

Biochemistry and Biotechnology

General Information

Degrees

The Biochemistry and Biotechnology Program provides academic programs leading to the undergraduate B.S. degree or the graduate M.S. degree in Biochemistry and Biotechnology. These degrees are offered in cooperation with the Department of Biology and the Department of Chemistry and Biochemistry. Faculty members in this program are engaged in teaching and research in areas such as biochemistry, genetics, molecular biology, cell biology and developmental biology. Majors have the opportunity through coursework, laboratories, seminars and research experience to develop the knowledge and skills necessary to enter the workforce or to go on with further graduate education.

Career Outlook

The emerging Biotechnology sector is increasing the regional and national demand for workers with significant training in molecular biology, biochemistry, and genetics. The St. Louis metropolitan area has long been a major center for biochemistry and biotechnology, and in the past decade it has become a national hub for life sciences research and development activity. A degree in Biochemistry and Biotechnology provides students with the training they need to become part of the broad biotechnology and life sciences industries.

Undergraduate Studies

Degree Requirements

Bachelor of Science in Biochemistry and Biotechnology

General Education Requirements

Students must satisfy the university and college general education requirements (<http://bulletin.umsl.edu/generaleducationrequirements>). Some math or science courses required for the major may be used to meet the science and mathematics requirement of the university. There is no foreign language requirement for the degree.

All Biochemistry & Biotechnology majors are required to take a capstone seminar (either CHEM 4797 or BIOL 4797) during the semester in which they plan to graduate (the winter semester for students graduating in the summer). Students may not receive credit for both CHEM 4797 and BIOL 4797).

Satisfactory/Unsatisfactory Option

Up to 18 credit hours may be taken on a satisfactory /unsatisfactory (s/u). Excluded from this option are required courses in biology, chemistry, physics, and mathematics.

Non-major Biology or Chemistry courses

Courses in Biology with a number less than 1800 and courses in Chemistry with a number less than 1100 do not count toward the credit hours required for a major in biochemistry and biotechnology.

Research for Credit

A maximum of 3 credit hours from any combination of BIOL 4905 and CHEM 3905 may be applied toward the Biochemistry & Biotechnology program.

Transfer of Credit from Saint Louis Community Colleges

Students transferring BIO 219 and BIO 220 from Saint Louis Community Colleges will not have to complete BIOL 4614. However, they will have to take an additional 3 credit hours of Biochemistry and Biotechnology Elective coursework.

Biology Core Courses

| | | |
|-----------|---|---|
| BIOL 1831 | Introductory Biology: From Molecules To Organisms | 5 |
| BIOL 2012 | Genetics | 3 |
| BIOL 2013 | Genetics Laboratory | 2 |
| BIOL 2482 | Microbiology | 3 |
| BIOL 2483 | Microbiology Laboratory | 2 |
| BIOL 3622 | Cell Biology | 3 |

Chemistry Core Courses

| | | |
|-----------|--|---|
| CHEM 1111 | Introductory Chemistry I | 5 |
| CHEM 1121 | Introductory Chemistry II | 5 |
| CHEM 2223 | Quantitative Analysis | 3 |
| CHEM 2612 | Organic Chemistry I | 3 |
| CHEM 2622 | Organic Chemistry II | 3 |
| CHEM 2633 | Organic Chemistry Laboratory | 2 |
| CHEM 3302 | Physical Chemistry For The Life Sciences | 3 |

Math and Physics Core Courses

| | | |
|--------------|----------------------------------|---|
| MATH 1030 | College Algebra | 3 |
| MATH 1035 | Trigonometry | 2 |
| MATH 1100 | Basic Calculus | 3 |
| or MATH 1800 | Analytic Geometry And Calculus I | |
| PHYSICS 1011 | Basic Physics I | 4 |
| PHYSICS 1012 | Basic Physics II | 4 |

Biochemistry and Biotechnology Core Courses

| | | |
|----------------|---|---|
| BIOL 4602 | Molecular Biology (if both courses are taken, one can be used as an elective) | 3 |
| or BIOL 4612 | Molecular Genetics Of Bacteria | |
| BIOL 4614 | Biotechnology Laboratory I (if both courses are taken , one can be used as an elective) | 4 |
| or BIOL 4615 | Biotechnology Laboratory II | |
| BIOL/CHEM 4712 | Biochemistry | 3 |
| CHEM 4733 | Biochemistry Laboratory | 2 |
| CHEM 4722 | Advanced Biochemistry | 3 |
| BIOL 4797 | Biochemistry and Biotechnology Seminar (Students may not receive credit for both BIOL 4797 and CHEM 4797) | 1 |
| or CHEM 4797 | Biochemistry and Biotechnology Seminar | |

Biochemistry and Biotechnology Elective Courses

| | | |
|------------------------------|--------------------------------|---|
| Select two of the following: | | 6 |
| BIOL 4550 | Bacterial Pathogenesis | |
| BIOL 4602 | Molecular Biology | |
| BIOL 4612 | Molecular Genetics Of Bacteria | |

| | |
|-------------|---|
| BIOL 4614 | Biotechnology Laboratory I |
| BIOL 4615 | Biotechnology Laboratory II |
| BIOL 4622 | Cellular Basis of Disease |
| BIOL 4632 | Nucleic Acid Structure And Function |
| BIOL 4642 | Plant Molecular Biology and Genetic Engineering |
| BIOL 4652 | Virology |
| BIOL 4842 | Immunobiology |
| BIOL 4905 | Research (up to 3 credit hours) |
| BIOL 4920 | Selected Topics in Biology (when relevant) |
| CHEM 3643 | Advanced Organic Chemistry Laboratory |
| CHEM 3905 | Chemical Research |
| CHEM 4772 | Physical Biochemistry |
| Total Hours | |
| | 80 |

Electives

Recommendations include basic statistics (MATH 1310 or MATH 1320), computer science, public speaking (COMM 1040), foreign language, ethics, and undergraduate research.

B.S./M.S. Dual Degree Program in Biochemistry and Biotechnology

The BS/MS ("2+3") BCBT program is an accelerated program that allows students of appropriate academic ability and maturity to complete both a B.S. and a M.S. in Biochemistry and Biotechnology in five years of full time study. The program allows students to apply 12 of the 30 M.S. credit hours towards the B.S. (per the approval of the College of Arts and Sciences), reducing the overall required hours for the two. Students will pay graduate credit hour tuition for all courses applied to the graduate degree. All other requirements for the B.S. and M.S. degrees remain in effect.

Admission Requirements

Students interested in this program must go through a two-step admission process. First, applicants for Provisional Status must have completed all courses in the biology, chemistry, math and physics cores of the B.S. BCBT program. CHEM 4712/ BIOL 4712 Biochemistry must be in progress or completed prior to applying for Provisional Graduate status. Applicants should have completed all of the general education requirements. Applicants must also have a minimum G.P.A. of 3.0 (both overall and in science courses) and must submit at least two letters of recommendation (one instructor and one academic advisor is recommended).

The second step of the admission process is the transition from Provisional status to formal graduate status. Admission requirements for formal graduate status are the same as for the traditional MS program.

Awarding of Degrees

Both degrees (the B.S. and M.S.) will be awarded when all requirements for the entire program have been completed. In other words, the B.S. and M.S. degrees will be simultaneously awarded at the completion of study.

Students who officially withdraw from the BS/MS Dual BCBT Degree Program and who have successfully completed all of the requirements for the B.S. degree will be awarded the B.S. degree.

Research Opportunity

Students may use up to 3 credit hours of undergraduate research as elective hours in the B.S. degree. This provides an opportunity to gain research experience under the supervision of a faculty member. The project will normally include a review of the literature, laboratory experience and a final research report.

Minor in Biology

Students who complete the B.S. degree in Biochemistry and Biotechnology may also obtain a minor in biology by completing BIOL 1821, Introductory Biology : Organisms and the Environment. The minor must be approved by the chair of the Department of Biology. At least 9 hours of the biology course credits must be taken in residence at UMSL. Candidates must have a cumulative grade point average of 2.0 or better in the minor, and none of the courses may be taken on a satisfactory/unsatisfactory (S/U) basis.

Minor in Chemistry

Students who complete the B.S. degree in Biochemistry and Biotechnology will also fulfill the course requirements for a minor in Chemistry. A GPA of at least 2.0 is required for the courses presented for the minor. At least three courses toward the Chemistry minor must be completed at UMSL.

Learning Outcomes

Students often think of the physical and life sciences as areas in which one masters a collection of "scientific facts". However, an education in Biochemistry & Biotechnology involves much more than memorizing facts. Students in this program will develop a well-rounded set of competencies in several critical areas. These include:

- **Discipline-Specific Knowledge.** Graduates from this program will have a solid foundation in the content areas of chemistry, biology, and biochemistry. A certain emphasis on specific, descriptive data is necessary. But the larger emphasis is on a clear understanding of the overriding principles and theorems of these areas that allow students to evaluate specific data within a larger context.
- **Laboratory Skills.** Scientists not only learn the results of others, they work in the lab to generate new knowledge. Graduates will learn the basic skills associated with performing laboratory experiments in chemistry, biology, and biochemistry, and they will learn how to critically evaluate their data. This includes an appreciation of the potential sources of error associated with laboratory measurements.
- **Problem Solving Skills.** Graduates will develop the ability to solve problems in their discipline. In part, this expands on laboratory skills, as students learn how to interpret and evaluate their data. These skills also include learning how to take general principles from various areas of chemistry, biochemistry, and biology and apply them to the solution of specific problems.
- **Communication Skills.** Graduates must not only be able to solve problems, they must also be able to communicate those solutions to others. Graduates will learn how to write scientific reports and papers and will be able to make effective oral presentations of their results and ideas.
- **Scientific Literacy.** Scientists must be able to build on the previous work of others and to put their new results into the larger context of the field. This requires the ability to work effectively with the scientific literature. Graduates will be able to use the specialized search engines associated with the vast literature in chemistry, biology, and

biochemistry to find and retrieve information. Graduates will also have the knowledge background necessary to read papers from the literature with good comprehension.

- Professional Ethics. Graduates will understand and respect the accepted standards of conduct associated with the scientific profession. This will include honestly and objectively evaluating and reporting data and demonstrating the proper respect for the published work of others.

Graduate Studies

Degree Requirements

Master of Science in Biochemistry and Biotechnology

The Biochemistry and Biotechnology Program offers three types of Master of Science degrees.

- One is a non-thesis option suitable for those with laboratory research experience or for others, such as educators, who do not require research experience.
- The second is a 32 credit hour Professional Science emphasis area that includes a strong business component for students who are interested in learning more about the business aspects of companies. This track may not be appropriate for students who are interested in pursuing a PhD or working primarily as laboratory scientists.
- The third option includes laboratory-based research under the supervision of one of the program faculty members, leading to a written thesis. All students admitted to the graduate program are considered to be in the non-thesis program. They may transfer into the thesis program after they have been accepted as a thesis student by one of the faculty.

M.S. Admission Requirements

Applicants to the M.S. program must submit a completed application and personal data forms, two letters of recommendation from faculty at previously-attended colleges or universities, and transcripts of all previous postsecondary academic work. Applicants whose undergraduate degree is from a university outside of the United States must submit GRE scores (verbal, quantitative, and analytical). For students with a degree from a U.S. university, submission of Graduate Record Examination scores, although not required, is highly recommended. Admission as a regular graduate student requires graduation from an accredited college with a minimum grade point overall and in biology and chemistry courses of 3.0 (where A=4.0). Students will generally be expected to have completed a major in biology, chemistry, biochemistry or biotechnology. In addition to the Graduate School admission requirements, applicants should have completed an undergraduate course in biochemistry (equivalent to BIOL 4712 / CHEM 4712). Successful applicants will typically have completed courses in organic chemistry, cell biology, and genetics. Applicants may be asked to make up any deficiencies in these areas as a condition of enrollment.

All international applicants, except those from countries where English is the primary language, must take the TOEFL. Ordinarily, a score of 213 on the computer-based exam (550 on the paper-based exam or 80 on the internet-based exam) or better is required.

Requirements

Both the thesis and non-thesis options require a total of 30 graduate credit hours, of which at least half must be at the 5000-level or above. A maximum of 12 or 5 credit hours of Graduate Research (BIOL 6905 or

CHEM 6905) may be applied toward the 30 credit hour total for the thesis or non-thesis options, respectively. Students must have a 3.0 GPA in non-research courses.

Required Courses

| | | |
|-----------|--------------------------------------|---|
| CHEM 4722 | Advanced Biochemistry | 3 |
| CHEM 5774 | Bioinformatics | 3 |
| BIOL 6615 | Advanced Biotechnology Laboratory II | 4 |
| BIOL 6602 | Advanced Molecular Biology | 3 |
| BIOL 6889 | Graduate Seminar | 2 |

Elective Courses

| | | |
|-----------|--|------|
| CHEM 4733 | Biochemistry Laboratory | 2 |
| CHEM 4772 | Physical Biochemistry | 3 |
| CHEM 5694 | Special Topics In Organic Chemistry | 3 |
| CHEM 5794 | Special Topics In Biochemistry | 3 |
| CHEM 6787 | Problem Seminar In Biochemistry | 1 |
| CHEM 6905 | Graduate Research In Chemistry | 1-10 |
| BIOL 4842 | Immunobiology | 3 |
| BIOL 5069 | Topics In Cellular And Molecular Biology | 1 |
| BIOL 6442 | Advanced Developmental Biology | 3 |
| BIOL 6550 | Advanced Bacterial Pathogenesis | 3 |
| BIOL 6602 | Advanced Molecular Biology | 3 |
| BIOL 6612 | Advanced Molecular Genetics Of Bacteria | 3 |
| BIOL 6622 | Advanced Cellular Basis of Disease | 3 |
| BIOL 6632 | Advanced Nucleic Acid Structure And Function | 3 |
| BIOL 6642 | Advanced Plant Biology And Biotechnology | 3 |
| BIOL 6652 | Advanced Virology | 3 |
| BIOL 6699 | Graduate Internship In Biotechnology | 1-4 |
| BIOL 6889 | Graduate Seminar | 2 |
| BIOL 6905 | Graduate Research In Biology | 1-10 |
| BIOL 6920 | Topics In Biology (when relevant) | 2-5 |

Professional Science Master's Emphasis

This track requires a total of 32 graduate credit hours, of which at least half must be at the 5000-level or above. Students take 21 credit hours of science courses (Biology and Chemistry) and 9 hours in business courses. In addition, each student is required to take 2 credit hours of either an on-campus practicum course or an off-campus internship.

Required Courses in Biology and Chemistry

| | | |
|--------------|---|---|
| CHEM 4722 | Advanced Biochemistry | 3 |
| CHEM 5774 | Bioinformatics | 3 |
| or BIOL 5436 | Applied Bioinformatics | |
| BIOL 6615 | Advanced Biotechnology Laboratory II | 4 |
| BIOL 6602 | Advanced Molecular Biology | 3 |
| or BIOL 6612 | Advanced Molecular Genetics Of Bacteria | |
| BIOL 6889 | Graduate Seminar | 2 |

Required Internship or Practicum

Choose one of the following:

| | |
|----------------|-----------------------------------|
| CHEM/BIOL 5798 | Practicum in Science in Business |
| CHEM/BIOL 5799 | Internship in Science in Business |

| Professional Science Business Electives | | 9 |
|---|--|-----------|
| MGMT 3623 | Industrial And Organizational Psychology | |
| BUS AD 5000 | Economics For Managers | |
| BUS AD 5100 | Managerial Communication | |
| MGMT 5600 | Managing People in Organizations | |
| MKTG 5700 | Contemporary Marketing Concepts | |
| BUS AD 5900 | Law, Ethics And Business | |
| Elective Courses in Biology and Chemistry | | 6 |
| CHEM 4733 | Biochemistry Laboratory | |
| CHEM 4764 | Interdisciplinary Topics In Biochemistry | |
| CHEM 4772 | Physical Biochemistry | |
| CHEM 5694 | Special Topics In Organic Chemistry | |
| CHEM 5794 | Special Topics In Biochemistry | |
| CHEM 6787 | Problem Seminar In Biochemistry ¹ | |
| CHEM 6905 | Graduate Research In Chemistry ² | |
| or BIOL 6905 | Graduate Research In Biology | |
| BIOL 4842 | Immunobiology | |
| BIOL 6602 | Advanced Molecular Biology | |
| BIOL 6612 | Advanced Molecular Genetics Of Bacteria | |
| BIOL 6622 | Advanced Cellular Basis of Disease | |
| BIOL 6632 | Advanced Nucleic Acid Structure And Function | |
| BIOL 6642 | Advanced Plant Biology And Biotechnology | |
| BIOL 6652 | Advanced Virology | |
| BIOL 6920 | Topics In Biology | |
| Total Hours | | 32 |

¹ Can be repeated for up to 2 credit hours.

² Can be taken for up to 2 credit hours in either CHEM 6905 or BIOL 6905. Students must have a 3.0 GPA in non-research courses.

Sample Four Year Plan

First Year

| Fall | Hours Spring | Hours |
|----------------------------------|--|-------|
| INTDSC 1003 ¹ | 1 CHEM 1111 | 5 |
| MATH 1030 | 3 EXPLORE - Humanities & Fine Arts | 3 |
| MATH 1035 | 2 EXPLORE - Social & Behavioral Sciences | 3 |
| CORE - First Year Writing | 3 Cultural Diversity Requirement | 3 |
| CORE - US History & Government | 3 | |
| EXPLORE - Humanities & Fine Arts | 3 | |
| | 15 | 14 |

Second Year

| Fall | Hours Spring | Hours |
|--|--|-------|
| MATH 1100 | 3 BIOL 2012 | 3 |
| CHEM 1121 | 5 BIOL 2013 | 2 |
| BIOL 1831 | 5 CHEM 2612 | 3 |
| EXPLORE - Social & Behavioral Sciences | 3 EXPLORE - Social & Behavioral Sciences | 3 |
| | EXPLORE - Humanities & Fine Arts | 3 |
| | 16 | 14 |

Third Year

| Fall | Hours Spring | Hours |
|-----------|--------------|-------|
| BIOL 3622 | 3 BIOL 2482 | 3 |

| | | |
|----------------------------------|----------------------------|----|
| BIOL 4614 | 4 BIOL 2483 | 2 |
| CHEM 2622 | 3 CHEM 2223 | 3 |
| PHYSICS 1011 | 4 PHYSICS 1012 | 4 |
| CORE - Communication Proficiency | 3 Biochem/Biotech Elective | 3 |
| | 17 | 15 |

Fourth Year

| Fall | Hours Spring | Hours |
|--------------------------|---------------------|-------|
| Biochem/Biotech Elective | 3 BIOL 4602 | 3 |
| CHEM 2633 | 2 CHEM 4722 | 3 |
| CHEM 4712 or BIOL 4712 | 3 CHEM 3302 | 3 |
| CHEM 4733 | 2 Elective or minor | 6 |
| CHEM 4797 | 1 | |
| ENGL 3100 | 3 | |
| | 14 | 15 |

Total Hours: 120

¹ INTDSC 1003 is required only for first-time freshmen and transfer students with less than 24 college credits.

² The general education courses listed assumes the U.S. History/ Government requirement is fulfilled with a Social/Behavioral Science or Humanities general education course.

Please Note: This plan is an example of what a four year plan could look like for a typical student. Placement exam scores in math as well as the completion of coursework may change the plan. It should not be used in the place of regular academic advising appointments. All students are encouraged to meet with their advisor each semester. All requirements are subject to change

BIOL 1831 Introductory Biology: From Molecules to Organisms (MOTR BIOL 150L): 5 semester hours

Prerequisites: A minimum of high school chemistry and MATH 1030; ENGL 1100 or equivalent (may be taken concurrently). Required for students intending to major in biology or take specified biology courses at the 2000 level or above. This course presents an introduction to some of the principles of biology and scientific methodology applied to the molecular/ cellular through organ system levels of organization. Topics include: cell structure, metabolism, reproduction, heredity and major physiological processes regulated by organ systems. Three hours of lecture, three and one half hours of lab, and one hour of discussion per week.

BIOL 2012 Genetics: 3 semester hours

Prerequisites: BIOL 1831 (majors must also take BIOL 1821) MATH 1030, and CHEM 1111 or (CHEM 1081 plus CHEM 1091). Fundamental principles of inheritance, including classical genetic theory as well as recent advances in the molecular basis of heredity. Three hours of lecture per week. Fulfills Science/Math requirement.

BIOL 2013 Genetics Laboratory: 2 semester hours

Prerequisites: Concurrent registration in BIOL 2012, or consent of instructor. Laboratory to accompany BIOL 2012. Three and one-half hours of organized laboratory time per week. Students may need to return to the laboratory at unscheduled times to complete some exercises.

BIOL 2482 Microbiology: 3 semester hours

Prerequisites: BIOL 1831 (majors must also take BIOL 1821), MATH 1030, and CHEM 1111. Study of microorganisms, their metabolism, genetics, and their interaction with other forms of life. Three hours of lecture per week.

BIOL 2483 Microbiology Laboratory: 2 semester hours

Prerequisite: BIOL 2482 (may be taken concurrently). Experimental studies and procedures of microbiological techniques. Three and one-half hours of organized laboratory time per week. Students will need to return to the laboratory at unscheduled times to complete some exercises.

BIOL 3622 Cell Biology: 3 semester hours

Prerequisites: BIOL 1831, BIOL 2012, CHEM 2612, and MATH 1030. Examination of the organization and basic processes of cells including tissues, organelles, glycolysis, respiration, photosynthesis, trafficking, cytoskeleton, signal transduction, and cell division.

BIOL 3699 Undergraduate Internship in Biotechnology: 1-4 semester hours

Prerequisites: BIOL 1821, BIOL 1831, and CHEM 1111 and CHEM 1121 and consent of instructor. Concurrent enrollment in CHEM 2612 or higher is strongly encouraged. A 2.5 GPA and enrollment in the undergraduate Biotechnology Certificate Program is required. Internship will consist of a period of observation, experimentation and on-the-job training in a biotechnology laboratory. The laboratory may be industrial or academic. Credit will be determined by the number of hours a student works each week and in consultation between the intern's supervisor and instructor. Internship assignments will be commensurate with the education and experience of the student. Two credits may be used to fulfill the lab requirement.

BIOL 4442 Developmental Biology: 3 semester hours

Prerequisites: BIOL 2012 and BIOL 3622. A study of the basic principles that shape the embryonic and post-embryonic development of animals with an emphasis on the underlying cellular and molecular mechanisms. Specific topics include fertilization, determination of cell fate and differentiation, cell migration, establishment of the body plan, formation of selected organs and organ systems, stem cells, and limb regeneration. Environmental influences on development and the impact of developmental biology on modern medicine are also discussed. Three hours of lecture/discussion per week. Students may not receive credit for both BIOL 4442 and BIOL 6442.

BIOL 4550 Bacterial Pathogenesis: 3 semester hours

Prerequisites: BIOL 2012 and BIOL 2482. Examination of the strategies bacterial pathogens use to infect animals. Topics include host immune responses to infection, bacterial virulence factors, regulation of bacterial virulence, and the cellular and molecular approaches used to study host/parasite interactions. Three hours of lecture per week. Students may not receive credit for both BIOL 4550 and BIOL 6550.

BIOL 4602 Molecular Biology: 3 semester hours

Prerequisites: BIOL 2012 and CHEM 2612. A study of the principles of molecular biology, with emphasis on understanding the genetic regulation of DNA, RNA, and protein synthesis and function in eukaryotic cells. Three hours of lecture per week. Students may not receive credit for BIOL 4602 and either BIOL 6602, or any course previously called Gene Expression in Eukaryotes or Advanced Gene Expression in Eukaryotes.

BIOL 4608 Synthetic Biology: 3 semester hours

Prerequisites: BIOL 2012, BIOL 2482. A study of the molecular biology of microbial cells, in the context of synthetic biological systems. Topics include DNA replication, transcription, translation, gene regulation and protein structure as well as aspects of genetic engineering as they apply to the construction of novel biological systems. Following an introduction to the design of biological parts used in synthetic biology, students read, discuss and present recent journal articles in order to learn about current advances and applications of synthetic biology. Three hours of lecture per week. Students may not receive credit for BIOL 4608 and BIOL 6608.

BIOL 4612 Molecular Genetics of Bacteria: 3 semester hours

Prerequisites: BIOL 2012 and BIOL 2482. A study of the molecular biology of gene replication, transfer, and expression in bacterial cells. Topics include DNA replication, transcription and translation, mutagenesis, DNA repair and recombination, gene transfer, and the regulation of genes and global expression systems. Three hours of lecture per week. Student may not receive credit for BIOL 4612 and either BIOL 6612 or any course previously called Gene Expression in Prokaryotes or Advanced Gene Expression in Prokaryotes.

BIOL 4614 Biotechnology Laboratory I: 4 semester hours

Prerequisites: BIOL 2012 or consent of instructor. An introduction to the fundamental concepts that underlie the field of biotechnology. Both the basic principles of molecular biology and hand-on experience with the techniques of the field will be addressed through lectures, discussions, and a series of laboratory exercises. Two hours of lecture and four hours of laboratory per week. Fulfills a laboratory requirement only; may not be used to fulfill the higher level (4000-5000) lecture course requirement for the B.A. or B.S. degree in biology. Students may not receive credit for BIOL 4614 and a comparable biotechnology course from another institution.

BIOL 4615 Biotechnology Laboratory II: 4 semester hours

Prerequisites: BIOL 4614 and either BIOL 4602 or BIOL 4612, or consent of instructor. An in-depth look at theory and practice of biotechnology. Lectures and discussion will examine the underlying principles, and laboratory exercises will present hands-on experience with current techniques. One hour of lecture and six hours of laboratory per week. Fulfills a laboratory requirement only; may not be used to fulfill the higher level (4000-5000) lecture course requirement for the B.A. or B.S. degree in biology. Students may not receive credit for BIOL 4615 and BIOL 6615.

BIOL 4622 Cellular Basis of Disease: 3 semester hours

Prerequisites: BIOL 3622. A study of the structural organization and processes of eukaryotic cells, focusing on how defects in cellular function lead to genetic diseases and cancer. Topics of discussion may include membrane dynamics, intracellular trafficking, signal transduction, and the cell cycle. Three hours of lecture per week. Students may not receive credit for both BIOL 4622 and BIOL 6622.

BIOL 4632 Nucleic Acid Structure and Function: 3 semester hours

Prerequisites: BIOL 2012 and BIOL 4712 or equivalent, or consent of instructor. A comprehensive view of the structural properties of DNA and RNA that promote molecular interactions and biological function. Topics will include the physical properties of nucleic acids, the formation and biological importance of higher order structures, RNA enzymatic activities, nucleic acid-protein interactions, and RNA metabolism. Three hours of lecture per week. Students may not receive credit for both BIOL 4632 and BIOL 6632.

BIOL 4642 Plant Molecular Biology and Genetic Engineering: 3 semester hours

Prerequisites: BIOL 2012, BIOL 3622. This course covers topics such as molecular and cellular aspects of plant growth, development, and responses to environmental stress and pathogen attack, using the experimental approaches of genetics, molecular biology, and biochemistry. Plant growth manipulation and genetic engineering, including techniques required for DNA transfer and plant regeneration, as well as current and potential future applications, such as engineered resistance to stress, developmental engineering, and metabolic engineering, also will be covered. Students may not receive credit for both BIOL 4642 and BIOL 6642.

BIOL 4652 Virology: 3 semester hours

Prerequisite: BIOL 2012 and BIOL 3622. This first half of the course entails a comparative study of the structure, replication, and molecular biology of viruses. The second half of the course focuses on the pathogenesis, control, and evolution of animal viruses. Three hours of lecture per week. Students may not receive credit for both BIOL 4652 and BIOL 6652.

BIOL 4662 Human Pathology: 3 semester hours

Prerequisites: BIOL 3622 or consent of the instructor. A study of disease processes as they affect the human body. The course will examine both the proximate causes and underlying mechanisms of disease. Specific conditions will be used to illustrate application of clinical approaches in determining the origin, development, and effects of a disease.

BIOL 4712 Biochemistry: 3 semester hours

Same as: CHEM 4712. Prerequisites: CHEM 2612 and either BIOL 1831 or CHEM 2622. Examines the chemistry and function of cell constituents, and the interaction and conversions of intracellular substances. Students may not receive credit for both BIOL 4712 and CHEM 4712.

BIOL 4797 Biochemistry and Biotechnology Seminar: 1 semester hour

Same as CHEM 4797. Prerequisites: Senior standing in the Biochemistry and Biotechnology program and consent of faculty advisor. This course will focus on selected publications related to biochemistry and biotechnology from both refereed journals and news sources. Students are expected to participate in discussions and to prepare oral and written presentations. Completion of the Major Field Achievement Test in Biochemistry & Biotechnology is a course requirement. May not be taken for graduate credit.

BIOL 4822 Introduction to Neuroscience: 3 semester hours

Prerequisite: BIOL 3802 or consent of instructor. The study of nervous systems, featuring the cellular bases of initiation and conduction to the impulse, synaptic transmission, and the network integrative function of invertebrate and vertebrate nervous systems. This course emphasizes the multidisciplinary nature of the neurosciences, including anatomical, physiological and molecular approaches to understanding neural function. Three hours of lecture per week.

BIOL 4842 Immunobiology: 3 semester hours

Prerequisite: BIOL 3622 and CHEM 2612. The fundamental principles and concepts of immunology and immunochemistry. Emphasis on the relation of immunological phenomena to biological phenomena and biological problems. Three hours lecture per week.

BIOL 4905 Research: 1-3 semester hours

Prerequisites: Consent of faculty research advisor. Research in an area selected by the student in consultation with and under the direct supervision of an UMSL biology faculty research adviser. Research opportunities are subject to availability and must be approved in advance of beginning research. The project may include the reading of pertinent literature, laboratory or field experience, including keeping of a logbook, and a summary paper and a presentation, all based on an average 8 hours per week per credit during a 15 week semester at the discretion of the instructor. Credit arranged. Course may be repeated for a total of up to 5 credit hours. A maximum of one lab requirement may be satisfied using any two BIOL 4905 credits. Additional credits may be applied toward the total biology hours required for the biology BA or BS. May not be taken for graduate credit.

BIOL 4920 Selected Topics in Biology: 3 semester hours

Prerequisites: Junior standing and consent of instructor. The topic for this course will vary each semester. Topics offered for the following semester will be posted in the departmental office. This course may be repeated once if the topic is different.

BIOL 5069 Topics In Cellular And Molecular Biology: 1 semester hour

Prerequisite: Graduate standing or consent of instructor. Presentation and discussion of student and faculty research projects and/or current research articles in molecular, cellular and developmental biology. May be repeated. Course graded on a satisfactory/unsatisfactory basis.

BIOL 5436 Applied Bioinformatics: 3 semester hours

Prerequisites: BIOL 4712 or BIOL 4602 or consent of instructor. This course provides a survey of the various computational approaches that can be used to solve biological problems. Specific attention will be focused on biological databases and methods for using and interpreting database information, sequence alignments, functional genomics, structure prediction, high-throughput analyses, and proteomics. Three hours of lecture per week.

BIOL 5798 Practicum in Science in Business: 1-2 semester hours

Same As CHEM 5798. Prerequisites: Graduate standing and enrollment in a Professional Science emphasis in Chemistry, Biochemistry & Biotechnology, or Biology. Students will integrate and apply their scientific expertise to a practical, business-related problem. The course will emphasize interdisciplinary team-work as well as both written and oral communication skills.

BIOL 5799 Internship in Sciences in Business: 1-2 semester hours

Same As CHEM 5799. Prerequisites: Graduate standing and enrollment in a Professional Science emphasis area in Chemistry, Biochemistry & Biotechnology, or Biology. The internship will consist of a period of on-the-job training at a local company. Credit hours will be determined by the number of hours the student works each week and in consultation between the intern's supervisor and the course instructor. Internship assignments will be commensurate with the education and experience of the student, with an emphasis on work at the interface between the scientific and business components of the company. A written report describing the internship project is required.

BIOL 6550 Advanced Bacterial Pathogenesis: 3 semester hours

Prerequisites: BIOL 2012 and BIOL 2482. Examination of the strategies bacterial pathogens use to infect animals. Topics include host immune responses to infection, bacterial virulence factors, regulation of bacterial virulence, and the cellular and molecular approaches used to study host-parasite interactions. Students may not receive credit for both BIOL 6550 and BIOL 4550. Students will be required to give an oral presentation and/or write an extra paper on a topic relevant to the course. Three hours of lecture per week.

BIOL 6602 Advanced Molecular Biology: 3 semester hours

Prerequisites: BIOL 2012 and CHEM 2612, or consent of instructor. A study of the principles of molecular biology, with emphasis on understanding the genetic regulation of DNA, RNA, and protein synthesis and function in eukaryotic cells. Three hours of lecture per week. Students will be required to give an oral presentation and/or write an extra paper on a topic relevant to the course. Students may not receive credit for both BIOL 6602 and BIOL 4602, or any course previously called Gene Expression in Eukaryotes or Advanced Gene Expression in Eukaryotes.

BIOL 6608 Advanced Synthetic Biology: 3 semester hours

Prerequisites: BIOL 2012, BIOL 2482. A study of the molecular biology of microbial cells, in the context of synthetic biological systems. Topics include DNA replication, transcription, translation, gene regulation and protein structure as well as aspects of genetic engineering as they apply to the construction of novel biological systems. Following an introduction to the design of biological parts used in synthetic biology, students read, discuss and present recent journal articles in order to learn about current advances and applications of synthetic biology. Three hours of lecture per week. Students may not receive credit for both BIOL 4608 and BIOL 6608.

BIOL 6612 Advanced Molecular Genetics of Bacteria: 3 semester hours

Prerequisites: BIOL 2012 and BIOL 2482. A study of the molecular biology of gene replication, transfer, and expression in bacterial cells. Topics include DNA replication, transcription and translation, mutagenesis, DNA repair and recombination, gene transfer, and the regulation of genes and global expression systems. Three hours of lecture per week. Students will be required to give an oral presentation and/or write an extra paper on a topic relevant to the course. Student may not receive credit for both BIOL 6612 and BIOL 4612 or any course previously called Gene Expression in Prokaryotes or Advanced Gene Expression in Prokaryotes.

BIOL 6615 Advanced Biotechnology Laboratory II: 4 semester hours

Prerequisites: BIOL 4614 and either BIOL 4602 or BIOL 4612, or consent of instructor. An in-depth look at the theory and practice of biotechnology. Lectures and discussion will examine the underlying principles, and laboratory exercises will present hands-on experience with current techniques. One hour of lecture and six hours of laboratory per week. Students will be required to give an oral presentation and/or write an extra paper on a topic relevant to the course. Students may not receive credit for both BIOL 6615 and BIOL 4615 or any course previously called Techniques in Molecular Biology or Advanced Techniques in Molecular Biology.

BIOL 6622 Advanced Cellular Basis of Disease: 3 semester hours

Prerequisites: BIOL 3622, or consent of instructor. A study of the structural organization and processes of eukaryotic cells, focusing on how defects in cellular function lead to genetic diseases and cancer. Topics of discussion may include membrane dynamics, intracellular trafficking, signal transduction, and the cell cycle. Three hours of lecture per week. Students may not receive credit for both BIOL 6622 and BIOL 4622.

BIOL 6632 Advanced Nucleic Acid Structure and Function: 3 semester hours

Prerequisites: BIOL 2012 and BIOL 4712 or equivalent, or consent of instructor. A comprehensive view of the structural properties of DNA and RNA that promote molecular interactions & biological function. Topics will include the physical properties of nucleic acids, the formation and biological importance of higher order structures, RNA enzymatic activities, nucleic acid-protein interactions, and RNA metabolism. Three hours of lecture and one hour of discussion per week. Students may not receive credit for both BIOL 4632 and BIOL 6632.

BIOL 6642 Advanced Plant Biology and Biotechnology: 3 semester hours

Prerequisites: Graduate standing. Topics may include molecular and cellular aspects of plant growth, development, and responses to environmental stress and pathogen attack, using the experimental approaches of genetics, molecular biology, and biochemistry. Plant growth manipulation and genetic engineering, including the techniques required for DNA transfer and plant regeneration, as well as current and potential future applications, such as engineered resistance to stress, developmental engineering, and metabolic engineering, also will be covered. Student may not receive credit for both BIOL 4642 and BIOL 6642.

BIOL 6652 Advanced Virology: 3 semester hours

Prerequisites: BIOL 2012, BIOL 3622, and graduate standing. This first half of the course entails a comparative study of the structure, replication, and molecular biology of viruses. The second half of the course focuses on the pathogenesis, control, and evolution of animal viruses. Three hours of lecture, one hour of discussion or seminar per week. Students may not receive credit for both BIOL 4652 and BIOL 6652.

BIOL 6699 Graduate Internship in Biotechnology: 1-4 semester hours

Prerequisites: Graduate standing and enrollment in graduate Biotechnology Certificate Program. 6 credit hours maximum (maximum of 8 combined credit hours of BIOL 6905 and internship) Internship will consist of period of observation, experimentation and on-the-job training in biotechnology laboratory. The laboratory may be industrial or academic. Credit will be determined by the number of hours the student works each week and in consultation between the intern's supervisor and the instructor. Internship assignments will be commensurate with the education and experience of the student.

BIOL 6889 Graduate Seminar: 2 semester hours

Presentation and discussion of various research problems in biology. Graduate student exposure to the seminar process.

BIOL 6905 Graduate Research in Biology: 1-10 semester hours

Research in area selected by student in consultation with faculty members.

BIOL 6915 Graduate Research Practicum: 1-2 semester hours

Prerequisite: Consent of instructor. This course is designed for graduate students wishing to pursue research experience in an area outside their dissertation topic. The project can be techniques-oriented or focused on a specific research question. The credit hours will depend on the time commitment to the project as decided by the supervisory faculty member.

CHEM 1111 Introductory Chemistry I (MOTR CHEM 150L): 5 semester hours

Prerequisite: MATH 1030 (or a score of 26 or higher on either the Math ACT or the Missouri Math Placement Test) and MATH 1035 (MATH 1035 may be taken concurrently). Presents an introduction to the fundamental laws and theories of chemistry. Laboratory experiments are designed to demonstrate some aspects of qualitative and quantitative analysis and to develop skills in laboratory procedures. Chemistry majors may not include both CHEM 1011 and CHEM 1111 in the 120 hours required for graduation. Three hours of lecture, one and one-half hours of workshop, and three hours of laboratory per week.

CHEM 1121 Introductory Chemistry II: 5 semester hours

Prerequisite: CHEM 1111 or advanced placement. Lecture and laboratory are a continuation of CHEM 1111. Three hours of lecture, one and one-half hours of workshop and three hours laboratory per week.

CHEM 2223 Quantitative Analysis: 3 semester hours

Prerequisites: CHEM 1121. Principles and practice of elementary quantitative chemistry. The lecture treats descriptive statistics with emphasis on small samples; various types of competing equilibria pertaining to acid-base, complexometric, and potentiometric titrations; and an introduction to spectrophotometric processes. The laboratory provides exercises in titrimetric gravimetric, and spectrophotometric techniques. Both portions of the course deal with the analytical chemistry of environmentally-significant problems. Two hours of lecture and four and one-half hours of laboratory weekly.

CHEM 2612 Organic Chemistry I: 3 semester hours

Prerequisite: CHEM 1121 (may be taken concurrently). An introduction to the structure, properties, synthesis, and reactions of aliphatic and aromatic carbon compounds. Three hours of lecture per week.

CHEM 2622 Organic Chemistry II: 3 semester hours

Prerequisite: CHEM 2612. A systematic study of organic reactions and their mechanisms; organic synthetic methods. Three hours of lecture per week.

CHEM 2633 Organic Chemistry Laboratory: 2 semester hours

Prerequisite: CHEM 2612. An introduction to laboratory techniques and procedures of synthetic organic chemistry including analysis of organic compounds. One hour of lecture and four and one-half hours of laboratory per week.

CHEM 3643 Advanced Organic Chemistry Laboratory: 2 semester hours

Prerequisites: CHEM 3022. Identification of organic compounds by classical and spectroscopic methods; advanced techniques in synthesis and separation of organic compounds. One hour of lecture and four and one-half hours of laboratory per week. Not for graduate credit.

CHEM 3905 Chemical Research: 1-10 semester hours

Prerequisite: Consent of instructor. Independent laboratory and library study, in conjunction with faculty member, of fundamental problems in chemistry. A written report describing the research is required.

CHEM 4302 Survey of Physical Chemistry with Applications to the Life Sciences: 3 semester hours

Prerequisites: CHEM 2612 and MATH 1800 or MATH 1100, and PHYSICS 1012. This course covers the principles of physical chemistry with applications to the life sciences. Topics will include thermodynamics, equilibria, kinetics, and spectroscopy. This course will be taught simultaneously with CHEM 3302, but students in CHEM 4302 will have additional assignments or projects. No student may receive credit for both CHEM 3302 and CHEM 4302. No student may receive credit for both 4302 and 5302.

CHEM 4712 Biochemistry: 3 semester hours

Same as BIOL 4712. Prerequisites: CHEM 2612 and either BIOL 1831 or CHEM 2622. Examines the chemistry and function of cell constituents, and the interaction and conversions of intracellular substances. Students may not receive credit for both BIOL 4712 and CHEM 4712.

CHEM 4722 Advanced Biochemistry: 3 semester hours

Prerequisite: CHEM 4712. This course covers selected advanced topics in the chemistry of life processes. Students may not receive credit for both CHEM 4722 and CHEM 5722.

CHEM 4733 Biochemistry Laboratory: 2 semester hours

Prerequisites: CHEM 4712 (may be taken concurrently), and CHEM 2223. Laboratory study of biochemical processes in cellular and subcellular systems with emphasis on the isolation and purification of proteins (enzymes) and the characterization of catalytic properties. One hour of lecture and four and one-half hours of laboratory per week.

CHEM 4772 Physical Biochemistry: 3 semester hours

Prerequisites: CHEM 3312 or CHEM 4712 or BIOL 4712. This course is designed to acquaint students with concepts and methods in biophysical chemistry. Topics that will be discussed include protein and DNA structures, forces involved in protein folding and conformational stability, protein-DNA interactions, methods for characterization and separation of macromolecules, and biological spectroscopy. Students may not receive credit for both CHEM 4772 and CHEM 5772.

CHEM 4797 Biochemistry and Biotechnology Seminar: 1 semester hour

Same as CHEM 4797. Prerequisites: Senior standing in the Biochemistry and Biotechnology program and consent of faculty advisor. This course will focus on selected publications related to biochemistry and biotechnology from both refereed journals and news sources. Students are expected to participate in discussions and to prepare oral and written presentations. Completion of the Major Field Achievement Test in Biochemistry & Biotechnology is a course requirement. May not be taken for graduate credit.

CHEM 4814 Special Topics in Chemistry: 1-10 semester hours

A reading and seminar course in selected advanced topics.

CHEM 4897 Seminar: 2 semester hours

Prerequisites: CHEM 3022 and senior standing. This course will provide students with the opportunity to listen to talks presented by students, faculty, and invited speakers. Students must complete a comprehensive examination before the end of the course. Chemistry majors should enroll during the semester in which they intend to graduate. One hour seminar and one hour discussion per week.

CHEM 5394 Special Topics in Physical Chemistry: 1-3 semester hours

Prerequisite: Consent of instructor. The topic for this course may change from semester to semester, and more than one course or topic can be offered in a given semester. The course may be taken more than once for credit provided that the topic is different in each case. The course can have more than one instructor.

CHEM 5396 Directed Readings in Physical Chemistry: 1-3 semester hours

Prerequisites: Consent of Physical Chemistry Faculty. A series of readings of monographs, review papers, and/or research publications for a particular student directed at providing that student with appropriate background preparation for experimental or theoretical Ph.D.-level research in an area of physical chemistry. The particular readings will be selected by the physical chemistry staff. Potential topics include but are not limited to advances in Electrochemistry, Surface Chemistry, Thermodynamics, Molecular Spectroscopy, Quantitative Absorption Spectroscopy using new Methodologies, Applications of Group Theory in Spectroscopy, and Computational Chemistry. Assessment may be in various forms including by assignments and seminars. Students may take this course more than once for credit through the particular topic must be different in each case.

CHEM 5494 Special Topics in Inorganic Chemistry: 1-3 semester hours

Prerequisite: Consent of instructor. The topic for this course may change from semester to semester, and more than one course or topic can be offered in a given semester. The course may be taken more than once for credit provided that the topic is different in each case. The course can have more than one instructor.

CHEM 5694 Special Topics in Organic Chemistry: 1-3 semester hours

Prerequisite: Consent of instructor. The topic for this course may change from semester to semester, and more than one course or topic can be offered in a given semester. The course may be taken more than once for credit provided that the topic is different in each case. The course can have more than one instructor.

CHEM 5774 Bioinformatics: 3 semester hours

Prerequisites: CHEM 4712 or equivalent. This course introduces modern approaches in bioinformatics and computational biochemistry. Topics to be covered include a survey of biological databases, predictions from protein and DNA sequences, sequence alignment and sequence database searches, building phylogenetic trees, three-dimensional protein structure prediction, molecular modeling and simulation, and computational genomics. Additional independent study work is required. Students may not receive credit for both CHEM 4774 and CHEM 5774.

CHEM 5794 Special Topics in Biochemistry: 1-3 semester hours

Prerequisites: Consent of instructor. The topic for this course may change from semester to semester, and more than one course or topic can be offered in a given semester. The course may be taken more than once for credit provided that the topic is different in each case. The course can have more than one instructor.

CHEM 5798 Practicum in Science in Business: 1-2 semester hours

Same As BIOL 5798. Prerequisites: Graduate standing and enrollment in a Professional Science emphasis in Chemistry, Biochemistry & Biotechnology, or Biology. Students will integrate and apply their scientific expertise to a practical, business-related problem. The course will emphasize interdisciplinary team-work as well as both written and oral communication skills.

CHEM 5799 Internship in Science in Business: 1-2 semester hours

Same As BIOL 5799. Prerequisites: Graduate standing and enrollment in a Professional Science emphasis area in Chemistry, Biochemistry & Biotechnology, or Biology. The internship will consist of period of on-the-job training at a local company. Credit hours will be determined by the number of hours the student works each week and in consultation between the intern's supervisor and the course instructor. Internship assignments will be commensurate with the education and experience of the student, with an emphasis on work at the interface between the scientific and business components of the company. A written report describing the internship project is required.

CHEM 6787 Problem Seminar in Biochemistry: 1 semester hour

Prerequisite: Consent of the biochemistry staff. Problems from the current literature, presentations and discussions by faculty, students and visiting scientists. Ph.D. students may take more than once for credit. Up to three credits may be applied to the M.S. degree program.

CHEM 6897 Chemistry Colloquium: 1 semester hour

Presentation of papers by students, faculty and invited speakers. One hour per week.

CHEM 6905 Graduate Research In Chemistry: 1-10 semester hours