

BIOLOGY (BIOL)

BIOL300. INTRODUCTION TO QUANTITATIVE BIOLOGY I. 3.0 Semester Hrs.

This 3-credit course is designed as an introductory course for Quantitative Biosciences and Engineering (QBE) majors, providing them with the foundational skills needed to be a biologist, bioengineer, or medical doctor in the 21st century. Since biological data and questions are becoming more quantitative and more precise in nature, so must our approaches to our analysis. Accordingly, this course will explore the basics of how to access and analyze existing various types biological data across a wide range of biological scales including sequencing data at the molecular scale, microscopy data at the cellular and organismal scale, and tabular data at the ecological scale. From this data, students will learn to conduct fundamental data analysis and produce appropriate visualizations to illustrate their interpretations of the key results.

Prerequisite: CBEN120, CSCI101. Co-requisite: MATH201, MATH225.

Course Learning Outcomes

- Access and organize existing biological data sets
- Produce plots and visualizations of biological data sets
- Develop, write, and implement code in Python to analyze data in a biological context
- Implement functions in Python to simulate and gain insight into biological processes
- Conduct null hypothesis significance testing with respect to biological problems
- Identify probability distributions as they appear in and apply to biological processes
- Conduct linear regression on biological data

BIOL301. INTRODUCTION TO QUANTITATIVE BIOLOGY II. 3.0 Semester Hrs.

This course will extend the applications of quantitative biology, building from the foundation in biological data analysis established in BIOL300. Students will learn how to model biological systems both mathematically and computationally and ultimately compare model predictions to experimental data. Mathematical modeling will involve developing and solving differential equations to describe biological processes. Computational modeling will involve writing Python code to simulate various biological processes to gain insights into their behavior. Lastly, as a boarder type of modeling, students will explore biological sequences and genomes to develop both phylogenetic and metabolic models of organisms. Prerequisite: BIOL300.

Course Learning Outcomes

- Develop differential equations to model biological systems at different scales (e.g. molecular, cellular, populations) Solve simple differential equations analytically for steady state, and explain the biological implications Solve complex differential equations computationally and plot dynamics to gain insight into biological processes Create code to stochastically and deterministically simulate biological processes Compare predictions from computational and mathematical models with results from experimental data Analyzing biological sequences to develop phylogenetic models of how organisms evolved Analyze genome sequences for metabolic properties and pathway development

BIOL399. INDEPENDENT STUDY. 1-6 Semester Hr.

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

BIOL415. QUANTITATIVE BIOSCIENCES AND ENGINEERING FIELD SESSION. 3.0 Semester Hrs.

In this course students will apply all they have learned in QBE courses to date to tackle large projects that have important societal, environmental, energy, and health impacts. Projects will include hands-on collection and analysis of field samples and modern molecular biology and biochemistry laboratory work. Students will need to use their molecular biology, biochemistry, experimental, data analysis, and computational skills to succeed in this course, which will ultimately prepare students for the next steps in their QBE and professional careers. Prerequisite: BIOL301, CHGN431.

Course Learning Outcomes

1. Explain and apply foundational biological concepts in the areas of molecular biology and biochemistry to solve novel problems related to genomic microbial exploration and recombinant protein production
2. Explain and apply core skills and concepts in mathematical, physical, and data sciences including basic programming, working with biological datasets, modeling biological processes, and visualizing data
3. Conduct rigorous experimental biological research through hypothesis testing, experimental design, use of research equipment, data collection, data analysis, and statistical analysis
4. Communicate your progress and results through written reports and oral presentations to diverse audiences
5. Work in diverse teams using multidisciplinary skills and effective communication to establish goals, plan tasks, and solve problems
6. Evaluate the ethical and cultural impacts of genomic microbial exploration and recombinant protein production on local communities, worldwide society, and the environment

BIOL498. SPECIAL TOPICS IN BIOLOGY. 6.0 Semester Hrs.

(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once, but no more than twice for the same course content. Variable credit: 0 to 6 credit hours. Repeatable for credit under different titles.

BIOL500. CELL BIOLOGY AND BIOCHEMISTRY. 4.0 Semester Hrs.

This course will provide students with deep biological insight as well as hands-on experience of studying a biological question at the level of the cell, including gene expression and localization of proteins in eukaryotic cells, to the level of the protein, from molecular biology of the gene to characterization of posttranslational modifications, and protein purification and biochemical and biophysical characterization of protein structure and dynamics. These fundamental properties will be linked to protein activity and function. The emphasis of this course is on quantitative biology. Wherever appropriate, advanced concepts of protein chemistry and physics will be integrated into the delivery of the basic concepts. The course includes a 3 credit hour lecture section and a 1 credit hour lab section.

Course Learning Outcomes

- Students will be familiar with basic terminology of all aspects of biology and will be able to recognize important cellular functions by their names

- Students will be able to define the chemical building blocks of biomolecules and understand how these connect to biological functions
- Students will be able to visualize protein and other molecular structures and their interactions using pymol software
- Students will have gained sufficient insight into different areas of biology and medicine to make informed decisions on their future career path
- Students will be able to make quantitative statements on the major biological processes
- Students will be familiar with modern –omics approaches and will know what can and what cannot be learned from them
- Students will be trained to identify opportunities for studying the interfaces between Mines' themes of earth, environment and energy and specific applications in biology and health
- Students will gain an appreciation of the benefits of integrating quantitative, computational approaches and design experimental approaches to test predictions
- Students will be able to analyze large datasets as a result of the sister course and derive biological hypotheses from them based on current understanding of biomolecules studied in this class
- Students will be able to critically evaluate existing bio/medical data and derive gaps in knowledge
- Students will be trained in active thinking and design of future work to address identified gaps

BIOL501. ADVANCED BIOCHEMISTRY. 3.0 Semester Hrs.

Advanced study of the major molecules of biochemistry: amino acids, proteins, enzymes, nucleic acids, lipids, and saccharides- their structure, chemistry, biological function, biosynthesis, and interaction. Stresses bioenergetics and the cell as a biological unit of organization. Advanced discussion of the intertwining of molecular genetics, biomolecule synthesis, and metabolic cycles. Prerequisites: CHGN428 or BIOL500.

Course Learning Outcomes

- Demonstrate a broad knowledge of the fundamental introductory concepts of Chemistry, Biology and Physics
- Demonstrate a thorough knowledge of the intersection between the disciplines of Biology and Chemistry.
- Locate, critically analyze, interpret and discuss data, hypotheses, results, theories, and explanations found in the primary literature, applying knowledge from Chemistry and Biology.
- Appreciate the way in which practitioners in the disciplines of Biology and Chemistry intersect and bring their expertise to bear in solving complex problems involving living systems.

BIOL510. BIOINFORMATICS. 3.0 Semester Hrs.

Bioinformatics is a blend of multiple areas of study including biology, data science, mathematics and computer science. The field focuses on extracting new information from massive quantities of biological data and requires that scientists know the tools and methods for capturing, processing and analyzing large data sets. Bioinformatics scientists are tasked with performing high-throughput, next-generation sequencing. They analyze DNA sequence alignment to find mutations and anomalies and understand the impact on cellular processes. The bioinformatician uses software to analyze protein structure and its impact on cell function. Learning how to design experiments and perform advanced statistical analysis is essential for anyone interested in this field, which is main goal of this course. Prerequisite: CSC1102.

Course Learning Outcomes

- 1. knowledge and awareness of the basic principles and concepts of biology, computer science and mathematics;
- 2. existing software effectively to extract information from large databases and to use this information in computer modeling;
- 3. problem-solving skills, including the ability to develop new algorithms and analysis methods;
- 4. an understanding of the intersection of life and information sciences, the core of shared concepts, language and skills;
- 5. the ability to speak the language of structure-function relationships, information theory, gene expression, and database queries.

BIOL520. SYSTEMS BIOLOGY. 3.0 Semester Hrs.

This course provides students an introduction to the emerging field of systems biology. It will consist of lectures, group discussion sessions, and problem-solving sessions and/or computational labs. Students will learn strategies and tools to interrogate biological systems using mathematical modeling. Topics of the course will come from typical aspects of biomathematical modeling including, but not limited to: the choice of a modeling framework from various approaches; the design of interaction diagrams; the identification of variables and processes; the design of systems models; standard methods of parameter estimation; the analysis of steady states, stability, sensitivity; numerical evaluations of transients; phase-plane analysis; simulation of representative biological scenarios. All theoretical concepts are exemplified with applications.

Course Learning Outcomes

- At the completion of the course, students will be able to:1. Describe and understand important types of quantitative/mathematical models used in the field of systems biology
- 2. Explain the basic strengths and limitations of quantitative/mathematical modeling of biological systems
- 3. Design and implement quantitative/mathematical models of biological systems
- 4. Apply appropriate techniques for steady-state and dynamical analysis of models
- 5. Utilize different modeling tools for the analysis of models and their output
- 6. Assimilate current systems biology literature, extend it in a final project, and communicate results professionally and effectively

BIOL590. QUANTITATIVE BIOSCIENCES & ENGINEERING GRADUATE SEMINAR. 1.0 Semester Hr.

(I,II) The Quantitative Biosciences and Engineering (QBE) Graduate Seminar provides a forum for QBE graduate students to participate in seminars given by QBE professionals, develop an enhanced understanding of the breadth of quantitative bioscience disciplines, and present their research projects. Grade is based on attendance over the semester. Full-time graduate students must enroll in the Graduate Seminar course every semester that they are enrolled at Mines. Repeatable; maximum 2 credits granted towards MS degree requirements and 4 credits maximum granted towards PhD Requirements.

BIOL598. SPECIAL TOPICS. 6.0 Semester Hrs.

(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once, but no more than twice for the same course content.. Variable credit: 0 to 6 credit hours. Repeatable for credit under different titles.

BIOL599. INDEPENDENT STUDY. 0.5-6 Semester Hr.

(I, II, S) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit: 0.5 to 6 credit hours. Repeatable for credit under different topics/experience and maximums vary by department. Contact the Department for credit limits toward the degree.

BIOL707. GRADUATE THESIS / DISSERTATION RESEARCH CREDIT. 1-15 Semester Hr.

(I, II, S) Research credit hours required for completion of a Masters-level thesis or Doctoral dissertation. Research must be carried out under the direct supervision of the student's faculty advisor. Variable class and semester hours. Repeatable for credit.