral program in chemistry are strongly encouraged to submit the subject-area GRE score (Subject No. 27). Applicants to the doctoral program in physics are strongly encouraged, but not required, to take the subject-area GRE exam in physics. Applicants to the doctoral program in molecular biochemistry and biophysics are strongly encouraged to take one of the subject exams in biology, molecular biology, chemistry or physics.

Meeting the minimum GPA and test score requirements does not guarantee admission. Test scores and GPA are just two of several important factors considered.

Applicants to one of the department's programs (Biology, Chemistry, Physics or Molecular Biochemistry and Biophysics) are expected to have a bachelors degree from an accredited institution with a major in that same discipline, or a closely allied major with additional coursework that prepares the student for graduate study in the chosen program. Students who have not completed all required courses may be accepted for general admission and can begin coursework, but must remove any deficiencies before the MCH, MAS, and M.S. comprehensive/Ph.D. qualifying examination.

* Paper-based test score/computer-based test score.

Departmental Graduate Examinations

All full-time students in the M.S. and Ph.D. programs are required to take and pass the written M.S. comprehensive/Ph.D. qualifying examination by the end of their fourth semester of study. Part-time students must pass this examination by a comparable stage of their programs. The examination is offered twice each academic year. A student may sit for the examination a maximum of four times. Students passing this examination at the Ph.D. level are judged to be qualified to continue in the Ph.D. program. Students passing at the Master of Science level or above may obtain their masters degree after completing the requirements described in the following sections. All students in the Ph.D. program who have passed the written qualifying examination must take and pass a comprehensive examination before the end of the sixth semester of full-time study. Part-time students must pass this examination by a comparable stage of their programs. This examination consists of a written proposal, an oral presentation and a defense of the proposal before a faculty committee. A student may take this examination a maximum of two times. Students passing this examination may continue with their research and will receive a Ph.D. upon satisfactory completion of all other required courses and general requirements of the Graduate College, a written dissertation and final oral thesis defense.

All students in the professional master degree programs are required to take and pass a written comprehensive exam. Students may sit for the exam a limited number of times, depending upon the individual program.

Biology

The department offers graduate programs leading to Master of Biology and to M.S. and Ph.D. degrees in biology, concentrating educational and research activities in the areas of biochemistry, biotechnology, cell and molecular biology, and microbiology. Graduate education in biology is available on either a full- or a part-time basis. Masters degree programs are designed so that they may be completed by part-time students. Doctoral-level courses are usually available in the evenings or on Saturdays. Each new graduate student is assigned a graduate student adviser and must obtain the approval of the adviser each semester before registering for any graduate classes.

Master of Biology

30–31 credit hours
Comprehensive examination

The Master of Biology is a course-only, professional masters degree program designed for professionals who seek advanced and specialized study in the field without the requirement of a thesis or project.

This program is also available on the Web, and at televised viewing sites throughout the Chicago area. Students should consult www.iit-online.iit.edu for more information.

Students must pass the written M.S. comprehensive examination (see "Departmental Graduate Examinations") in their respective areas of specialization: biochemistry, cell and molecular biology, or microbiology. Students in biotechnology may choose any of the three examinations.

The program consists of 30–31 hours of coursework as follows (credit hours in parentheses); 22-23 hours are in the selected area of specialization:

Cell and Molecular Biology

BIOL 504 Biochemistry (4)
BIOL 445 Cell Biology (3)
BIOL 515 Molecular Biology (3)
BIOL 526 Developmental Biology (3)
BIOL 562 Functional Genomics (3)
Two biology electives (6)

Microbiology

BIOL 503 Virology (3)
BIOL 504 Biochemistry (4)
BIOL 515 Molecular Biology (3)
BIOL 542 Advanced Microbiology (3)
BIOL 550 Bioinformatics and Biotechnology (3)
BIOL 562 Functional Genomics (3)
Biology elective (3)

Biochemistry

BIOL 513 Advanced Biochemistry (5)
BIOL 515 Molecular Biology (3)
BIOL 562 Functional Genomics (3)
CHEM 455 Advanced Organic Chemistry (3)
CHEM 538 Biophysical Chemistry (3)
Two electives (biology, chemistry or physics) (6)

Biotechnology

BIOL 504 Biochemistry (4)
BIOL 515 Molecular Biology (3)
BIOL 542 Advanced Microbiology (3)
BIOL 550 Bioinformatics and Biotechnology (3)
BIOL 562 Functional Genomics (3)
Two biology electives (6)

Students in each area of specialization also take the following three courses:

COM 421 Technical Communication (3)
CHEM 513 Statistics for Analytical Chemists (3)
AND
BIOL 511 Project Management (2) **OR**
CHEM 524 Synthesis and Intellectual Property (2)

Master of Science in Biology

33-34 credit hours
Comprehensive examination
Option 1: Thesis
Option 2: Library research project

A Master of Science student must complete a minimum of 33 credit hours of approved graduate work in one of the areas of specialization detailed below. This will include 25–29 credit hours of coursework and two credit hours of BIOL 595 Colloquium. Two options are available to complete the M.S. degree requirements: a thesis option and a non-thesis option.

Students must pass the written M.S. comprehensive examination (see "Departmental Graduate Examinations") in their respective areas of specialization: biochemistry, cell and molecular biology, or microbiology. Students in biotechnology may choose any of the three examinations.

Thesis Option

The thesis option is designed for individuals planning careers as experimental biologists, including those who may wish to pursue a Ph.D. Students choosing the thesis option must complete six credit hours of thesis research (BIOL 591). Students must also prepare a written thesis based on laboratory research.

Non-Thesis Option

The non-thesis option is intended as a terminal degree to meet the needs of teachers, science administrators, policy makers in the life sciences, patent attorneys and others.

Students who elect the non-thesis option must complete a library research project in one of the following courses: BIOL 572 (Literature in Biochemistry), BIOL 574 (Literature in Biotechnology), BIOL 576 (Literature in Cell and Molecular Biology), or BIOL 578 (Literature in Microbiology).

Master of Science in Biology with specialization in Biochemistry

34 credits

Students in this program complete 34 credits of graduate work, including the following courses (credit hours in parentheses):

BIOL 513 Advanced Biochemistry (5)
BIOL 515 Molecular Biology (3)
BIOL 519 Biochemistry Laboratory (3)
BIOL 520 Advanced Biochemistry Laboratory (3)
CHEM 538 Physical Biochemistry (3)

In addition, students must take one of the following classes.

CHEM 455 Advanced Organic Chemistry (3)
CHEM 500 Advanced Analytical Chemistry (3)
CHEM 553 Advanced Chemical Thermodynamics (3)

In addition to the basic sequence, students must take six to nine credit hours of approved electives, two credit hours of BIOL 595 (Colloquium), and either six credit hours of Research (BIOL 591 or CHEM 591) or BIOL 572. Other requirements are identical to those described previously for all M.S. students in biology. The requirements for admission to this program include one year of physical chemistry in addition to the usual requirements for admission to graduate study in biology.

Master of Science in Biology with specialization in Biotechnology

Students in this program complete 33 to 34 credits of graduate work, including the following (credit hours in parentheses):

BIOL 504 Biochemistry Lectures (4) **OR**
BIOL 513 Advanced Biochemistry (5)
AND
BIOL 515 Molecular Biology (3)
BIOL 519 Biochemistry Laboratory (3)
BIOL 533 Laboratory in Cell and Molecular Biology (3)
BIOL 542 Advanced Microbiology Lectures (3)
BIOL 550 Bioinformatics and Biotechnology (3)
BIOL 562 Functional Genomics (3)

In addition to three to six credits of appropriate electives, students specializing in biotechnology are required to take two credit hours of BIOL 595 (Colloquium) and either six hours of BIOL 591 (Research) or BIOL 574 (Literature in Biotechnology). Other requirements for the degree and for admission are identical to those for all M.S. students in biology.

Master of Science in Biology with specialization in Cell and Molecular Biology

Students in this program must complete 33-34 credit hours of graduate work, including the following (credit hours in parentheses):

BIOL 504 Biochemistry Lectures (4) **OR**
BIOL 513 Advanced Biochemistry (5)
AND
BIOL 445 Cell Biology (3)
BIOL 515 Molecular Biology (3)
BIOL 526 Developmental Biology (3)
BIOL 533 Laboratory in Cell and Molecular Biology (3)
BIOL 539 Advanced Cell Biology Laboratory (3)
BIOL 562 Functional Genomics (3)

In addition to three to six credits of approved electives, students specializing in cell and molecular biology must take two credit hours of BIOL 595 (Colloquium) and either six credit hours of BIOL 591 (Research) or BIOL 576 (Literature in Cell and Molecular Biology). Other requirements for the degree and requirements for admission are identical to those described previously for all M.S. students in biology.

Master of Science in Biology with specialization in Microbiology

Students in this program must complete 33-34 credit hours of graduate work, including the following (credit hours in parentheses):

BIOL 503 Biochemistry Lectures (4) **OR**
BIOL 513 Advanced Biochemistry (5)
AND
BIOL 503 Virology (3)
BIOL 533 Laboratory in Cell and Molecular Biology (3)
BIOL 542 Advanced Microbiology Lectures (3)
BIOL 562 Functional Genomics (3)

In addition to nine to 12 additional credit hours in approved microbiology electives, students specializing in microbiology must take two credit hours of BIOL 595 (Colloquium) and either six credit hours of BIOL 591 (Research) or BIOL 578 (Literature in Microbiology). Other requirements for the degree are identical to those described previously for all M.S. students in biology.

Doctor of Philosophy in Biology

84 credit hours
Written qualifying examination
Comprehensive examination
Dissertation and oral defense

A minimum of 84 credit hours is required for the Ph.D. degree in biology. Students should consult the section "Transfer Credits" on page 33 for rules on how many credit hours may be transferred from another institution. Completion of an M.S. degree is not normally required for admission to the full-time program for the Ph.D. degree but may be required of part-time students. Students must pass the Ph.D. qualifying examination in their respective areas of specialization: biochemistry, cell and molecular biology, or microbiology (see "Departmental Graduation Examinations").

Each student, in addition, will be required to pass a comprehensive examination (which serves partly as an oral defense of the thesis proposal) taken prior to performing the major portion of the dissertation research, and in any event, prior to the sixth semester of study and at least one year before oral defense of the thesis. The final examination for the Ph.D. degree consists of an oral presentation and defense of the dissertation.

The Ph.D. program is tailored to fit the student's background and goals and is subject to approval at the time of filing of the program of study (Form #401). Programs of study may be designed in any of the three areas of concentration. However, all programs of study must include at least 36 credit hours in formal courses (exclusive of BIOL 591 and BIOL 691).

Formal courses must include the classes listed below (credit hours in parentheses):

BIOL 445	Cell Biology (3)
BIOL 513	Advanced Biochemistry (5)
BIOL 515	Molecular Biology (3)
BIOL 526	Developmental Biology (3)
BIOL 542	Advanced Microbiology Lectures (3)
BIOL 550	Bioinformatics and Biotechnology (3)
BIOL 562	Functional Genomics (3)
BIOL 595	Colloquium (4)

In addition, Ph.D. candidates take the following two pairs of laboratory courses (credit hours in parentheses):

BIOL 519	Biochemistry (3)
BIOL 520	Advanced Biochemistry (3)
AND	
BIOL 533	Cell and Molecular Biology (3)
BIOL 539	Advanced Cell Biology (3)

All research for the dissertation must be carried out under the direct supervision of a faculty research adviser. The faculty research adviser will also act as the candidate's academic adviser. Students must have passed the written qualifying examination before registering for BIOL 691 (Ph.D. Thesis Research). Students may complete all formal course requirements for the Ph.D. degree as either full-time or part-time students.

Molecular Biochemistry and Biophysics (MBB)

The department offers interdisciplinary programs leading to M.S. and Ph.D. degrees in molecular biochemistry and biophysics. New advances in our understanding of biological function can be expected from a synthesis of molecular genetics, biochemistry and insights gained from molecular structural information. Individuals with a quantitative, physical approach will be best placed to be innovators in the field. MBB programs complement more traditional graduate programs in biology, chemistry and physics by offering an integrated, molecular-based approach to understanding biological problems, taking insights from all three disciplines.

A major focus of the program is on biophysical approaches to determining the structure of macromolecules and macromolecular assemblies. Faculty advisers are chosen from any of the participating departmental faculty regardless of their affiliation to a particular discipline; a particular strength of the participating faculty is in exploiting synchrotron x-ray sources for biological structural studies. MBB students will have access to state-of-the-art x-ray facilities at the nearby Advanced Photon Source, currently one of the most intense x-ray sources in the world.

Master of Science in Molecular Biochemistry and Biophysics

32 credit hours
Comprehensive examination
Thesis

A master's student must complete a minimum of 32 credit hours of approved graduate work, including a core of 21 credit hours, a minimum of five credits of approved electives, and six credit hours of research toward the thesis (BIOL, CHEM or PHYS 591)

Core courses (credit hours in parentheses)

BIOL 513	Advanced Biochemistry (5)
BIOL 515	Molecular Biology (3)
BIOL 445	Cell Biology (3)
CHEM 538	Physical Biochemistry (3)
CHEM 550	Chemical Bonding (3)
BIOL 584	Graduate Seminar (1)
BIOL 595	Colloquium (1)
BIOL 580	Laboratory Rotation in Molecular Biochemistry and Biophysics (2)

The electives are chosen from course offerings in the areas of genetics and genetic engineering, structural biophysics, or biochemistry and cellular biophysics. Specific electives are chosen in consultation with an academic adviser. Research for the dissertation must be carried out under the direct supervision of a participating faculty member; this faculty research adviser also acts as the candidate's academic adviser.

Doctor of Philosophy in Molecular Biochemistry and Biophysics

84 credit hours
Written qualifying examination
Comprehensive examination
Dissertation and oral defense

A minimum of 84 credit hours of instruction is required for the MBB Ph.D. Students should consult the section "Transfer Credits" on page 33 for rules on how many credit hours may be transferred from another institution. Completion of an M.S. degree is not normally required for admission to the Ph.D. program. Students must complete the 25 to 27 credit hours of core courses and at least four additional courses from the approved lists.

Each graduate student must take and pass the written Ph.D. qualifying examination in order to enter into candidacy for the doctorate. Each student, in addition, will be required to pass a comprehensive examination (which serves partly as an oral defense of the thesis proposal) taken prior to performing the major portion of the dissertation research, and in any event, prior to the sixth semester of study and at least one year before oral defense of the thesis. The final examination for the Ph.D. degree consists of an oral presentation and defense of the dissertation.

All students will be required to take the following courses, or have equivalent background (credit hours in parentheses).

Core courses

BIOL 513	Advanced Biochemistry (5)
BIOL 515	Molecular Biology (3)
BIOL 445	Cell Biology (3)
CHEM 538	Physical Biochemistry (3)
CHEM 550	Chemical Bonding (3)
BIOL 584	Graduate Seminar in Biology (1)
BIOL 684	Graduate Seminar in Biology (1)
BIOL 595	Colloquium (4)
BIOL 580	Laboratory Rotation in Molecular Biochemistry and Biophysics (2)

BIOL 584 must be taken by all Ph.D. students in their first year of full-time graduate study, while BIOL 684 must be taken after having passed the Ph.D. qualifying examination. BIOL 595 must be taken four times. BIOL 580 may be taken two times. MBB students, in consultation with their academic adviser, choose the remainder of their formal coursework from those courses in the areas listed below (credit hours in parentheses):

Genetics and Genetic Engineering

BIOL 562	Functional Genomics (3)
BIOL 526	Developmental Biology (3)

Structural Biophysics

PHYS 570	Introduction to Synchrotron Radiation (3)
BIOL 555	Macromolecular Structure Determination (3)
CHEM 505	Spectroscopic Methods I (3)
PHYS 561	Radiation Biophysics (3)
CHEM 454	Computer Applications in Chemistry (3)

Biochemistry and Cellular Biophysics

BIOL 519	Biochemistry Laboratory (3)
BIOL 533	Cell and Molecular Biology Laboratory (3)
CHEM 531	Tactics in Organic Synthesis (3)
CHEM 630	Special Topics in Organic Chemistry (2)
PHYS 410	Molecular Biophysics (3)

Other courses may be prescribed by the adviser/thesis committee according to the student's individual needs for the program of study. All research for the dissertation must be carried out under the direct supervision of a faculty research adviser who will also act as the candidate's academic adviser.

Chemistry

The department offers graduate programs leading to M.S. and Ph.D. degrees in chemistry. In addition, the department offers two professional master's programs designed for the part-time student and available through distance learning. The aim of these programs is to develop chemists who are able to think creatively and critically. Each student's program is planned individually to meet individual needs, interests and capabilities. In recognition of the value of teaching experience in strengthening an individual's understanding of his or her field of study and as an aid in making career decisions, the department requires all full-time students to participate in instructional activities.

Each new graduate student is assigned a graduate student adviser and must obtain the approval of the adviser each semester before registering for any graduate classes.

Master of Chemistry in Analytical Chemistry

32 credit hours
Comprehensive examination

The professional masters program in analytical chemistry is a part-time program for analytical chemists seeking to broaden their backgrounds in analytical chemistry. The specific goals of the program of study are to broaden and deepen knowledge of state-of-the-art analytical techniques, to learn how to design and manage projects, to gain an overview of statistical methods, and to improve communication skills. Candidates must possess a bachelor's degree (ideally in science or engineering) with two semesters of physical chemistry, two semesters of organic chemistry, and one semester of analytical chemistry. Candidates' advisers assist them in determining if any further prerequisites are necessary. A final comprehensive examination is required for graduation.

This program is also available on the Web, and at televised viewing sites throughout the Chicago area. Students should consult www.iit-online.iit.edu for more information.

The program of study consists of the following classes:

CHEM 500	Advanced Analytical Chemistry
CHEM 501	Liquid Chromatography
CHEM 502	Gas Chromatography
CHEM 503	Chromatographic Techniques
CHEM 505	Spectroscopic Methods I
CHEM 506	Sampling and Sample Preparation
CHEM 508	Analytical Methods Development
CHEM 509	Physical Methods of Characterization
CHEM 511	Project Management for Chemists
CHEM 512	Spectroscopic Methods II
CHEM 513	Statistics for Analytical Chemistry
COM 421	Technical Communication

Master of Chemistry

32 credit hours
Comprehensive examination option
Project with oral examination option

The Master of Chemistry program is designed for professionals pursuing advanced study on a part-time basis. It does not include a research requirement. Candidates for the Master of Chemistry degree must meet the requirements of the Graduate College for a professional master's degree. Students are required to complete satisfactorily six of the M.S. core courses (CHEM 500, CHEM 505, CHEM 518, CHEM 520, CHEM 521, CHEM 530, CHEM 531, CHEM 535, CHEM 550, CHEM 553). These must include either CHEM 550 (Chemical Bonding) or CHEM 505 (Spectroscopic Methods).

The student must additionally complete a specialized interdisciplinary program consisting of at least 12 credit hours in a coherent area of chemistry. The selection of the student's program must be made in consultation with an adviser and may be chosen from the suggested programs listed below or designed to suit the student's interests. This interdisciplinary program specialization may include chemistry and/or related coursework from other departments—for example, mathematics and physics, computer science, biology, law, business, environmental or chemical engineering. (The credits in law may not be applied toward the J.D. degree at Chicago-Kent College of Law.) Students must pass either one M.S. comprehensive examination as for the M.S. degrees described previously, or an oral final examination based primarily on the area of specialization. This may include defense of a project. Some of the possible areas of specialization are listed along with suggested courses:

Biochemistry/Biotechnology

BIOL 445	Cell Biology
BIOL 403	General Biochemistry
BIOL 404	Biochemistry Laboratory
BIOL 514	Toxicology
BIOL 515	Molecular Biology
BIOL 550	Industrial and Computational Biology

Environmental Chemistry

ENVE 401	Introduction to Water Resources Engineering
ENVE 410	Environmental Health Engineering
ENVE 463	Introduction to Air Pollution Control
ENVE 501	Environmental Chemistry
ENVE 506	Chemodynamics

Polymer Chemistry

CHE 450	Principles of Polymer Science and Engineering
CHE 538	Polymerization Reaction Engineering
CHE 555	Polymer Processing
CHEM 542	Characterization of Polymers
MMAE 580	Structure and Properties of Polymers
MMAE 581	Theory of Mechanical Behavior of Polymers

Master of Chemistry in Materials and Chemical Synthesis

31 credit hours
Comprehensive examination

The professional master's program in materials and chemical synthesis is a part-time program designed for scientists who wish to broaden their background in synthesis of new materials. The specific goals of the program of study are to broaden and deepen knowledge of state-of-the-art synthesis, purification, separation and characterization techniques; to learn how to design and manage projects; to sharpen intellectual property management techniques; to learn how to operate under regulatory constraints; and to improve communications skills. Candidates must have a bachelor's degree (ideally in science or engineering).

Advisers assist students in determining whether any prerequisites are necessary. A final comprehensive examination is required for graduation.

This program is also available on the Web, and at televised viewing sites throughout the Chicago area. Students should consult www.iit-online.iit.edu for more information.

The program of study consists of the following classes:

CHEM 454	Computer Applications in Chemistry
CHEM 505	Spectroscopic Methods I
CHEM 511	Project Management for Chemists
CHEM 521	Structural Inorganic and Solid-State Chemistry
CHEM 522	Efficient Chemical and Materials Synthesis
CHEM 524	Synthesis and Intellectual Property Management
CHEM 531	Tactics of Organic Synthesis
CHEM 535	Polymer Synthesis
CHEM 539	Introduction to Pharmaceutical Chemistry
ENVE 545	Environmental Regulations and Risk Assessment
COM 421	Technical Communication

Master of Science in Chemistry

32 credit hours
Comprehensive examination
Thesis and oral defense

Students seeking the M.S. degree must pass the written M.S. comprehensive examination in their respective areas of specialization: analytical, inorganic, organic, polymer or physical chemistry. The student must also write a thesis based on original research, which should be submitted no later than one calendar year after passing the qualifying examination.

An M.S. student must complete a minimum of 32 credit hours of approved coursework. This includes two credits of CHEM 585 (Colloquium) and the courses listed below:

CHEM 505	Spectroscopic Methods I
CHEM 550	Chemical Bonding
CHEM 584	Graduate Seminar

The student must also complete one of the two core courses in inorganic chemistry:

CHEM 520	Advanced Inorganic Chemistry **OR**
CHEM 521	Structural Inorganic and Solid-State Chemistry

AND one of the two core courses in organic chemistry:

CHEM 530	Organic Reaction Mechanisms **OR**
CHEM 531	Tactics of Organic Synthesis

The remainder of the program can consist of additional graduate courses and up to 12 credit hours of CHEM 591 (Thesis Research). Students are strongly encouraged to choose additional courses from those listed above or from the following classes:

CHEM 500	Advanced Analytical Chemistry
CHEM 518	Electrochemical Methods
CHEM 535	Polymer Synthesis
CHEM 553	Introduction to Chemical Thermodynamics

Doctor of Philosophy in Chemistry

84 credit hours
Written qualifying examination
Comprehensive examination
Dissertation and oral defense

A minimum of 84 credit hours is required for the Ph.D. in chemistry. Students should consult the section "Transfer Credits" on page 33 for rules on how many credit hours may be transferred from another institution. A student must pass the Ph.D. qualifying examination in the area of specialization. Examinations are given in the areas of analytical, inorganic, organic, polymer and physical chemistry. The Ph.D. program is tailored to fit the student's background and goals and is subject to approval at the time of filing of the Program of Study (Form #401).

The curriculum includes two credits of CHEM 585 (Colloquium) and the following required courses:

CHEM 505 Spectroscopic Methods I
CHEM 550 Chemical Bonding
CHEM 584 Graduate Seminar
CHEM 684 Graduate Seminar
CHEM 685 Colloquium

Additional required coursework includes a minimum of three courses chosen from the following core course list, including one course in inorganic chemistry and one course in organic chemistry.

CHEM 500 Advanced Analytical Chemistry
CHEM 518 Electrochemical Methods
CHEM 520 Advanced Inorganic Chemistry
CHEM 521 Structural Inorganic and Solid-State Chemistry
CHEM 530 Organic Reaction Mechanisms
CHEM 531 Tactics of Organic Synthesis
CHEM 535 Polymer Synthesis
CHEM 553 Introduction to Chemical Thermodynamics

The remainder of the program of study will be chosen in consultation with the student's adviser. All research for the dissertation must be carried out under the direct supervision of a faculty research adviser. The faculty research adviser also will act as the candidate's academic adviser. Students must have passed the written qualifying examination before registering for CHEM 691 (Ph.D. Thesis Research).

Physics

The department offers programs leading to M.S. and Ph.D. degrees in physics. The M.S. degree is not a prerequisite for the Ph.D. The department also offers a professional master's program in health physics designed for the part-time student and available through distance learning. Research is organized into small groups of faculty members, post-doctoral associates, graduate students and undergraduate students working on closely related projects. The principal active areas include experimental and theoretical condensed matter physics, experimental and theoretical elementary particle physics, synchrotron radiation physics, accelerator physics, structural and computational biophysics, magnetism and electrodynamics. Classes are generally small and informal, and thesis research is carried out in close collaboration with the faculty adviser.

In recognition of the value of teaching experience in strengthening an individual's understanding of his or her field of study and as an aid in making career decisions, the department requires full-time students to participate in instructional activities. Each new graduate student is assigned a graduate student adviser and must obtain the approval of the adviser each semester before registering for any graduate classes.

Master of Health Physics

30 credit hours
Comprehensive examination

Designed primarily for working professional health physicists in government, medicine, research and industry, this program combines technical depth with the interdisciplinary viewpoints of law, management and communications. The degree can be completed in four semesters and two summer sessions of part-time study. Applicants must have completed coursework in calculus through differential equations and a calculus-based general physics sequence. A course in modern physics, including some basic quantum mechanics, is strongly recommended.

This program is also available on the Web, and at televised viewing sites throughout the Chicago area. Students should consult www.iit-online.iit.edu for more information.

Required courses

PHYS 561	Radiation Biophysics
PHYS 571	Health Physics I
PHYS 572	Health Physics II
PHYS 573	Standards, Statutes and Regulations
PHYS 575	Case Studies in Health Physics
PHYS 576	External Dosimetry
PHYS 577	Internal Dosimetry
PHYS 770	Instrumentation for Radiation Health Physics
COM 421	Technical Communication
PSYC 556	Organizational Psychology
MATH 474	Probability and Statistics

Master of Science in Physics

32 credit hours
Comprehensive examination
Thesis and oral defense

For those interested in research, seven to nine credit hours of PHYS 591 (Thesis Research) may be applied to the 32-credit-hour requirement. The basic program of coursework must include two credits of PHYS 585 (Colloquium) and the M.S. core:

PHYS 501	Methods of Theoretical Physics I
PHYS 505	Electromagnetic Theory
PHYS 508	Analytical Dynamics
PHYS 509	Quantum Theory I

The remaining course requirements may be satisfied by additional graduate or advanced undergraduate electives.

Doctor of Philosophy in Physics

84 credit hours, approved by faculty adviser
Written qualifying examination
Comprehensive examination
Dissertation and oral defense, supervised by faculty member and approved by thesis committee

The requirements for the degree consist of a program of 84 credit hours approved by the faculty adviser; passing the Ph.D. qualifying and comprehensive examinations; and the completion of a research thesis supervised by a faculty member and approved by a thesis committee. Students should consult the section "Transfer Credits" on page 33 for rules on how many credit hours may be transferred from another institution. The required coursework includes 2 hours of PHYS 585 (Colloquium) and the graduate core:

PHYS 501	Methods of Theoretical Physics I
PHYS 505	Electromagnetic Theory
PHYS 508	Analytical Dynamics
PHYS 509	Quantum Theory I
PHYS 515	Statistical Mechanics

and at least three specialized or advanced physics graduate courses chosen from the following:

PHYS 502	Methods of Theoretical Physics II
PHYS 507	Electrodynamics
PHYS 510	Quantum Theory II
PHYS 511	Advanced Quantum Mechanics I
PHYS 512	Advanced Quantum Mechanics II
PHYS 533	Group Theory in Physics
PHYS 537	Physics of the Solid State I
PHYS 538	Physics of the Solid State II
PHYS 545	Elementary Particle Physics
PHYS 553	Quantum Field Theory
PHYS 561	Radiation Biophysics
PHYS 570	Introduction to Synchrotron Radiation

The remaining course requirements may be satisfied by additional graduate or advanced undergraduate electives and research. Students are encouraged to participate in faculty research programs and seminars early in their graduate careers. Thesis work may follow from these activities. All research for the dissertation must be carried out under the direct supervision of a faculty research adviser. Students must have passed the written qualifying examination before registering for PHYS 691 (Ph.D. Thesis Research).

Certificate Programs

Analytical Methods Development

Required courses
CHEM 506 Sampling and Sample Preparation
CHEM 508 Analytical Methods Development

AND two courses selected from the list of electives below.

Analytical Spectroscopy

Required courses
CHEM 505 Spectroscopic Methods I
CHEM 512 Spectroscopic Methods II

AND two courses selected from the list of electives below.

Chromatography

Required courses
CHEM 501 Liquid Chromatography
CHEM 502 Gas Chromatography

AND two courses selected from the list of electives below.

Electives for Analytical Methods Development, Analytical Spectroscopy and Chromatography

CHEM 500 Advanced Analytical Chemistry
CHEM 501 Liquid Chromatography
CHEM 502 Gas Chromatography
CHEM 503 Chromatographic Techniques
CHEM 505 Spectroscopic Methods
CHEM 506 Sampling and Sample Preparation
CHEM 509 Physical Methods of Characterization
CHEM 510 Electronics and Interfacing
CHEM 511 Project Management
CHEM 512 Spectroscopic Methods II
CHEM 513 Statistics for Analytical Chemists
COM 421 Technical Communications

Characterization of Inorganic and Organic Materials

Required courses
CHEM 505 Spectroscopic Methods I
CHEM 509 Physical Methods of Characterization
CHEM 512 Spectroscopic Methods II

AND
CHEM 502 Gas Chromatography **OR**
CHEM 542 Polymer Characterization and Analysis

Radiological Physics

12 total credits selected from:
PHYS 561 Radiation Biophysics
PHYS 571 Health Physics I
PHYS 572 Health Physics II
PHYS 573 Standards, Statutes and Regulations
PHYS 575 Case Studies in Health Physics
PHYS 576 Internal Dosimetry
PHYS 577 External Dosimetry
PHYS 770 Instrumentation for Radiation Health Physics

Synthesis and Characterization of Inorganic Materials

Required courses
CHEM 505 Spectroscopic Methods I
CHEM 521 Structural Inorganic and Solid-State Chemistry
CHEM 522 Efficient Chemical and Materials Synthesis

AND one additional course selected from:
CHEM 502 Gas Chromatography
CHEM 509 Physical Methods of Characterization
CHEM 512 Spectroscopic Methods II
CHEM 535 Polymer Synthesis
CHEM 542 Polymer Characterization and Analysis

Synthesis and Characterization of Organic Materials

Required courses
CHEM 505 Spectroscopic Methods I
CHEM 531 Tactics in Organic Synthesis
CHEM 539 Introduction to Pharmaceutical Chemistry

AND one course from the following:
CHEM 502 Gas Chromatography
CHEM 509 Physical Methods of Characterization
CHEM 512 Spectroscopic Methods II
CHEM 535 Polymer Synthesis
CHEM 542 Polymer Characterization and Analysis

Course Descriptions

Numbers in parentheses represent class, lab and total credit hours, respectively.

Biology

BIOL 503
Virology
This course will cover topics related to animal viruses, including the cycle of major viral classes, viral pathogenesis, emergence, and control. Recent advances in these areas will be discussed in conjunction with readings from the original literature. Prerequisite: BIOL 504 or equivalent or instructor's consent. BIOL 214 and BIOL 445 recommended. (3-0-3)

BIOL 504
Biochemistry Lectures
Molecules of biological significance; reaction thermodynamics and kinetics; metabolism; cellular localization of biochemical function; proteins; nucleic acids; transcription; translation. Prerequisites: BIOL 115 and CHEM 237. (4-0-4)

BIOL 513
Advanced Biochemistry
Intensive course that covers the chemical structure and function of biological macromolecules: proteins, nucleic acids, polysaccharides. Biochemical thermodynamics, kinetics, bioenergetics and modern methodology are emphasized. Also, metabolism, photosynthesis, lipids and membranes. Prerequisites: One year of organic chemistry, an undergraduate course in biochemistry, and one semester of physical chemistry recommended, or instructor's consent. (5-0-5)

BIOL 514
Toxicology
Initial lectures cover basic principles in chemical toxicity, such as dose response, indices of numerical toxicity, metabolism and factors influencing toxicity. Mechanisms of organic toxicity will be presented to include central nervous system, liver, kidney, respiratory system, reproductive system and the hematological system. Special topic lectures will emphasize the mechanism of toxicity for specific metals, pesticides, solvents and substances of abuse. (3-0-3)

BIOL 515
Molecular Biology
A survey of topics including structure of nucleic acids, translation, transcription, replication, organization of DNA, RNA processing, genomics, and control of gene expression. Prerequisite: BIOL 504 or equivalent or instructor's consent. (3-0-3)

BIOL 519
Biochemistry Laboratory
Introduction to modern biochemical techniques, including analytical methods for macromolecules, enzyme reactions, spectrophotometry, purifications, centrifugation, chromatography, electrophoresis, structure modeling. Prerequisite: Previous or concurrent enrollment in BIOL 513 or BIOL 504 or instructor's consent. (0-9-3)

BIOL 520
Advanced Biochemistry Laboratory
A continuation of BIOL 519 in which students will undertake individual research projects. Prerequisite: BIOL 519 or instructor's consent. (0-9-3)

BIOL 521
Advanced Micro Genetics Lab
Introduction to independent research in microbial physiology and genetics. Prerequisite: instructor's consent. (0-9-3)

BIOL 526
Developmental Biology
This course covers the cellular and molecular processes involved in generating an embryo, in creating various tissues and organs, and the effect of external stimuli on development. Topics include: genome structure, gene expression and regulation, cell cycle control, pattern formation, signal transduction, gametogenesis, organogenesis, and methods used in studying developmental biology. In addition to studies of model organisms, examples relevant to human diseases are covered. (3-0-3)

BIOL 527
Immunology and Immunochemistry
Basic concepts of immunology, immunochemistry, both biological and molecular. Prerequisite: BIOL 504 or instructor's consent. (3-0-3)

BIOL 533
Laboratory in Cell and Molecular Biology
This course covers a number of essential techniques in cell and molecular biology with emphases on both the methodologies and the experimental details. Laboratory procedures include basic cell culture skills and relevant laboratory equipment usage. Experimental procedures include polymerase chain reaction and human DNA polymorphism, Drosophila polytene chromosome cytology, plasmid DNA preparation, western blot, gene delivery, yeast two-hybrid screens, immunofluorescence, immunoprecipitation, cell cycle arrest and analysis, and cell differentiation. Prerequisite BIOL 445 or instructor's consent. (0-9-3)

BIOL 539
Advanced Cell Biology Laboratory
Introduction to independent research in cell and molecular biology. Prerequisite: BIOL 533. (0-9-3)

BIOL 542
Advanced Microbiology
This course will introduce students to advanced topics in microbial kinetics, genomics and proteomics. Using a variety of Internet tools, the student will be able to compare data from these three areas, and use them to predict biological properties of microorganisms. The kinetics portion (about half of the course) will include the following topics: introduction to zero, first and second order whole microbial cell reactions occurring in batch culture; comparison of batch, fed-batch and chemostat kinetics; yield coefficients; productivity coefficients; material balances; and reaction rate determinations of the four nutritional classes of microbes. (3-0-3)

BIOL 550
Bioinformatics and Biotechnology
This course will present an historical introduction to bioinformatics as a driving force for biotechnological advances. Topics covered will include: collecting and storing sequences in the lab; alignment of pairs of sequences; multiple sequence alignment; phylogenetic prediction; database searching for similar sequences; gene prediction; protein classification and structure prediction; and genome analysis. (3-0-3)

BIOL 555
Macromolecular Structure Determination
Macromolecular crystallographic methods, including crystallization, data processing, phasing, and structure refinement; multi-dimensional NMR techniques; spectroscopic techniques; structural comparisons and characterizations; fiber diffraction and solution scattering. Prerequisite: instructor's consent. (3-0-3)

BIOL 562
Current Topics in Functional Genomics
This course is designed to give students a foundation in advanced theoretical and applied methods in modern molecular research. It will emphasize both established and novel approaches to solving problems of functional and comparative genomics, and systems biology. It will also focus on applications of advanced molecular techniques in areas of significant economic and biomedical importance. Prerequisite: BIOL 515 or instructor's consent. (3-0-3)

BIOL 572
Literature in Biochemistry
A topic from the current literature in biochemistry is selected by students for preparation of a paper. Prerequisite: instructor's consent. (3-0-3)

BIOL 574
Literature in Biotechnology
A topic from the current literature in biotechnology is selected by students for preparation of a paper. Prerequisite: instructor's consent. (3-0-3)

BIOL 576
Literature in Cell and Molecular Biology
A topic from the current literature in cell and molecular biology is selected by students for preparation of a paper. Prerequisite: instructor's consent. (3-0-3)

BIOL 578
Literature in Microbiology
A topic from the current literature in microbiology is selected by students for preparation of a paper. Prerequisite: instructor's consent. (3-0-3)

BIOL 580
Laboratory Rotation in Molecular Biochemistry and Biophysics
Short, individual research projects under the supervision of departmental faculty. Students will rotate through two to three different faculty laboratories in one semester. This helps ensure a good match between supervisor, project and student, as well as provide a broader technical base to the student than provided by a single laboratory. The course may be taken twice. (0-6-2)

BIOL 584, 684
Graduate Seminar in Biology
To foster scientific communication skills, students are required to present seminars based on the scientific literature. (1-0-1); (1-0-1)

BIOL 591
M.S. Thesis Research
(Credit: Variable)

BIOL 595
Biology Colloquium
Lectures by invited scientists in areas of biology generally not covered in the department. Must be taken two times by M.S. students and four times by Ph.D. students. (1-0-1)

BIOL 691
Ph.D. Thesis Research
(Credit: Variable)

BIOL 695
Biology Colloquium
Lectures by invited scientists in areas of biology generally not covered in the department. For full-time graduate students who have completed the BIOL 595 requirement. (1-0-0)

Undergraduate Biology Courses Available to Graduate Students

BIOL 410
Medical Microbiology

BIOL 414
Genetics for Engineering Scientists

BIOL 430
Animal Physiology

BIOL 445
Cell Biology

Chemistry

CHEM 500
Advanced Analytical Chemistry
An overview of analytical chemistry with discussions of complex ionic equilibria, electroanalytical techniques including potentiometric, voltametric, coulometric and conductometric methods, ion chromatography, capillary electrophoresis and sensor technology. (3-0-3)

CHEM 501
Liquid Chromatography
Theory and practice of liquid chromatography with an emphasis on high-performance liquid chromatography. (3-0-3)

CHEM 502
Gas Chromatography
Theory and practice of gas chromatography with emphasis in capillary gas chromatograph spectrometry. (2-0-2)

CHEM 503
Chromatographic Techniques
Theory and practice of separation methods other than gas and highperformance liquid chromatography. Topics to be discussed include size-exclusion chromatography, affinity chromatography, thin-layer chromatography, supercritical fluid chromatography, electrophoresis, high-speed countercurrent chromatography and flow-injection analysis. (3-0-3)

CHEM 504
Electroanalytical Chemistry
Fundamentals including pulse and differential pulse techniques, electrochemical detection for chromatography, flow-injection analysis and remote chemical sensors. (2-0-2)

CHEM 505
Spectroscopic Methods I
Theories of spectroscopic transitions and their applications in structural elucidations and quantitative analysis. Topics include ultraviolet/visible, infrared, Raman and nuclear magnetic resonance spectroscopy and mass spectrometry. (3-0-3)

CHEM 506
Sampling and Sample Preparation
Techniques and devices for sampling in diverse media will be treated, followed by a discussion of sample treatment prior to analysis including isolation, concentration and fractionation of analytes and classes of analytes. (3-0-3)

CHEM 508
Analytical Methods Development
A seminar course presenting analytical methods in complex matrices with emphasis on methods development and validation. (2-0-2)

CHEM 509
Physical Methods of Characterization
A survey of physical methods of characterization including x-ray diffraction and fluorescence surface techniques, including SEM, TEM, AES and ESCA, thermal methods and synchrotron radiation methods. (3-0-3)

CHEM 510
Electronics and Interfacing
Elementary circuit analysis, operational amplifiers, digital electronics, signal processing and interfacing of instruments using modern computer software and hardware. (2-0-2)

CHEM 511
Project Management
Introduction to concepts and techniques used to design and/or analyze a project to develop a set of tasks to accomplish the project, to coordinate and to monitor the work involved in the tasks, and to deliver a final product or service. Budgetary considerations will also be discussed. (2-0-2)

CHEM 512
Spectroscopic Methods II
A continuation of the study of optical methods covering atomic absorption spectroscopy, atomic and flame emission spectroscopy, chemiluminescence, fluorescence, phosphorescence, light scattering and refractometry. (2-0-2)

CHEM 513
Statistics for Analytical Chemists
A survey providing sufficient statistical background for scientists. The topics covered include probability, statistics, sampling estimation, regression analysis, experimental design, data analysis and signal enhancement. (3-0-3)

CHEM 518
Electrochemical Methods
Thermodynamics and potential, charge-transfer kinetics and mass transfer. Potential step and potential sweep methods, including hydrodynamic methods. Bulk electrolysis methods. Electrode reactions coupled with homogeneous chemical reactions. Double-layer structure and absorbed intermediates in electrode processes. Digital simulation of electrochemical processes. Students are expected to have some background in the physical chemistry of solutions and electroanalytical chemistry at the level of CHEM 500. (3-0-3)

CHEM 520
Advanced Inorganic Chemistry
Selective treatment of the chemistries of main group and transition elements with emphasis on coordination complexes, organometallic compounds and inorganic cages and clusters. Discussions of molecular symmetry, stereochemistry, bonding, electronic spectra, magnetic properties, reactions, kinetics and reaction mechanisms are included. (3-0-3)

CHEM 521
Structural Inorganic and Solid-State Chemistry
This course covers structure and bonding and structure-property relationships in inorganic molecules and solids. Descriptions of crystal structures, spectroscopic and x-ray diffraction techniques for structure determination and properties of solids are included. (3-0-3)

CHEM 522
Efficient Chemical and Materials Synthesis
The design and development of environmentally benign chemical pathways: challenges and opportunities. High-yield and zero-waste chemical processes. Representative processes. (3-0-3)

CHEM 524
Synthesis and Intellectual Property Management
This course focuses on the management of intellectual property. Professionals will lead discussions on the control and dissemination of materials concerning intellectual property. This will be combined with technical presentations by students in the classroom. Topics of discussion will include invention disclosures, intellectual property rights, proprietary materials, justification for patents, types of patents, terms of a patent, patents procedure, licensing procedure and security considerations. Access to patented materials and disclosure of materials under patent process will be covered. (2-0-2)

CHEM 530
Organic Reaction Mechanisms
A study of important mechanism classes and their relationship to the major reactions of organic chemistry. Emphasis will be placed on the study of reaction intermediates and on the methods used to characterize reaction pathways. Topics will include chemical bonding, aromaticity, stereochemistry, substitution, elimination, carbanion chemistry, free radical reactions, photochemistry and concerted reactions. Prerequisite: CHEM 455 or equivalent is recommended. (3-0-3)

CHEM 531
Tactics in Organic Synthesis
A study of modern synthetic strategies used in the preparation of complex organic molecules. Synthetic planning using the disconnection approach and the selection of reagents to solve regiochemical and stereochemical problems will be the underlying themes. Synthetic strategies to be discussed include tandem reactions, template and chelation effects, biomimetic tactics and the use of chiral terpenes, carbohydrates and amino acids in enantioselective syntheses. Target molecules will include natural products, pharmaceuticals and "smart" organic materials. Prerequisite: CHEM 455 or equivalent is recommended. (3-0-3)

CHEM 535
Polymer Synthesis
In-depth study of polymer synthesis, kinetics of polymerization, solution and thermal properties, processing and characterization techniques and rheological behavior. Selected topics include high-performance polymers, conducting polymers, electrooptical polymers, water-soluble polymers, biopolymers, medicinal polymers, photosensitive polymers and liquid crystalline polymers. Prerequisite: CHEM 470 or instructor's consent. (3-0-3)

CHEM 537
Polymer Chemistry Laboratory
This course will include the synthesis of a variety of polymers and their characterization using instrumental methods. Emphasis will be placed on factors that control polymer formation, methods for obtaining molecular weights and distributions of polymers, as well as thermal and mechanical characteristics of polymers. Prerequisite: CHEM 470 or instructor's consent. (1-6-3)

CHEM 538
Physical Biochemistry
The principles and techniques of physical chemistry applied to proteins, nucleic acids, polysaccharides and lipids. Prerequisites: CHEM 239, CHEM 344 (or equivalent). (3-0-3)

CHEM 539
Introduction to Pharmaceutical Chemistry
Fundamental concepts will be discussed, including modern principles of drug design; drug absorption, distribution and metabolism; theories of drug-receptor interactions; approaches to structure-activity relationships; chemical, physicochemical and structural considerations. The various classes of therapeutic agents will be surveyed with emphasis on possible modes of action. Methods of synthesis will be considered. Prerequisites: CHEM 239. (3-0-3)

CHEM 542
Polymer Characterization and Analysis
Overview of various characterization and analysis techniques in polymer science and technology, such as thermal analysis, mechanical property measurements, chromatographic separations, techniques for the determination of molecular weights and chemical analysis of polymer additives in polymer research, product development, quality control and degradation studies. A general discussion on industrial problem solving using multiple characterization techniques. (3-0-3)

CHEM 548
Electrochemical Methods
Thermodynamics and potential, charge-transfer kinetics and mass transfer. Potential step and potential sweep methods, including hydrodynamic methods. Bulk electrolysis methods. Electrode reactions coupled with homogeneous chemical reactions. Double-layer structure and absorbed intermediaries in electrode processes. Digital simulation of electrochemical processes. Students are expected to have some background in the physical chemistry of solutions and electroanalytical chemistry at the level of CHEM 500. (3-0-3)

CHEM 550
Chemical Bonding
Review of the postulatory basis of quantum mechanics and application to 1-D and 3-D systems. Hydrogenic and symmetry-adapted spin orbitals and bond formation. Ground and excited states. Commonly used semi-empirical molecular orbital methods. Prerequisite: CHEM 344 or equivalent, or instructor's consent. (3-0-3)

CHEM 552
Chemical Kinetics
Types of reactions, reaction order, activation energy, transition states, isotope effects and the mechanism of reactions. Determination of the rates of free radical reactions. Primary processes in thermal, photochemical and other radiation-induced reactions. Prerequisites: CHEM 550, CHEM 553 (or equivalent). (3-0-3)

CHEM 553
Introduction to Chemical Thermodynamics
Fundamental laws of thermodynamics; application to simple chemical systems. Prerequisite: CHEM 344 or equivalent. (3-0-3)

CHEM 560
Advanced Chemistry Projects
Advanced chemistry projects to be carried out under the direction of a faculty member. These projects may involve computational, theoretical, experimental work or a combination of these. Projects based on experimental work may be carried out in the research lab of the instructor. Topics of the advanced projects will be selected by the faculty member offering the course and will not necessarily be related to the dissertation topic of the student. (0-12-4)

CHEM 584
Graduate Seminar in Chemistry
To foster scientific communications skills, students are required to present seminars based on the scientific literature. Required of all first-year M.S. and Ph.D. students. (1-0-1)

CHEM 585
Chemistry Colloquium
Lectures by invited scientists in areas of chemistry generally not covered in the department. Must be taken two times by M.S. students and four times by Ph.D. students. (1-0-1)

CHEM 591
Thesis Research
(Credit: Variable)

CHEM 594
Special Problems
Designed for non-thesis M.S. only. (Credit: Variable)

CHEM 597
Reading and Special Problems
Independent study to meet the special needs of graduate students in department-approved graduate degree programs. Requires the written consent of the instructor. May be taken more than once. Receives a letter grade. (Credit: Variable)

CHEM 610, 611
Special Topics in Analytical Chemistry
Topics of current interest in analytical chemistry including advanced electrochemistry, surface spectroscopy of electrode surfaces, separations, laboratory automation and new spectroscopic techniques. (2-0-2); (2-0-2)

CHEM 620, 621
Special Topics in Inorganic Chemistry
Topics of current interest in inorganic chemistry, including organometallic chemistry, homogeneous catalysis, inorganic reaction mechanisms, inorganic stereochemistry, materials chemistry, x-ray crystallography, synthetic and physical methods in inorganic and materials chemistry and chemical applications of group theory. (2-0-2);

CHEM 630, 631
Special Topics in Organic Chemistry
Topics of current interest in organic chemistry including photochemistry, fluorine chemistry, heterocyclic chemistry, pharmaceutical chemistry and electrooptical organic chemistry. Prerequisite: CHEM 455 or instructor's consent. (2-0-2); (2-0-2)

CHEM 635
Heterocyclic Chemistry
Of the vast array of structures which organic compounds adopt, many contain ring systems as a component. When the ring is made up of carbon and at least one other element, the compound is classified as a heterocycle. The aims of this course are to identify the effects that the presence of such ring systems have on the chemistry of a molecule; to show how the rings can be made, and to describe some of the uses of the compounds in organic synthesis, in medicine and in other contexts. The chemistry of aromatic five-, six- and seven-membered ring compounds with one or more nitrogen, oxygen and/or sulfur atoms will be emphasized. Prerequisite: CHEM 239, CHEM 455 or instructor's consent. (3-0-3)

CHEM 650, 651
Special Topics in Physical Chemistry
Topics of current interest in physical chemistry, including atmospheric chemistry, ion molecule reactions, laser chemistry, theories of gas phase reactions, scattering theory, interaction of radiation with matter, and time-dependent relaxation methods. (2-0-2); (2-0-2)

CHEM 684
Graduate Seminars in Chemistry
To foster scientific communications skills, students are required to present seminars based on the scientific literature. Required of all Ph.D. students who have passed the written qualifying examination. (1-0-1)

CHEM 685
Chemistry Colloquium
Lectures by invited scientists in areas of chemistry generally not covered in the department. For full-time graduate students who have completed the CHEM 585 requirement. (1-0-0)

CHEM 691
Ph.D. Thesis Research
(Credit: Variable)

Undergraduate Chemistry Courses Available to Graduate Students

CHEM 415
Inorganic Chemistry

CHEM 416
Advanced Chemistry Laboratory

CHEM 451
Modern Techniques in Chemical Literature

CHEM 454
Computer Applications in Chemistry

CHEM 455
Advanced Organic Chemistry

CHEM 470
Introduction to Polymers

Physics

PHYS 501, 502
Methods of Theoretical Physics I, II
Linear vector spaces. Functions of a complex variable. Fourier series and integrals. Differential and integral equations. Special functions. Green's functions. Group theory. Prerequisite: MATH 252. (4-0-4); (4-0-4)

PHYS 505
Electromagnetic Theory
Maxwell's equations. Electromagnetic waves and radiation. Prerequisites: PHYS 414, MATH 252. (4-0-4)

PHYS 507
Electrodynamics
Covariant formulation of Maxwell's equations. Variational principles of classical field theory. Theory of radiation reactions. Topics in contemporary electrodynamics. Prerequisite: PHYS 505. (4-0-4)

PHYS 508
Analytical Dynamics
Newton's laws. Lagrange's equations. Central forces. Invariance properties and conservation laws. Collections of particles. Rigid body motions. Small vibrations. Hamilton's equations. Canonical transformations. Hamilton-Jacobi theory. Approximation methods. Special theory of relativity. Classical theory of fields. Prerequisites: PHYS 309, MATH 252. Recommended corequisite: PHYS 501. (4-0-4)

PHYS 509, 510
Quantum Theory I, II
Postulates and theory of measurement in quantum mechanics. Momentum eigenstates, wave packets and passage to the classical limit. Angular momentum eigenstates. Stationary states of a particle in central field. Approximation methods. Identical particles, introduction to second quantization. Transition probabilities. S matrix formalism, approximation methods for decay and scattering problems. The Lorentz group and relativistic wave equations. Dirac particle in a central field. Prerequisites: PHYS 406, PHYS 501, PHYS 508 or instructor's consent. (4-0-4); (4-0-4)

PHYS 511, 512
Advanced Quantum Mechanics I, II
Applications and extensions of basic principles introduced in PHYS 509 and PHYS 510. Typical subject areas include atomic and molecular structure, group-theoretical analysis of spectra, many-body problems, including second quantization, density matrix. Hartree-Fock method. BCS theory. Introduction to quantum fields. Feynman diagrams. Green's functions, quantum electrodynamics. Prerequisites: PHYS 509, PHYS 510. (4-0-4); (4-0-4)

PHYS 515
Statistical Mechanics
Kinetic theory and Boltzmann's H-theorem. Quantum statistics. Fermi-Dirac and Bose-Einstein systems. Density matrix. Fluctuations. Behavior of complex and chaotic systems. Prerequisites: PHYS 304, PHYS 406 and PHYS 508, or instructor's consent. (4-0-4)

PHYS 521
Quantum Electronics
The Schrodinger equation. Matrix formulation. Quantization of lattice vibrations and electromagnetic fields. Optical beams and resonators. The interaction of radiation and atomic systems. Lasers. Optical waveguides and devices. Frequency conversion. Quantum noise. Same as ECE 521. Prerequisite: ECE 307 or instructor's consent. (3-0-3)

PHYS 533
Group Theory in Physics
Development of the theory of finite groups and group representations and application to diverse subjects in physics. Point groups. Introduction to SU(2) and the rotation group. Spinors and tensors. Prerequisite: MATH 252. (4-0-4)

PHYS 537, 538
Physics of the Solid State I, II
Crystal structure and crystal binding. Lattice vibrations and phonons. Free electron model of metals and semiconductors. Energy band theory. Transport phenomena. Magnetic, optical properties of solids. Superconductivity. Prerequisites: PHYS 406, MATH 252. (4-0-4); (4-0-4)

PHYS 545
Elementary Particle Physics
Principal theories of elementary particles and their interactions, including important features of experimental data. Mesons, baryons and leptons. Particle classification schemes. Brief introduction to quantum field theory and Feynman diagrams. Strong, electromagnetic and weak interactions. Scattering matrix. Phenomenological descriptions of high-energy scattering and particle production. Speculations on quarks, magnetic monopoles and other exotic particles. Prerequisite: PHYS 510 or instructor's consent. (4-0-4)

PHYS 553
Quantum Field Theory
Relativistic wave equations. Semiclassical and quantum theories of radiation. Photoelectric effect. Pair production. Bremsstrahlung. Compton scattering. Second quantization of the electron field. Renormalization. Lamb shift. Vacuum polarization. Exact methods for external field problems. Prerequisite: PHYS 505. (4-0-4)

PHYS 561
Radiation Biophysics
Energy loss by ionizing radiation. Target theory. Direct and indirect action. Radiation effects in iomolecules. Radiation inactivation of enzymes, nucleic acids and viruses. Biological effects of ultraviolet radiation. Photosensitization. Radiation protection and sensitization. Radiation effects in vivo, radiation therapy, phototherapy. Prerequisite: PHYS 410 or instructor's consent. (3-0-3)

PHYS 570
Introduction to Synchrotron Radiation
Production and characterization of synchrotron radiation, dynamical and kinematical diffraction, absorption and scattering processes, x-ray optics for synchrotron radiation, and x-ray detectors. Overview of experimental techniques, including XAFS, XPS, SAXS, WAXS, diffraction, inelastic x-ray scattering, fluorescence spectroscopy, microprobe, tomography and optical spectroscopy. (3-0-3)

PHYS 571
Health Physics I
Fundamentals of health physics will be presented, with an emphasis on problem-solving and computer modeling. Topics covered begin with the physics of radiation production: review of atomic and nuclear structure and quantum mechanics; nuclear structure and radioactivity; production of x-rays. The second part of the course focuses on the interaction of radiation with matter, including energy-loss mechanisms, secondary processes, stopping power and range. Required prerequisites: MATH 252, PHYS 203. Suggested prerequisite: PHYS 348. (3-0-3)

PHYS 572
Health Physics II
Continuation of the basic health physics sequence, including neutron production and interaction with matter; methods of radiation detection; radiation dosimetry; chemical and biological effects of radiation; radiation protection standards; shielding; dosimetric models; accelerator, reactor and medical health physics. Prerequisite: PHYS 571. (3-0-3)

PHYS 573
Standards, Statutes and Regulations
This course studies the requirements of agencies that regulate radiation hazards, their basis in law and the underlying U.S. and international standards. An array of overlapping requirements will be examined. The effect regulatory agencies have upon the future of organizations and the consequences of noncompliance are explored. (3-0-3)

PHYS 575
Case Studies in Health Physics
Issues in operational health physics and regulatory affairs. Students will present problems and solutions drawn from their experience and the literature. Operational problems may include organizational issues, computer applications, measurements and dosimetry. Methods for compliance with EPA, NRC and OSHA and enforcement actions will emphasize technical and management techniques. (3-0-3)

PHYS 576
Internal Dosimetry
Calculation of internal dose from radiation sources. Internal dose is a function of the form of radioactive material, route of intake,biochemistry, metabolic activity and gross and cellular physiology. (2-0-2)

PHYS 577
External Dosimetry
Calculation of external dose from radiation sources. External dose is determined for uniform fields, nonuniform fields, and local deposition. External sources include immersion in a cloud of radioactive gas and skin contamination. (2-0-2)

PHYS 585
Physics Colloquium
Lectures by invited scientists in areas of physics generally not covered in the department. Must be taken twice by M.S. students and four times by Ph.D. students. (1-0-1)

PHYS 591
Thesis Research
(Credit: Variable)

PHYS 597
Reading and Special Problems
Independent study to meet the special needs of graduate students in department-approved graduate degree programs. Requires the written consent of the instructor. May be taken more than once. Receives a letter grade. (Credit: Variable)

PHYS 685
Physics Colloquium
Lectures by invited scientists in areas of physics generally not covered in the department. For full-time graduate students who have completed the PHYS 595 requirement. (1-0-0)

PHYS 691
Ph.D. Thesis Research
(Credit: Variable)

PHYS 770
Instrumentation for Radiation Health Physics
Detecting and measuring radioactive material and radiation levels depends upon many types of detectors and instrumentation. Theory of detectors ranging from chambers operating in pulse and current producing modes to solid-state detectors is applied to measuring and monitoring systems. Electronics ranging from simple-rate meters and scalers to high-speed multichannel analyzers is used. Computer linked instrumentation and computer-based applications are applied to practical problems. (0-6-2)