The Department of Biological and Chemical Sciences offers B.S., M.S., and Ph.D. degrees in the fields of chemistry, biology, 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 master’s degrees and related certificate programs for part-time students, both on campus and through distance learning.

### Degrees Offered

**In Biology**
Professional Science Master of Biology with specialization in:
- Biochemistry
- Cell and Molecular Biology
- Microbiology
Master of Science in Biology
Master of Science in Molecular Biochemistry and Biophysics
Doctor of Philosophy in Biology
Doctor of Philosophy in Molecular Biochemistry and Biophysics

**In Chemistry**
Master of Chemistry in Analytical Chemistry
Master of Chemistry in Materials Chemistry
Master of Chemistry
Master of Science in Chemistry
Doctor of Philosophy in Chemistry

### Certificate Programs

**In Chemistry**
- Analytical Method Development
- Analytical Spectroscopy
- Characterization of Inorganic and Organic Materials
- Chromatography
- Regulatory Science
- Synthesis and Characterization of Inorganic Materials
- Synthesis and Characterization of Organic Materials

### Research Centers

International Center for Sensor Science and Engineering (ICSSE)

### 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, materials chemistry, organic chemistry, polymer chemistry, surface chemistry, physical chemistry, and medicinal chemistry. 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. Collaborative programs are carried on with Fermi National Accelerator Laboratory, Argonne National Laboratory, and the Advanced Photon Source.
Faculty

Biology Faculty

Antipova, Olga, Research Assistant Professor. B.Sc., M.S., Nizhny Novgorod Technical University (Russia); Ph.D., Illinois Institute of Technology.

Bekyarova, Tanya I., Senior Lecturer and Associate Chair for Biology. M.S., University of Plovdiv (Bulgaria); Ph.D., Illinois Institute of Technology. Muscle contraction and regulation. Biology and Biophysics.

Chakravarthy, Srinivas, Research Assistant Professor. B.Sc., Osmania University (India); M.Sc., Kasturba Medical College (India); Ph.D. Colorado State University.

Dushay, Mitchell, Assistant Professor. B.A., Brown University; Ph.D., Brandeis University. Drosophila genetics, immunology, eukaryotic transcription. Cell and Molecular Biology.

Howard, Andrew, Associate Professor of Biology and Physics and Laboratory Safety Officer. B.A., Pomona College; Ph.D., University of California-San Diego. Methods development and macromolecular crystallography. Biochemistry, Molecular Biochemistry, and Biophysics.

Irving, Thomas C., Professor of Biology, Physics, and Biomedical Engineering and Executive Associate Chair for Biology. B.Sc., M.Sc., Ph.D., University of Guelph (Canada). Structure and biophysics of macromolecular systems, muscle structure and physiology, synchrotron radiation instrumentation. Biochemistry, Molecular Biochemistry, and Biophysics.

Krikorian, Charles, Senior Lecturer and Director of Master’s Program. B.S., University of Illinois, Urbana-Champaign; Ph.D., Loyola University; J.D., DePaul University.

Mehta, Rajendra, Professor. B.S., M.S., Gujarat University (India); Ph.D., University of Nebraska. Efficacy and mechanism of action of chemopreventive agents in experimental carcinogenesis of breast, colon, lung, and prostate. Cell and Molecular Biology.

Menhart, Nicholas G., Associate Professor. B.Sc., Ph.D., University of Waterloo (Canada). Spectroscopic techniques for the study of multi-domain proteins. Biochemistry, Molecular Biochemistry, and Biophysics.

Orgel, Joseph, Associate Professor. B.Sc.(Hons.), Ph.D., Stirling University. Extracellular matrix function and structure, protein folding.

Pombert, Jeah-Francois, Assistant Professor. B.Sc., M.Sc., Ph.D., Universite Laval (Canada).

Spink, Kathryn M., Senior Lecturer and Chair of the Pre-Medical Advisory Committee. B.S., Michigan Technological University; Ph.D., Michigan State University. Molecular genetics of mammalian viruses. Cell and Molecular Biology, Microbiology.

Stark, Benjamin C., Professor, Associate Dean for Research, and Acting Chair. B.S., University of Michigan; M.Ph., Ph.D., Yale University. Biochemistry and molecular biology of bacterial respiration, fermentation, bioremediation. Microbiology, Biotechnology, Cell and Molecular Biology.

Webster, Dale A., 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. Biochemistry, Microbiology, Biotechnology.


Zhang, Chunbo, Research Assistant Professor. B.Agr., M.Agr., Zhejiang Fisheries College (China); Ph.D., University of Manitoba (Canada). Use of molecular genetics, biophysics, immunohistochemistry, pharmacology, and behavior to study olfactory transduction in the mouse and in fish. Cell and Molecular Biology.
Chemistry Faculty

Cage, Brant, Assistant Professor. B.S., University of West Florida; Ph.D., Florida State University. Synthesis and biophysical applications of magnetic materials, design and building sensitive instrumental techniques to characterize magnetic materials; theoretical analysis of novel materials with superior properties for particular needs, such as magnetic resonance imaging (MRI) enhancement, magnetic refrigeration, and standards for MRI.

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

Eisenberg, Walter C., Emeritus Professor. 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.

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

Guan, Xiyun (Richard), Associate Professor. B.S., China University of Geosciences; M.S., Chinese Academy of Geological Sciences; Ph.D., University of Kentucky. Bioanalytical and bio-physical chemistry with an emphasis on the development of biosensors for bio-terrorist/biodefense chemicals, environmental pollutants, toxins, DNA and protein molecules.

Hock, Adam S., Assistant Professor. B.S., University of Delaware; Ph.D., Massachusetts Institute of Technology. Homogeneous and heterogenous inorganic and organometallic synthesis and catalysis; rational and tunable methods for the preparation of light-harvesting and novel electronic materials; structure, bonding, and electronic properties of molecular and extended materials.

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

Khan, M. Ishaque, Professor and Executive Associate Chair for Chemistry. Ph.D., Indian Institute of Technology (India). Design, synthesis, and property studies of advanced materials. Current focus is on nanomaterials for applications in chemical sensing, energy storage, and biomedical usage, and nanostructured catalysts for detection and removal of toxic gases from industrial exhaust and flue gas streams, selective oxidation, (hydrocarbon’s transformation into useful industrial feed-stocks), and hydro treating catalysis.

Mandal, Braja K., Professor. B.Sc., University of Calcutta (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.

Minh, David Do Le, Assistant Professor. B.A., University of California, Berkeley; M.S., Ph.D., University of California, San Diego. Computational chemical biology and structure-based drug design; theoretical chemistry, especially statistical mechanics; biophysical chemistry.

Nguyen, Diep, Industry Professor. B.S., Ph.D., McGill University. Characterization and study of structure-property relationships in industrial polymeric materials.

Rogachev, Andrey, Assistant Professor. M.S., Ph.D., Moscow State University (Russia). Chemistry at magnetic centers, theoretical point of view; luminescence and bioluminescence; chemistry and physics of curved polyaromatic systems (buckybowls and fullerenes); multi-reference approach to spectroscopic, magnetic, and catalytic properties of organic, organometallic, and bio-(in)organic systems.

Unni, Aditya K., Assistant Professor. B.A., St. Olaf College; Ph.D., University of Chicago. Synthesis of small molecule natural products with interesting structural characteristics and biological activities. Developing reactions, specifically in asymmetric catalysis, to access high value chemical building blocks for organic synthesis.

Wang, Rong, Associate Professor and Associate Chair of Chemistry. B.S., M.S., Jilin University (China); Ph.D., University of Tokyo (Japan). Scanning probe microscopy, bioconjugate chemistry, biocompatible materials, method of development for single cell characterization and manipulation, analysis of effects of microenvironments on protein/cell/tissue function and dynamics.

Zion, Benjamin, Lecturer. B.A., Lawrence University; Ph.D., University of Chicago. Reactions at surfaces. Current focus is on chemical education and course development with special attention to instrumentation.
Admission Requirements

Cumulative undergraduate GPA minimum: 3.0/4.0
TOEFL minimum: 550/213/80*

The Graduate Record Examination (GRE) is required for all applicants. The GRE minimum scores are:

Ph.D.: 310 (quantitative + verbal),
3.0 (analytical writing)

Masters Program: 300 (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 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, or Molecular Biochemistry and Biophysics) are expected to have a bachelor’s 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/computer-based/internet-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 officially for the examination a maximum of two 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 master’s 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’s degree programs (MAS) are required to take and pass a 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. Master's degree programs are designed so that they may be completed by part-time students. Doctoral-level courses are usually available either in the evenings, on Saturdays, or on the internet. Each new graduate student is assigned a graduate student advisor and must obtain the approval of the advisor each semester before registering for any graduate classes.

Master of Biology

Minimum 30 credit hours
Comprehensive examination

The Professional Master of Biology is a course-only, professional master's 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 http://iit.edu/iit_online/ for more information.

Students must pass the written 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 a minimum of 30 credit hours of coursework as follows.

Cell and Molecular Biology
BIOL 401 Introductory Biochemistry AND
BIOL 402 Metabolic Biochemistry
OR
BIOL 504 Biochemistry
BIOL 515 Molecular Biology
BIOL 526 Developmental Biology
BIOL 544 Molecular Biology of Cells
AND 6-9 hours of approved electives

Microbiology
BIOL 401 Introductory Biochemistry AND
BIOL 402 Metabolic Biochemistry
OR
BIOL 504 Biochemistry
BIOL 515 Molecular Biology
BIOL 542 Advanced Microbiology
BIOL 544 Molecular Biology of Cells
AND 6-9 hours of approved electives

Biochemistry
BIOL 401 Introductory Biochemistry AND
BIOL 402 Metabolic Biochemistry
OR
BIOL 504 Biochemistry
BIOL 512 Advanced Biochemistry
BIOL 515 Molecular Biology
BIOL 544 Molecular Biology of Cells
AND 6-9 hours of approved electives

Biotechnology
BIOL 401 Introductory Biochemistry AND
BIOL 402 Metabolic Biochemistry
OR
BIOL 504 Biochemistry
BIOL 515 Molecular Biology
BIOL 544 Molecular Biology of Cells
BIOL 562 Current Topics in Functional Genomics
AND 6-9 hours of approved electives

Students in each area of specialization also take the following three courses:
CHEM 513 Statistics for Analytical Chemists AND
COM 421 Technical Communication
OR
COM 523 Communicating Science
COM 580 Topics in Communication AND
BIOL 511 Project Management: Business Principles
OR
INTM 511 Industrial Leadership
OR
BIOL 524 Science and Law: An Introduction to Intellectual Property Law and Patents
Master of Science in Biology
32-34 credit hours
Comprehensive examination
Option 1: Thesis
Option 2: Library or Laboratory research project

A Master of Science student must complete 32-34 credit hours of approved graduate work in one of the areas of specialization detailed below. This will include 26-30 credit hours of coursework and one credit hour of BIOL 595 Colloquium. Two options are available to complete the M.S. degree requirements: a thesis option and a nonthesis 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. This option is available on a competitive basis. 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 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); or BIOL 581 Capstone; or a laboratory research project in BIOL 522 (Research Techniques in the Biological Sciences I) plus BIOL 523 (Research Techniques in Biological Sciences II).

Master of Science in Biology
Required Courses (15 hours)
- BIOL 501 Graduate Laboratory Techniques
- BIOL 504 Biochemistry
- BIOL 515 Molecular Biology
- BIOL 533 Advanced Graduate Laboratory Techniques
- BIOL 544 Molecular Biology of Cells

Additional Requirements (7 hours)
- BIOL 581 Capstone AND
- BIOL 595 Colloquium
- AND One additional elective

OR
- BIOL 522 Research Techniques in Biological Sciences I
- AND
- BIOL 523 Research Techniques in Biological Sciences II

OR
- BIOL 591 Research

OR
- CHEM 591 Research

Elective Courses (6 hours)
- BIOL 410 Medical Microbiology
- BIOL 426 Concepts of Cancer Biology
- BIOL 430 Animal Physiology
- BIOL 503 Virology
- BIOL 514 Toxicology
- BIOL 520 Laboratory Rotation
- BIOL 526 Developmental Biology
- BIOL 527 Immunology and Immunochemistry
- BIOL 542 Advanced Microbiology
- BIOL 545 Advanced Cell Biology
- BIOL 550 Bioinformatics
- BIOL 562 Current Topics in Functional Genomics
### Master of Science in Biology with Specialization in Biochemistry

32 credit hours

**Required Courses (19 hours)**
- BIOL 501 Graduate Laboratory Techniques
- BIOL 504 Biochemistry
- BIOL 512 Advanced Biochemistry
- BIOL 515 Molecular Biology
- BIOL 533 Advanced Graduate Laboratory Techniques
- BIOL 544 Molecular Biology of Cells
- BIOL 555 Macromolecular Structure

**Additional Requirements (7 hours)**
- BIOL 595 Colloquium AND BIOL 591 Research
- OR
- CHEM 591 Research
- OR
- BIOL 572 Literature in Biochemistry AND one additional elective
- OR
- BIOL 522 Research Techniques in Biological Sciences I AND BIOL 523 Research Techniques in Biological Sciences II

**Elective Courses (6 hours)**
- BIOL 410 Medical Microbiology
- BIOL 426 Concepts of Cancer Biology
- BIOL 430 Animal Physiology
- BIOL 503 Virology
- BIOL 514 Toxicology
- BIOL 520 Laboratory Rotation
- BIOL 526 Developmental Biology
- BIOL 527 Immunology and Immunochemistry
- BIOL 542 Advanced Microbiology
- BIOL 545 Advanced Cell Biology
- BIOL 550 Bioinformatics
- BIOL 562 Current Topics in Functional Genomics

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 Cell and Molecular Biology

32-34 credit hours

**Required Courses (19-21 hours)**
- BIOL 501 Graduate Laboratory Techniques
- BIOL 504 Biochemistry
- OR
- BIOL 401 Introductory Biochemistry AND BIOL 402 Metabolic Biochemistry
- BIOL 515 Molecular Biology
- BIOL 526 Developmental Biology
- BIOL 533 Advanced Graduate Laboratory Techniques
- BIOL 544 Molecular Biology of Cells
- BIOL 545 Advanced Cell Biology

**Additional Requirements (7 hours)**
- BIOL 595 Colloquium AND BIOL 591 Research
- OR
- BIOL 576 Literature in Cell Biology AND one additional elective
- OR
- BIOL 522 Research Techniques in Biological Sciences I AND BIOL 523 Research Techniques in Biological Sciences II

**Elective Courses (6 hours)**
- BIOL 410 Medical Microbiology
- BIOL 426 Concepts of Cancer Biology
- BIOL 430 Animal Physiology
- BIOL 503 Virology
- BIOL 514 Toxicology
- BIOL 520 Laboratory Rotation
- BIOL 527 Immunology and Immunochemistry
- BIOL 542 Advanced Microbiology
- BIOL 550 Bioinformatics
- BIOL 555 Macromolecular Structure
- BIOL 562 Current Topics in Functional Genomics

Other requirements are identical to those described previously for all M.S. students in biology.
# Master of Science in Biology with Specialization in Microbiology

32-34 credit hours

## Required Courses (22-24 hours)

- **BIOL 501** Graduate Laboratory Techniques
- **BIOL 503** Virology
- **BIOL 504** Biochemistry OR **BIOL 401** Introductory Biochemistry
- **BIOL 515** Molecular Biology
- **BIOL 533** Advanced Graduate Laboratory Techniques
- **BIOL 542** Advanced Microbiology
- **BIOL 544** Molecular Biology of Cells
- **BIOL 562** Current Topics in Functional Genomics

## Additional Requirements (7 hours)

- **BIOL 595** Colloquium AND **BIOL 591** Research
- OR **BIOL 578** Literature in Microbiology AND one additional elective
- OR **BIOL 522** Research Techniques in Biological Sciences I AND **BIOL 523** Research Techniques in Biological Sciences II

## Elective Courses (3 hours)

- **BIOL 410** Medical Microbiology
- **BIOL 426** Concepts of Cancer Biology
- **BIOL 430** Animal Physiology
- **BIOL 512** Advanced Biochemistry
- **BIOL 514** Toxicology
- **BIOL 520** Laboratory Rotation
- **BIOL 526** Developmental Biology
- **BIOL 527** Immunology and Immunochemistry
- **BIOL 545** Advanced Cell Biology
- **BIOL 550** Bioinformatics
- **BIOL 555** Macromolecular Structure
- **BIOL 562** Current Topics in Functional Genomics

Other requirements are identical to those described previously for all M.S. students in biology.
Doctor of Philosophy in Biology

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

A minimum of 72 credit hours is required for the Ph.D. degree in biology. Students should consult the Transfer Credit section in this bulletin 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 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 core courses listed below:

**Required Courses**
- BIOL 504 Biochemistry
- BIOL 515 Molecular Biology
- BIOL 544 Molecular Biology of Cells
- BIOL 595 Biology Colloquium (4 times)

**Elective Courses**
- BIOL 410 Medical Microbiology
- BIOL 426 Concepts of Cancer Biology
- BIOL 430 Animal Physiology
- BIOL 503 Virology
- BIOL 514 Toxicology
- BIOL 520 Laboratory Rotation
- BIOL 526 Developmental Biology
- BIOL 527 Immunology and Immunochemistry
- BIOL 542 Advanced Microbiology
- BIOL 545 Advanced Cell Biology
- BIOL 550 Bioinformatics
- BIOL 555 Macromolecular Structure
- BIOL 562 Current Topics in Functional Genomics
- BIOL 597 Special Problems
- PHYS 410 Molecular Biophysics

All research for the dissertation must be carried out under the direct supervision of a faculty research advisor. The faculty research advisor will also act as the candidate’s academic advisor. 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 advisors 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
- Option 1: Thesis
- Option 2: Library or Laboratory research project

A master’s student must complete 32 credit hours of approved graduate work, including a core of 22 credit hours, 1 hour of BIOL 595 (Colloquium), 3 credit hours of approved electives, and 6 credit hours of research toward the thesis (BIOL, CHEM, or PHYS 591); or BIOL 572 (Literature in Biochemistry) and one additional elective, or BIOL 522 (Research Techniques in the Biological Sciences), and 3 credit hours of BIOL 597 (Special Topics).

Required Courses (22 hours)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>BIOL 501</td>
<td>Graduate Laboratory Techniques</td>
</tr>
<tr>
<td>BIOL 504</td>
<td>Biochemistry</td>
</tr>
<tr>
<td>BIOL 512</td>
<td>Advanced Biochemistry</td>
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<tr>
<td>BIOL 515</td>
<td>Molecular Biology</td>
</tr>
<tr>
<td>BIOL 533</td>
<td>Laboratory in Cell and Molecular Biology</td>
</tr>
<tr>
<td>BIOL 544</td>
<td>Molecular Biology of Cells</td>
</tr>
<tr>
<td>BIOL 555</td>
<td>Macromolecular Structure</td>
</tr>
<tr>
<td>PHYS 410</td>
<td>Molecular Biophysics</td>
</tr>
</tbody>
</table>

Additional Requirements (7 hours)

- BIOL 595 Colloquium
- BIOL 591 Research
- OR
- CHEM 591 Research
- OR
- PHYS 591 Research
- OR
- BIOL 572 Literature in Biochemistry AND one additional elective
- OR
- BIOL 522 Research Techniques in Biological Sciences I
- AND
- BIOL 523 Research Techniques in Biological Sciences II

Elective Courses (3 hours)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>BIOL 410</td>
<td>Medical Microbiology</td>
</tr>
<tr>
<td>BIOL 426</td>
<td>Concepts of Cancer Biology</td>
</tr>
<tr>
<td>BIOL 430</td>
<td>Animal Physiology</td>
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<tr>
<td>BIOL 503</td>
<td>Virology</td>
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<td>BIOL 514</td>
<td>Toxicology</td>
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<tr>
<td>BIOL 520</td>
<td>Laboratory Rotation</td>
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<td>BIOL 526</td>
<td>Developmental Biology</td>
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<td>BIOL 527</td>
<td>Immunology and Immunochemistry</td>
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<tr>
<td>BIOL 542</td>
<td>Advanced Microbiology</td>
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<tr>
<td>BIOL 545</td>
<td>Advanced Cell Biology</td>
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<tr>
<td>BIOL 550</td>
<td>Bioinformatics</td>
</tr>
<tr>
<td>BIOL 562</td>
<td>Current Topics in Functional Genomics</td>
</tr>
</tbody>
</table>

The elective is chosen in consultation with an academic advisor. Research for the dissertation must be carried out under the direct supervision of a participating faculty member; the faculty research advisor also acts as the candidate’s academic advisor.

Thesis Option

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

The non-thesis option is intended as a 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 BIOL 572 (Literature in Biochemistry), or BIOL 581 Capstone, or a laboratory based research project in BIOL 522 (Research Techniques in the Biological Sciences) plus BIOL 523 (Research Techniques in Biological Sciences II).

Doctor of Philosophy in Molecular Biochemistry and Biophysics

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

A minimum of 72 credit hours of instruction is required for the MBB Ph.D. Students should consult the section Transfer Credits on page 31 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 20 credit hours of core courses and at least five additional courses from the list of electives.

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 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). The program of study must include at least 36 credit hours in formal courses (exclusive of BIOL 591 and BIOL 691). All students will be required to take the following courses, or have equivalent background:

Required Courses
- BIOL 504 Biochemistry
- BIOL 512 Advanced Biochemistry
- BIOL 515 Molecular Biology
- BIOL 544 Molecular Biology of Cells
- BIOL 555 Macromolecular Structure
- BIOL 584 Graduate Seminar in Biology
- BIOL 595 Biology Colloquium
- PHYS 410 Molecular Biophysics

MBB students, in consultation with their academic advisor, choose the remainder of their formal coursework from the following list of elective courses:

Elective Courses
- BIOL 410 Medical Microbiology
- BIOL 414 Genetics for Engineering Sciences
- BIOL 426 Concepts of Cancer Biology
- BIOL 430 Animal Physiology
- BIOL 503 Virology
- BIOL 514 Toxicology
- BIOL 520 Laboratory Rotation
- BIOL 526 Developmental Biology
- BIOL 527 Immunology and Immunochemistry
- BIOL 542 Advanced Microbiology
- BIOL 545 Advanced Cell Biology
- BIOL 550 Bioinformatics
- BIOL 562 Current Topics in Functional Genomics
- BIOL 597 Special Problems
- CHEM 538 Physical Biochemistry

Other courses may be prescribed by the advisor/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 advisor who will also act as the candidate’s academic advisor.
Chemistry

The department offers graduate programs leading to M.S. and Ph.D. degrees in chemistry. Each student’s program is planned individually to meet individual needs, interests, and capabilities. 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 new graduate student is assigned a graduate student advisor and must obtain the approval of the advisor each semester before registering for any graduate classes.

Master of Chemistry in Analytical Chemistry

32 credit hours
Comprehensive examination

The professional master’s program in analytical chemistry is a part-time program for working chemists seeking to strengthen their understanding of analytical chemistry. The specific goal of the program is to provide the student with a broad and in-depth understanding of state-of-the-art analytical techniques with a firm grounding in separation science, spectroscopy, method development, and sample preparation. In addition, students acquire professional skills in effective communication, statistics, and business principles. Candidates must possess a bachelor’s degree (ideally in science or engineering) with at least one semester of calculus, one semester of calculus-based physical chemistry, one semester of analytical chemistry, and two semesters of organic chemistry. Candidates’ advisors assist them in determining if any further prerequisites are necessary. A final comprehensive exam is required for graduation. This program is also available via the internet. Students should consult science.iit.edu/programs/graduate/master-chemistry-analytical-chemistry for more information.

Required Courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>CHEM 500</td>
<td>Advanced Analytical Chemistry</td>
</tr>
<tr>
<td>CHEM 505</td>
<td>Spectroscopic Methods I</td>
</tr>
<tr>
<td>CHEM 506</td>
<td>Sampling and Sample Preparation</td>
</tr>
<tr>
<td>CHEM 508</td>
<td>Analytical Methods Development</td>
</tr>
<tr>
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<tr>
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<td>Statistics for Analytical Chemists</td>
</tr>
<tr>
<td>CHEM 515</td>
<td>Gas Chromatography - Theory and Practice</td>
</tr>
<tr>
<td>CHEM 516</td>
<td>Liquid Chromatography - Theory and Practice</td>
</tr>
</tbody>
</table>

AND one of the following three courses:

<table>
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<tr>
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<tbody>
<tr>
<td>CHEM 542</td>
<td>Polymer Characterization and Analysis</td>
</tr>
<tr>
<td>CHEM 543</td>
<td>Analytical Chemistry in Pharmaceutical Laboratories</td>
</tr>
<tr>
<td>CHEM 544</td>
<td>Colloids and Colloid Analysis</td>
</tr>
</tbody>
</table>

AND two of the following three courses:

<table>
<thead>
<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>CHEM 511</td>
<td>Project Management</td>
</tr>
<tr>
<td>COM 523</td>
<td>Communicating Science</td>
</tr>
<tr>
<td>INTM 511</td>
<td>Industrial Leadership</td>
</tr>
<tr>
<td>SCI 511</td>
<td>Project Management</td>
</tr>
<tr>
<td>SCI 522</td>
<td>Public Engagement for Scientists</td>
</tr>
</tbody>
</table>
Master of Chemistry in Materials Chemistry

31 credit hours
Comprehensive examination

The professional master’s program in materials chemistry is a part-time program designed for scientists who wish to broaden their background in synthesis and characterization of materials and chemical systems and their properties. The program combines modern materials design and synthesis strategies with innovative characterization techniques, computational and simulation methods, environmental regulations, project management, technical communication, and intellectual property management. It is structured to provide students with opportunities to develop a broad and in-depth understanding of the state-of-the-art in materials synthesis and characterization, learn to design and manage projects, sharpen their intellectual property management techniques, learn how to operate under regulatory constraints, and to improve communication skills. Students have the option to concentrate in inorganic or organic materials, or polymers.

Candidates must have a bachelor’s degree (ideally in science or engineering), with at least two semesters of organic chemistry and two semesters of calculus. The academic advisor assists 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.edu/csl/che/ for more information.

Required Courses

- CHEM 454 Chemical Modeling and Simulation
- CHEM 505 Spectroscopic Methods I
- CHEM 509 Physical Methods of Characterization
- CHEM 511 Project Management: Business Principles
- CHEM 521 Structural Inorganic and Materials Chemistry
- CHEM 522 Efficient Chemical and Materials Synthesis
- CHEM 524 Synthesis and Intellectual Property Management
- COM 523 Communicating Science

Elective Courses (choose 3)

- CHEM 470 Introduction to Polymers
- CHEM 513 Statistics for Analytical Chemists
- CHEM 530 Organic Reaction Mechanisms
- CHEM 531 Tactics in Organic Synthesis
- CHEM 535 Polymer Synthesis
- CHEM 542 Polymer Characterization and Analysis
- PHYS 431 Nanoscience
Master of Chemistry

32 credit hours
Comprehensive examination

A minimum of 32 credit hours is required for the Master of Chemistry degree. A minimum of 20 credits of 500 level coursework is required with 15 credits required from the Chemistry disciplines. A maximum of 12 credits of 400 level coursework may be used to fulfill graduate study requirements. Students seeking the Master of Chemistry degree must pass a final oral comprehensive examination.

The Master of Chemistry 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, when 9 credits earned or in-progress.

Credit Hour Summary (32 credits)
CHEM 584  Graduate Seminar (must be taken once)
CHEM 585  Chemistry Colloquium (must be taken twice)
Core Courses: 12 credits
CHEM Electives: 17 credits

Required Courses
CHEM 584  Graduate Seminar (must be taken once)
CHEM 585  Chemistry Colloquium (must be taken twice)

Elective Courses: 17 Credits
Electives will be chosen in consultation with the student’s advisor

A minimum of four core courses (12 credits) chosen from the following core areas (six disciplines):

Organic Chemistry
CHEM 455  Advanced Organic Chemistry
OR
CHEM 530  Organic Reaction Mechanisms

Analytical Chemistry
CHEM 500  Advanced Analytical Chemistry
OR
CHEM 505  Spectroscopic Methods I

Inorganic Chemistry
CHEM 520  Advanced Inorganic Chemistry
OR
CHEM 521  Structural Inorganic and Materials Chemistry

Physical Chemistry
CHEM 550  Chemical Bonding

Polymer Chemistry
CHEM 470  Introduction to Polymers
OR
CHEM 535  Polymer Synthesis

Biochemistry
BIOL 504  Biochemistry
Master of Science in Chemistry

32 credit hours
Comprehensive examination
Thesis and oral defense

A minimum of 32 credit hours is required for the Master of Science (M.S.) in Chemistry degree. A minimum of 20 credits of 500 level coursework is required with 15 credits required from the Chemistry disciplines. A maximum of 12 credits of 400 level coursework may be used to fulfill graduate study requirements. Students seeking the M.S. in Chemistry degree must pass the written comprehensive examination in their area of specialization (as determined by the student’s academic advisor and by the declaration of a specialization by the student) by the end of the fourth semester in the master of science in chemistry degree program. The comprehensive examinations are given in the following areas:

- Analytical Chemistry
- Biochemistry
- Computational Chemistry
- Inorganic Chemistry
- Organic Chemistry
- Physical Chemistry
- Polymer Chemistry

The student must also write a thesis based on original research and defend it before his or her M.S. thesis committee, which includes registration in 6-8 credits of research coursework numbered 591. The thesis and oral defense should be completed before the end of their 3rd year of academic study.

The M.S. 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, when 9 credits are earned or in-progress.

Credit Hour Summary (32 credits)
CHEM 584 Graduate Seminar (must be taken once)
CHEM 585 Chemistry Colloquium (must be taken twice)

Core Courses: 12 credits
CHEM Electives: 9-11 credits
CHEM 591: 6-8 credits

Required Courses
CHEM 584 Graduate Seminar (must be taken once)
CHEM 585 Chemistry Colloquium (must be taken twice)
CHEM 591: 6-8 credits

Elective Courses: 9-11 Credits
Electives will be chosen in consultation with the student’s research advisor

A minimum of four core courses (12 credits) chosen from the following core areas (six disciplines):

- Organic Chemistry
  CHEM 455 Advanced Organic Chemistry
  OR
  CHEM 530 Organic Reaction Mechanisms
- Analytical Chemistry
  CHEM 500 Advanced Analytical Chemistry
  OR
  CHEM 505 Spectroscopic Methods I
- Inorganic Chemistry
  CHEM 520 Advanced Inorganic Chemistry
  OR
  CHEM 521 Structural Inorganic and Materials Chemistry
- Physical Chemistry
  CHEM 550 Chemical Bonding
- Polymer Chemistry
  CHEM 470 Introduction to Polymersy
  OR
  CHEM 535 Polymer Synthesis
- Biochemistry
  BIOL 504 Biochemistry
Doctor of Philosophy in Chemistry

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

A minimum of 72 credit hours is required for the Ph.D. in chemistry. Students who have received an M.S. degree from another university may petition for transfer of up to 32 credit hours, applicable toward the Ph.D. degree. Students must pass the Ph.D. qualifying examination in their area of specialization (as determined by the student’s thesis advisor) by the end of their fourth semester in the Ph.D. program. Ph.D. qualifying examinations are given in the following areas:

- Analytical Chemistry
- Biochemistry
- Computational Chemistry
- Inorganic Chemistry
- Organic Chemistry
- Physical Chemistry
- Polymer Chemistry

The comprehensive examination will be taken and passed on each student’s research progress and thesis proposal. A student must write a thesis proposal and present a research seminar on his or her thesis progress before their Ph.D. thesis committee, which includes registration in 24-36 credits of research coursework numbered 691. Students must pass the comprehensive exam before the end of their 3rd year. The final phase in the Ph.D. degree program is the successful oral defense of the dissertation and submission of a Ph.D. dissertation approved by the academic advisor and the thesis committee.

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).

Credit Hour Summary (72 credits)
CHEM 584  Graduate Seminar (must be taken once)
CHEM 585  Colloquium in Chemistry (must be taken twice)
CHEM 684  Graduate Seminar (must be taken once)
CHEM 685  Chemistry Colloquium (must be taken twice)
CHEM Core Courses: 12 credits
CHEM Electives: 18-30 credits
CHEM 691: 24-36 credits

Required Courses
CHEM 584  Graduate Seminar
CHEM 585  Chemistry Colloquium (must be taken twice)
CHEM 684  Graduate Seminar
CHEM 685  Chemistry Colloquium (must be taken twice)

Elective Courses: 18-30 Credits
Electives will be chosen in consultation with the student’s research advisor

The required coursework includes a minimum of four core courses chosen from the following courses. Each of the four core courses must be chosen from six different chemistry disciplines including analytical chemistry, biochemistry, inorganic chemistry, organic chemistry, physical chemistry, and polymer chemistry.

Organic Chemistry
CHEM 455  Advanced Organic Chemistry
OR
CHEM 530  Organic Reaction Mechanisms

Analytical Chemistry
CHEM 500  Advanced Analytical Chemistry
OR
CHEM 505  Spectroscopic Methods I

Inorganic Chemistry
CHEM 520  Advanced Inorganic Chemistry
OR
CHEM 521  Structural Inorganic and Materials Chemistry

Physical Chemistry
CHEM 550  Chemical Bonding

Polymer Chemistry
CHEM 470  Introduction to Polymers
OR
CHEM 535  Polymer Synthesis

Biochemistry
BIOL 504  Biochemistry
Certificate Programs - In Chemistry

Analytical Method 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 515 Gas Chromatography - Theory and Practice
- CHEM 516 Liquid Chromatography - Theory and Practice

**AND** two courses selected from the list of electives below.

Regulatory Science

**Required Courses**
- CHEM 518 Understanding ICH Guidelines
- CHEM 519 Good Manufacturing Practices

**AND** two courses selected from the list of electives below.

Electives for Analytical Method Development, Analytical Spectroscopy, Chromatography, and Regulatory Science

- CHEM 500 Advanced Analytical Chemistry
- CHEM 505 Spectroscopic Methods I
- CHEM 506 Sampling and Sample Preparation
- CHEM 508 Analytical Methods Development
- CHEM 509 Physical Methods of Characterization
- CHEM 512 Spectroscopic Methods II
- CHEM 513 Statistics for Analytical Chemists
- CHEM 515 Gas Chromatography - Theory and Practice
- CHEM 516 Liquid Chromatography - Theory and Practice
- CHEM 542 Polymer Characterization and Analysis
- CHEM 543 Analytical Chemistry in Pharmaceutical Sciences
- CHEM 544 Colloids and Colloid Analysis

Graduate Certificate Program in Materials Chemistry

The following three Graduate Certificate Programs are available:

**Synthesis and Characterization of Inorganic Materials**
- CHEM 505 Spectroscopic Methods I
- CHEM 509 Physical Methods and Characterization
- CHEM 542 Polymer Characterization and Analysis

**Synthesis and Characterization of Organic Materials**
- CHEM 521 Structural Inorganic and Materials Chemistry
- CHEM 522 Efficient Chemical and Materials Synthesis
- CHEM 530 Organic Reaction Mechanisms
- CHEM 531 Tactics in Organic Synthesis
- CHEM 535 Polymer Synthesis

**Characterization of Inorganic and Organic Materials**
- CHEM 521 Structural Inorganic and Materials Chemistry
- CHEM 522 Efficient Chemical and Materials Synthesis
- CHEM 530 Organic Reaction Mechanisms
- CHEM 531 Tactics in Organic Synthesis
- CHEM 535 Polymer Synthesis

To earn a certificate in materials chemistry a minimum of 12 credit hours of course work from the following two groups of courses is required. At least one course must be chosen from Group A and at least one course must be chosen from Group B. The remaining credit hours may be chosen from either group, depending upon the certificate program. Each of these courses, if completed with a B or higher, may be later applied toward the Master of Chemistry in Materials Chemistry degree if you apply and are accepted to the degree program.
Course Descriptions

Biology

BIOL 501  
Graduate Laboratory Techniques  
This course will provide training in biological laboratory techniques. This will include basic laboratory protocols, safety, record keeping, proper use of equipment, and fundamental techniques common to many sub-specializations. (0-3-2)

BIOL 503  
Virology  
This course will cover topics related to animal viruses including the life cycles 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(s): [(BIOL 445) OR (BIOL 515)] (3-0-3)

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

BIOL 511  
Project Management: Business Principles  
Introduction to concepts and techniques used to design and/or analyze a project 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. Open only to Biology or Molecular Biochemistry and Biophysics majors. (2-0-2)

BIOL 512  
Advanced Biochemistry  
This course provides an advanced view of modern biochemistry building on studies done in BIOL 504 of metabolism, enzyme mechanisms, and kinetics, as well as theoretical aspects of various laboratory techniques used in biochemistry. Instructor permission required. Prerequisite(s): [(BIOL 504)] (3-0-3)

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. Prerequisite(s): [(BIOL 401) OR (BIOL 430) OR (CHEM 237)] (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(s): [(BIOL 401)] (3-0-3)

BIOL 520  
Laboratory Rotation  
Independent study in the research laboratory of a faculty member. (0-9-3)

BIOL 522  
Research Techniques in the Biological Sciences I  
Experimental techniques in biochemistry, cell Biology, biotechnology, and microbiology are offered as discreet modules. Students select appropriate modules to complement other laboratory courses. Thus a student who has completed, for example, BIOL 533, (Laboratory in Cell and Molecular Biology) would select two modules chosen from cell biology, biotechnology, or microbiology. A written report is required at the completion of each module. Instructor permission required. (1-6-3)

BIOL 523  
Research Techniques in Biological Sciences II  
This course is a continuation of BIOL 522 where students have to complete the research project started in BIOL 522 and a write a report in the form of a scientific paper. (0-3-3)

BIOL 524  
This course focuses on the interaction of science and law, specifically intellectual property. Topics will include patents, the ethical and legal issues involved with gene patenting, inventorship and collaborations, trade secrets, and the legal system as it relates to intellectual property. (0-1-2)

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 & Immunochemistry  
Basic concepts of immunology, immunochemistry, both biological and molecular. (3-0-3)

BIOL 533  
Advanced Graduate Laboratory Techniques  
This course covers a number of essential techniques in cell and molecular biology, biochemistry, and structural biology with emphases on both the methodologies and the experimental details. Laboratory procedures include cell culture skills and relevant laboratory procedures. This course is arranged modules from which students choose according to their areas of specialization. Prerequisite(s): [(BIOL 501 with min. grade of B)] (0-9-3)
BIOL 542
Advanced Microbiology
This course surveys a variety of topics regarding the biology of microbes. These include cell structure, metabolism, physiology, strategies for obtaining energy, and how this relates to microbial ecology, genetics, and comparative genomics.
(3-0-3)

BIOL 544
Molecular Biology of Cells
This is a graduate-level cell biology course. The course contains two parts: initial lectures cover cellular structure and function emphasizing the molecular components, organelles, and regulation of cellular processes; the second part covers special topics emphasizing experimental approaches and molecular mechanisms of cellular regulation.
(3-0-3)

BIOL 545
Advanced Cell Biology
This course is a continuation of BIOL 544 and focuses on recent advances in the area of cell biology. The course covers, in depth, eukaryotic cellular processes, structure-function relationships, and cellular signaling networks in response to physiological and pathological stimuli. The course will also cover frontier topics in the area of cell biology. Emphasis will be on experimental approaches. Instructor permission required.
Prerequisite(s): [(BIOL 445 and BIOL 446) OR (BIOL 533 and BIOL 544)]
(3-0-3)

BIOL 550
Bioinformatics
This course is tailored for life science graduates having little to no prior knowledge of Unix/Linux-like operating systems. Topics covered will include Linux/UNIX-like operating systems, the Bash shell, Perl programming, collecting and storing sequences in the lab, multiple sequence alignments, database searching for similar sequences, gene prediction, genome analysis, and phylogenetic prediction.
(3-0-3)

BIOL 555
Macromolecular Structure
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. Instructor permission required.
(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(s): [(BIOL 515)]
(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. Instructor permission required.
(0-0-3)

BIOL 574
Literature in Biotechnology
A topic from the current literature in biotechnology is selected by students for preparation of a paper. Instructor permission required.
(0-0-3)

BIOL 576
Literature in Cell & Molecular Biology
A topic from the current literature in cell and molecular biology is selected by students for preparation of a paper. Instructor permission required.
(0-0-3)

BIOL 578
Literature in Microbiology
A topic from the current literature in microbiology is selected by students for preparation of a paper. Instructor permission required.
(0-0-3)

BIOL 581
Capstone
In this course, students will be provided with the opportunity to perform a research project that is the culmination of their Master’s education. This course involves the research and preparation of a group project. Students will develop a formal work reflecting integration of the scientific knowledge and technical skills learned in the Master’s programs through a project chosen by the group. The course will explore online collaboration tools to allow participation of online students. Each group will present its Capstone project at the end of the class. Instructor consent is required.
(3-0-3)

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

BIOL 591
Research & Thesis M.S.
Instructor permission required.
(Credit: Variable)

BIOL 594
Research Problems
Instructor permission required.
(Credit: Variable)

BIOL 595
Biology Colloquium
Lectures by invited scientists in areas of biology generally not covered in the department.
(1-0-1)

BIOL 597
Special Problems
Special problems in biology. Instructor permission required.
(Credit: Variable)

BIOL 600
Continuation of Residence
(0-0-1)

BIOL 691
Research & Thesis PHD
Research and Thesis for Ph. D. students.
(Credit: Variable)
Undergraduate Courses available to Graduate Students

Note: Students may take up to an approved number of the following courses.

**Biology Courses**

- **BIOL 401**
  - Introductory Biochemistry
- **BIOL 402**
  - Introductory Biochemistry
- **BIOL 410**
  - Medical Microbiology
- **BIOL 414**
  - Genetics for Engineering Scientists
- **BIOL 426**
  - Concepts of Cancer Biology
- **BIOL 430**
  - Animal Physiology
- **BIOL 445**
  - Cell Biology

**Chemistry Courses**

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

- **CHEM 502**
  - Gas Chromatography, Gas Chromatography Mass Spectrometry
  - Theory and practice of gas chromatography with emphasis in capillary gas chromatography and gas chromatography mass spectrometry.
  - (2-0-2)

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

- **CHEM 505**
  - Spectroscopic Methods
  - 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 & 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 & 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: Business Principles
  - 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. Open only to Analytical Chemistry, Chemistry or Materials and Chemical Synthesis majors.
  - (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 515**
  - Gas Chromatography – Theory & Practice
  - This course will cover theory and concepts of gas chromatographic analysis and its practical application in solving analytical problems. Topics include basic theory of chromatographic separation, separation dynamics, instrumentation, column selection, quantitative techniques, and practical applications.
  - (3-0-3)

- **CHEM 516**
  - Liquid Chromatography – Theory & Practice
  - This course will cover the operating principles and applications of state-of-the-art LC/HPLC instrumentation and analysis. Topics include basic theory of liquid chromatography, instrumentation, optimization of LC separation, quantitative techniques, and the diverse range of analytical applications amenable to LC analysis.
  - Prerequisite(s): [(CHEM 515)]
  - (3-0-3)
CHEM 518  
**Understanding the International Conference on Harmonization Guidelines**  
The International Conference on Harmonization (ICH) was revolutionized in the 1980's to provide a forum for the pharmaceutical industry to discuss regulatory requirements for registration of new chemical entity. These guidelines have been significantly influenced the content of FDA draft guidelines to develop the scientific information and manufacturing controls. Thus, proper understanding of these guidelines is essential in the drug development process. This course will be designed to focus exclusively on guidelines associated with the registration of small molecules. Completing this course, students will understand the expectations set forth in various FDA and ICH quality topics in order to implement these guidelines and/or engage the regulatory agencies in dialogue in order to provide justification of data or present clear scientific rationale.  
(3-0-3)  

CHEM 519  
**Good Manufacturing Practices**  
This course provides an introduction to current good manufacturing practices (GMP) regulations and their implementation to different areas of the manufacturing process such as laboratory records, equipment, personnel, facilities, etc. The course will help students to recognize the regulatory actions and financial risks for non-compliance.  
(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 & Materials 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 & Materials Synthesis**  
(3-0-3)  

CHEM 524  
**Synthesis & 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 the technical presentations by the students in the classroom. Topics of discussion will include invention disclosures, intellectual property rights, proprietary materials, justification for patents, types of patents, the 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, carbocation chemistry, free radical reactions, photochemistry and concerted reactions.  
Prerequisite(s): [(CHEM 455)]  
(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 stereo chemical 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(s): [(CHEM 530)]  
(3-0-3)  

CHEM 535  
**Polymer Synthesis**  
This course will cover the basics of polymer synthesis including traditional polymerization techniques, such as free-radical and ion liquid polymerizations, and step-growth polymerization. Newer methods of polymer synthesis, such as ring-opening metathesis and controlled free-radical polymerizations, will also be discussed. Students will be introduced to the methods of preparation of advanced polymer structures, such as block, star and brush copolymers, dendrimers, and hyperbranched polymers.  
Prerequisite(s): [(CHEM 289)]  
(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(s): [(CHEM 470)]  
(1-6-3)  

CHEM 538  
**Physical Biochemistry**  
The principles and techniques of physical chemistry applied to proteins, nucleic acids, polysaccharides and lipids.  
Prerequisite(s): [(CHEM 239 and CHEM 344)]  
(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.  
Prerequisite(s): [(CHEM 239)]  
(3-0-3)
CHEM 542
Polymer Characterization & Analysis
This course will provide an overview of the common techniques for polymer characterization, studying structure-property relationships, and polymer morphology. The course will focus on thermal and mechanical characterization of polymers as well as polymer rheology. Examples and uses of major commercial polymers and advanced functional polymers will be introduced.
(3-0-3)

CHEM 543
Analytical Chemistry in Pharmaceutical Laboratories
This course is designed to complement the current curriculum of the professional master degree in analytical chemistry. It is a review of the requirements a student may face as a professional chemist in a regulated industry. The course focus is on the requirements and common topics facing today’s pharmaceutical industry. While individual agencies have specific regulations, the fundamental ideas of these regulations are largely consistent across the board. For example, an analytical chemist versed in Good Laboratory Practices (GLP) under FDA can quickly pick up the GLP’s required by EPA.
(2-0-2)

CHEM 544
Colloids & Colloid Analysis
This course will begin a general overview of colloid science. This part of the course will introduce various types of colloids, touch on factors and conditions leading to their stability or instability, consider their evolution and will include a very limited discussion of the conditions under which they can form. The second part of the course will consist of a series of discussions of specific analytical techniques used to characterize colloidal systems, with particular emphasis on the physical characterization of the dispersed phase.
(2-0-2)

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 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 550
Chemical Bonding
Prerequisite(s): [(CHEM 344)]
(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.
Prerequisite(s): [(CHEM 550 and CHEM 553)]
(3-0-3)

CHEM 553
Introduction to Chemical Thermodynamics
Fundamental laws of thermodynamics; application to simple chemical systems.
Prerequisite(s): [(CHEM 344)]
(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. May be taken more than once and up to 12 credit hours.
(Credit: Variable)

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 PhD 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 time by M.S. students and four time by PhD. students.
(1-0-1)

CHEM 591
Graduate Seminar in Chemistry
Required of all first year M.S. and PhD students. Students are required to present seminars based on the scientific literature. To foster scientific communications skills, students are required to present seminars based on the scientific literature. Required of all first year M.S. and PhD students.
(1-0-1)

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

CHEM 596
Chemistry for Teachers-Elementary
Certification as chemistry teacher or approval of instructor. An in-service workshop for pre-college teachers emphasizing the phenomenological approach to the teaching of chemical science. (Credit: variable)
(Credit: Variable)

CHEM 597
Reading & 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)
(Credit: Variable)

CHEM 598
Chemistry for High School Teachers
Certification as teacher or approved of instructor. An in-service workshop for pre-college teachers emphasizing the phenomenological approach to teaching of chemical science at the high school level. (Credit: variable)
(Credit: Variable)

CHEM 600
Continuation of Residence
(0-0-1)
CHEM 610
Special Topics in Analytical Chemistry
Topics of current interest in analytical chemistry including advanced electro-chemistry, surface spectroscopy of electrode surfaces, separations, laboratory automation and new spectroscopic techniques.
(2-0-2)

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

CHEM 620
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 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
Special Topics in Organic Chemistry
Topics of current interest in organic chemistry including photochemistry, fluorine chemistry, heterocyclic chemistry, pharmaceutical chemistry and electro optical organic chemistry.
Prerequisite(s): [(CHEM 455)]
(2-0-2)

CHEM 631
Special Topics in Organic Chemistry
Topics of current interest in organic chemistry including photochemistry, fluorine chemistry, heterocyclic chemistry, pharmaceutical chemistry and electro optical organic chemistry.
Prerequisite(s): [(CHEM 455)]
(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(s): [(CHEM 239 and CHEM 455)]
(3-0-3)

CHEM 650
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)

CHEM 651
Special Topics in Physical Chemistry
Topics of current interests 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)

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.
Prerequisite(s): [(CHEM 585)]
(1-0-1)

CHEM 691
Research & Thesis Ph.D.
(Credit: Variable) Instructor permission required.
(Credit: Variable)

Undergraduate Courses Available to Graduate Students
Note: Students may take up to an approved number of the following courses.

CHEM 415
Inorganic Chemistry

CHEM 416
Inorganic Chemistry

CHEM 451
Modern Techniques in Chemical Literature

CHEM 454
Chemical Modeling and Simulation

CHEM 455
Chemical Modeling and Simulation

CHEM 470
Introduction to Polymers