Biology

Website (http://www.northeastern.edu/biology)

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The Department of Biology offers two majors, the BS in biology and the BS in cell and molecular biology. Both majors lay the groundwork for strong scientific training with basic course work in mathematics, chemistry, and physics, relevant to biology. In the biology major, students explore the organization and processes of life, from molecules and cells through organs and organ systems to populations, ecosystems, and evolution. The BS degree in cell and molecular biology offers a more focused program of study emphasizing processes operating at the cellular and molecular levels of biological systems. In both majors, students can select advanced electives to specialize in a subdiscipline of biology such as developmental biology, stem cell biology, microbiology, or physiology.

Our programs provide a wide range of relevant co-op opportunities in the renowned Boston-area biotechnology industry, hospitals, and research institutions, as well as across the country and at international sites.

There are a number of interdisciplinary opportunities involving biology: BS in biochemistry; BS in behavioral neuroscience; BS in computer science and biology; BS in biology and English; BS in biology and mathematics; BS in biology and political science; BS in biology/MS in biotechnology; BS/PhD in biology. Students interested in marine biology should investigate the degree programs offered by marine and environmental science. Double majors involving any two of these biology programs are not available due to curricular overlap.

Our degree programs are designed to prepare students to enter the job market directly or to go on to graduate, medical, veterinary, dental, law, or business school. Our graduates are qualified for a wide array of career paths in industrial and clinical research in any of the life sciences, in teaching at all levels, in state or federal government agencies, in medicine and other healthcare-related professions. Premedical, predental, and other preprofessional students are urged to consult with the prehealth advising program early in their careers at Northeastern.

Programs

Bachelor of Science (BS)

- Biology (http://catalog.northeastern.edu/undergraduate/science/biology/biology-bs)
- Cell and Molecular Biology (http://catalog.northeastern.edu/undergraduate/science/biology/cell-molecular-biology-bs)
- Biology and English (http://catalog.northeastern.edu/undergraduate/science/biology/biology-english-bs)
- Biology and Mathematics (http://catalog.northeastern.edu/undergraduate/science/biology/biology-mathematics-bs)
- Biology and Political Science (http://catalog.northeastern.edu/undergraduate/science/biology/biology-political-science-bs)
- Computer Science and Biology (http://catalog.northeastern.edu/undergraduate/computer-information-science/computer-information-science-combined-majors/computer-science-biology-bs)

Minors

- Biology (http://catalog.northeastern.edu/undergraduate/science/biology/biology-minor)

Accelerated Programs

See Accelerated Bachelor/Graduate Degree Programs (http://catalog.northeastern.edu/undergraduate/science/accelerated-bachelor-graduate-degree-programs/#programstext)

Courses

Biology Courses

BIOL 1000. Biology at Northeastern. 1 Hour.
Introduces first-year students to the major and the field of biology and to the professional and academic resources available to students at Northeastern University; acquaints students with their faculty, advisors, and fellow students; provides an initial orientation to undergraduate research, cooperative education, and other experiential learning options; helps develop the academic skills necessary to succeed; provides grounding in the culture and values of the university community; and assists in interpersonal skill development—in short, familiarizes students with the resources and skills needed to become a successful university student.

BIOL 1107. Foundations of Biology. 4 Hours.
Introduces evolutionary principles, cellular structure and function, genetic transmission, energy pathways, and physiology. Covers current topics in biology and evaluates and discusses current scientific literature. Explores the interdisciplinary nature of biology. Offers students an opportunity to prepare for the topical inquiries in biology courses.

BIOL 1108. Lab for BIOL 1107. 1 Hour.
Accompanies BIOL1107. Includes various lab experiments that emphasize evolutionary principles, cellular structure and function, genetic transmission, energy pathways, and physiology.

BIOL 1111. General Biology 1. 4 Hours.
Explores basic principles of biology with a focus on those features shared by all living organisms and seen through the lens of evolutionary theory. Through lectures, readings and discussion, offers students an opportunity to understand how the scientific method has been and is used to address biological questions. Central topics include recent advances in cell anatomy and physiology, including the interplay between organelles, membrane transport, and cell-signaling; energy transfer through cells and through the biosphere; cellular reproduction and cancer; heredity and human genetic disorders; and protein synthesis and biotechnology. Explores the societal implications of such topics as biopharmaceuticals, ocean acidification, climate change, human diseases, epigenetics, cancer, and cloning.

BIOL 1112. Lab for BIOL 1111. 1 Hour.
Accompanies BIOL 1111. Offers students an opportunity to collect quantitative data through hands-on experimentation as well as simulations. Data is analyzed statistically and presented in written form.

BIOL 1113. General Biology 2. 4 Hours.
Continues BIOL 1111. Examines the evolution of structural and functional diversity of organisms; the integrative biology of multicellular organisms; and ecological relationships at the population, community, and ecosystem levels.

BIOL 1114. Lab for BIOL 1113. 1 Hour.
Accompanies BIOL 1113. Covers topics from the course through various experiments.

BIOL 1115. General Biology 1 for Engineers. 4 Hours.
Introduces basic molecular and cellular biology principles and concepts. Offers students an opportunity to begin to apply chemical and engineering principles to further an understanding of selected physiological processes and biological systems. Topics include protein structure and function, cellular organization, energetics, information management, molecular transport, signaling, and motility.

BIOL 1116. Lab for BIOL 1115. 1 Hour.
Accompanies BIOL 1115. Covers topics from the course through various experiments.

BIOL 1117. Integrated Anatomy and Physiology 1. 4 Hours.
Introduces students to integrated human anatomy and physiology. Focuses on structure and function of cells and tissues. Presents the anatomy and physiology of skin, bones, muscles, blood, and the nervous system.

BIOL 1118. Lab for BIOL 1117. 1 Hour.
Accompanies BIOL 1117. Covers topics from the course through various experiments.

BIOL 1119. Integrated Anatomy and Physiology 2. 4 Hours.
Continues BIOL 1117. Presents the structure and function of the human endocrine, reproductive, cardiovascular, respiratory, urinary, and digestive systems as well as the regulation of metabolism and body temperature.

BIOL 1120. Lab for BIOL 1119. 1 Hour.
Accompanies BIOL 1119. Covers topics from the course through various experiments.

BIOL 1121. Basic Microbiology. 4 Hours.
Focuses on how to identify, control, and live with bacteria and viruses. Emphasizes the mechanisms of disease production, natural host defense systems, and medical interventions.

BIOL 1122. Lab for BIOL 1121. 1 Hour.
Accompanies BIOL 1121. Covers topics from the course through various experiments.

BIOL 1141. Microbes and Society. 4 Hours.
Introduces the unseen world of microorganisms. Students analyze how the growth and behavior of this diverse group of organisms affect many aspects of human society including agriculture and food preparation; drug development and manufacture; liquid and solid waste management; genetic engineering; geochemical cycles; and health and disease.

BIOL 1143. Biology and Society. 4 Hours.
Offers an overview of how biology weaves its way across a broad spectrum of complex societal issues. Introduces students to the biological mechanisms and processes responsible for genetic inheritance, energy transfer, evolution, and population dynamics, providing a framework within which students may critically interpret and discuss important biological information provided in public forums. Seeks to empower students to make informed choices at the policy and personal levels. Offers students an opportunity to acquire an understanding of the basic principles of biology and apply the scientific process to the analysis of contemporary issues. Using a thematic approach, covers a wide range of issues including the reemergence of plagues, biological weapons and security, the environment, and human health and wellness.

BIOL 1147. The Human Organism. 4 Hours.
Introduces the structure and function of the human body. Emphasizes the principles of biological and physical science as they relate to life processes in health and disease.

BIOL 1149. Biology of Human Reproduction. 4 Hours.
Studies sexual and reproductive function in the human male and female, that is, sexual development, coitus, fertilization, pregnancy, birth, and lactation. Discusses the methods of controlling fertility and sexually transmitted diseases. Analyzes factors affecting reproduction and sexuality in human population.

BIOL 1990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

BIOL 2299. Inquiries in Biological Sciences. 4 Hours.
Focuses on the latest developments in the field. Offers students an opportunity to explore both scientific practice and progress through readings, discussion, and projects and to expand and deepen their understanding of fundamental biological principles at the cellular and molecular level.

BIOL 2301. Genetics and Molecular Biology. 4 Hours.
Focuses on mechanisms of inheritance, gene-genome structure and function, and developmental genetics and evolution. Examples are drawn from the broad spectrum of plants, animals, fungi, bacteria, and viruses. Topics and analytical approaches include transmission genetics, molecular biology and gene regulation, DNA molecular methods, quantitative and population genetics, bioinformatics, genomics, and proteomics.

BIOL 2302. Lab for BIOL 2301. 1 Hour.
Accompanies BIOL 2301. Reinforces and extends concepts presented and practiced in the accompanying lecture course through the application of scientific investigation methods and data analysis.

BIOL 2309. Biology Project Lab. 4 Hours.
Offers an inquiry-based, intensive laboratory experience in which students have an opportunity to design and conduct independent research projects, applying approaches and techniques used in cell and molecular biology. Offers students an opportunity to present their results in professional formats.

BIOL 2321. Microbiology. 4 Hours.
Introduces morphological, ecological, and biochemical consideration of representative groups of bacteria. Introduces virology and microbial genetics; host-parasite relationships, prokaryotes of medical significance; and physical and chemical controls of microbial growth.

BIOL 2322. Lab for BIOL 2321. 1 Hour.
Accompanies BIOL 2321. Covers topics from the course through various experiments.

BIOL 2327. Human Parasitology. 4 Hours.
Examines the general biology, life cycles, modes of transmission, and pathogenesis of major parasites on global human health. Explores a number of important diseases, along with the diverse protozoans, worms, and arthropods responsible for them.

BIOL 2329. Bioethics. 4 Hours.
Offers students an opportunity to explore ethical issues arising from biological research and emerging technologies, to learn to identify and critically analyze potential ethical implications of biological research, and to evaluate theory-based arguments while respectfully engaging with a diversity of perspectives. Using their knowledge of basic cellular and molecular science as a foundation, students have an opportunity to gain a deeper understanding of the biology of genome editing and other molecular and cellular biology-based technologies. Examines the history and ethical dialogue around genome editing as an in-depth example of an emerging technology with wide-ranging applications. Studies additional technologies with respect to research progress, international perspectives, and potential implications in the areas of security, environmental protection, and personal health.

BIOL 2990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

BIOL 3401. Comparative Vertebrate Anatomy. 4 Hours.
Examines the morphology and phylogeny of the vertebrates.

BIOL 3403. Animal Behavior. 4 Hours.
Examines the evolution of animal behavior. Topics include how behaviors have evolved, the adaptive function of behavior, and the relative roles of genes and the environment in the development of behavior. Behaviors from feeding and reproductive strategies to communication and social behavior are considered. Implications for human behavior are considered.

BIOL 3405. Neurobiology. 4 Hours.
Introduces the cellular and molecular functioning of the nervous system, the organization of neurons into circuits, the processing of information, and the generation of motor output.

BIOL 3409. Current Topics in Biology. 4 Hours.
Examines selected topics in biology. Topics vary each semester. May be repeated without limit.

BIOL 3601. Neural Systems and Behavior. 4 Hours.
Reviews major experimental approaches and key concepts used in behavioral neurobiology. Begins with a look at its history. Topics covered include spatial orientation and sensory guidance, neuronal control of motor output, neuronal processing of sensory information, sensorimotor integration, neuromodulation, circadian rhythms and biological clocks, behavioral physiology of large-scale navigation, neurobiology of communication, and cellular mechanisms of learning and memory.

BIOL 3603. Mammalian Systems Physiology. 4 Hours.
Designed to familiarize students with fundamental principles in mammalian physiology. Emphasizes major organ systems integration. Where applicable, explores and uses human physiology to reinforce principles in physiology and build upon these principles by analyzing how major organ systems effectively network for proper organismal function. Initially covers the physiological principles of energy and metabolism in mammals, including human adaptation for basic energy requirements, and then delves into basics of membrane transport. Evaluates roles for organ systems integration in the respiratory, cardiovascular, gastrointestinal, hemopoietic, renal, and reproductive systems.

BIOL 3605. Developmental Neurobiology. 4 Hours.
Covers the cellular, molecular, and genetic processes that guide neural development. Focuses on how nerve cells are generated, patterned, and connected with one another to regulate animal behavior. Topics include cell differentiation, tissue patterning, neural plasticity, and cognitive development.

BIOL 3607. Current Trends in Reproductive Sciences. 4 Hours.
Introduces current trends in the field of reproductive sciences, spanning basic human reproduction, infertility, and potential horizons in medicine. Surveys topics in basic research that have the most promise to make an impact in the field of women's health. Emphasizes human health but includes animal models in the analysis.

BIOL 3609. Developmental Biology. 4 Hours.
Focuses on organismal development at cellular, molecular, and anatomical levels. Topics include gametogenesis, fertilization, cleavage, gastrulation, organogenesis, and metamorphosis. Invertebrates and vertebrates provide descriptive and experimental models. Laboratory work emphasizes echinoderms, amphibians, birds, and mammals.

BIOL 3611. Biochemistry. 4 Hours.
Covers structure and function of biomolecules, central concepts of bioenergetics and thermodynamics, enzyme kinetics and regulation, and metabolic pathways.

BIOL 3612. Lab for BIOL 3611. 1 Hour.
Accompanies BIOL 3611. Covers topics from the course through various experiments.

BIOL 3990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

BIOL 4701. Biology Capstone. 4 Hours.
Integrates and assesses the concepts and skills obtained from the entire biology curriculum, including experiential and classroom-based components. Requires reflection by students on their various educational experiences, extensive research of scientific questions related to these experiences, and development of an original research proposal. Offers students an opportunity to hone communication skills through formal and informal presentations, class discussion, and critique.

BIOL 4705. Neurobiology of Cognitive Decline. 4 Hours.
Introduces the neuroanatomical and cognitive sequelae of brain aging and neurodegenerative disease. Covers molecular and cellular processes that damage neurons, animal models, and brain imaging. Explores higher-level manifestations of damage to, for example, memory, language, and reward systems.

BIOL 4707. Cell and Molecular Biology. 4 Hours.
Integrates molecular biology and biochemistry in the cellular context. Focuses on the organization and function of eukaryotic cells, including the regulation of nuclear structure and gene expression, signal transduction, protein synthesis and growth, cellular energetics, the cytoskeleton and cell motility, cell division, and cell death. Emphasizes the scientific methodologies and approaches that underlie discovery in cell biology.

BIOL 4709. Neurobiology of Learning and Memory. 4 Hours.
Explores the neurobiology of learning and memory from the level of the synapse up to the neural systems underlying emergent mnemonic function. Topics include the synaptic mechanisms underlying neural plasticity; the molecular basis of mnemonic processes; and the neural circuits serving distinct memory systems. In addition to lecture-based material, students utilize primary research and review articles from the current scientific literature to evaluate data and develop hypotheses via oral presentations and active discussions in the classroom. The overarching goal of the course is to provide a neurobiological perspective on how information is encoded, consolidated, and later retrieved and the significance of dysfunction in these processes associated with neurologic deficits and disease.

BIOL 4970. Junior/Senior Honors Project 1. 4 Hours.
Focuses on in-depth project in which a student conducts research or produces a product related to the student's major field. Combined with Junior/Senior Project 2 or college-defined equivalent for 8 credit honors project. May be repeated without limit.

BIOL 4971. Junior/Senior Honors Project 2. 4 Hours.
Focuses on second semester of in-depth project in which a student conducts research or produces a product related to the student's major field. .

BIOL 4990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

BIOL 4991. Research. 4 Hours.
Offers independent laboratory research work on a chosen topic under the direction of members of the department. Course content depends on instructor. May be repeated without limit.

BIOL 4994. Internship. 4 Hours.
Offers students an opportunity for internship work. May be repeated without limit.

BIOL 5100. Biology Colloquium. 1 Hour.
Offers a series of colloquia in biological research by invited experts on current topics. May be repeated without limit.

BIOL 5306. Biological Clocks. 4 Hours.
Examines the expression of endogenously generated twenty-four-hour (circadian) rhythms in eukaryotic life, emphasizing theoretical foundations as well as current research strategies for understanding how biological clocks work. Presents analytic principles essential for understanding biological rhythmicity in any organism at any level of organization. Emphasizes strategies used to understand the concrete mechanisms underlying biological rhythmicity.

BIOL 5307. Biological Electron Microscopy. 4 Hours.
Presents techniques of electron microscopy applied to biological materials. Discusses specimen preparation, fixation, thin-sectioning, staining, operation of the microscopes, photographic techniques, and interpretation of electron micrographs. Requires student seminars and project.

BIOL 5308. Lab for BIOL 5307. 1 Hour.
Designed for graduate and advanced undergraduate students with no formal training in electron microscopy. Offers students an opportunity to acquire a thorough working knowledge of transmission and scanning electron microscopy by having each student process specimens from living tissue through the production of electron micrographs. This involves standard specimen preparation protocols including fixation, embedding, ultramicrotomy, staining, critical point drying, and sputter coating, as well as the independent operation of state-of-the-art electron microscopy equipment.

BIOL 5499. Plant Biotechnology. 4 Hours.
Designed as an introductory course on plant biotechnology for upper-level undergraduates and first-year graduate students. Using examples from current research, offers students an opportunity to review the technology used to modify and improve economically important plants for sustainable agriculture as well as for the production of pharmaceutical and medicinal products. Specific topics include principles of plant heredity and genetics (molecular biology), plant breeding and improvement, hormones and growth regulators, gene isolation, plant tissue culture and transformation, plant-based pharmaceutical production, and stress tolerance and improvement. The course consists of weekly lectures, laboratory demonstrations, and review sessions of recent literature.

BIOL 5541. Endocrinology. 4 Hours.
Explores the endocrine regulation of physiological systems, emphasizing current research. Lectures provide background, followed by analysis of primary literature and case studies. Topics include growth, reproduction, nutrient utilization, stress, and environmental endocrine disruption. Emphasizes humans but includes material on other animals, including invertebrates.

BIOL 5543. Stem Cells and Regeneration. 4 Hours.
Explores the biological basis of embryonic, adult, and induced pluripotent stem cells toward an understanding of their roles in development, homeostasis, and regeneration, as well as their therapeutic potential. The study of stem cells is a rapidly advancing area in biology and biomedicine. Although the biological basis of stem cells is a major focus, the course aims to put this knowledge into a biomedical context.

BIOL 5549. Microbial Biotechnology. 4 Hours.
Offers readings and seminar-style discussion from the current literature on important inventions and practical applications in biotechnology, with a focus on drug discovery.

BIOL 5569. Advanced Microbiology. 4 Hours.
Focuses on how microorganisms develop, exchange, and regulate genes, and survive in various environments. Emphasizes experimental design and proof, particularly as related to genetic exchange, gene regulation, single and multicellular development, and cell-cell communication.

BIOL 5573. Medical Microbiology. 4 Hours.
Emphasizes host-parasite interactions: virulence, toxins, natural flora, and immunological responses; characteristics of the common bacterial, rickettsial, and protozoal infections in humans; and epidemiology, pathology, vaccines, and chemotherapy.

BIOL 5581. Biological Imaging. 4 Hours.
Illustrates imaging principles and techniques and their application to biological problems. Topics vary and may include microscopic and macroscopic approaches in areas such as cellular and neurobiology, ecology, and biochemistry.

BIOL 5583. Immunology. 4 Hours.
Provides an overview of the structure and function of genes, proteins, and cells involved in the generation of the immune response. Emphasis is on molecular immunology and immunogenetics.

BIOL 5585. Evolution. 4 Hours.
Discusses history of evolutionary theory and lines of evidence. Emphasis is on mechanisms of speciation. Introduces and discusses current evolutionary topics.

BIOL 5587. Comparative Neurobiology. 4 Hours.
Presents a cellular approach to structure and function of the nervous system. Topics include neuronal anatomy, phylogeny of nervous systems, electrophysiology of membrane conductances, synaptic transmission, integration in nerve cells, neuronal networks, sensory systems, motor systems, sensory-motor integration, development and regeneration of neuronal connectivity, and fundamentals of neurotechnology for biomedics. Focuses on the development of these concepts from the primary research literature. A term project involves the design of a simple nervous system for a hypothetical animal.

BIOL 5591. Advanced Genomics. 4 Hours.
Intended for those familiar with the basics of genetics, molecular and cellular biology, and biochemistry, all of which are required to appreciate the beauty, power, and importance of modern genomic approaches. Introduces the latest sequencing methods, array technology, genomic databases, whole genome analysis, functional genomics, and more.

BIOL 5593. Cell and Molecular Biology of Aging. 4 Hours.
Covers the recent scientific discoveries that have transformed our understanding of the process of aging. Examines in-depth the current understanding of the molecular mechanisms that control life span in model organisms, including yeast, worms, flies, and mice. Discusses dietary interventions and pharmacological approaches that extend the life span and delay the onset of age-related diseases. Covers potential applications of the new science of aging to improve human health. Requires students to read, discuss, present, and report on primary research papers from the literature.

BIOL 5595. Cell and Molecular Neuroscience. 4 Hours.
Combines molecular biology, cell biology, pharmacology, and genetics to address the fundamental molecular properties of neurons and neuronal networks. At its core, the principles that govern the communication between cells of the nervous system are determined by their molecular components. The molecular landscape defines the individual properties of a neuron and the function of neuronal networks as a whole. Focuses on neuronal signaling through the function of ion channels and receptors, supramolecular mechanisms like synaptic transmission and axonal transport, and the molecular mechanisms that underlie biological networks and neural coding of information. Uses the fundamental understanding of molecular networks as a framework to explore the mechanisms that underlie neurological diseases and disorders. Discusses current treatments and therapies that rely on modulating neuronal signaling through molecular interactions.

BIOL 5597. Immunotherapies of Cancer and Infectious Disease. 4 Hours.
Describes the basic principles and the current promises and disappointments with immunotherapies of cancer. Provides a historical overview of the main barriers between tumors and antitumor killer cells. The unifying focus of the lectures is the role of immunological and physiological negative regulators, i.e., “brakes” of anti-tumor immune response. A significant part of the course is dedicated to the retrospective evaluation of the last three decades of the immunological and biochemical studies that culminated in identification of the “chief of tumor defense operations,” i.e., a hypoxia-adenosinergic pathway in the tumor microenvironment.

BIOL 5599. Principles of Data Management and Peer Review in Biology. 4 Hours.
Designed to familiarize students with the fundamentals of all aspects of data management within an academic setting. Topics include data acquisition, documentation and storage, intellectual property and patents, assignment of ownership, identification of conflicts of interest, and the peer review process for manuscript and grant submission. Responsible conduct of research (RCR) training is an important part of this course. Offers students an opportunity to become familiar with, and complete, fundamental training using nationally accepted standard certifications, including RCR training, pertaining to data management. Students analyze patent preparation and manuscript and grant peer review. Additionally, students participate in a study section review panel.

BIOL 5601. Multidisciplinary Approaches in Motor Control. 4 Hours.
Studies the field of human motor control, or motor neuroscience. Offers students an opportunity to obtain a fundamental understanding of the processes underlying the acquisition and control of sensorimotor behavior. The systems approach connects a variety of disciplines ranging from neurophysiology, to engineering, to neurorehabilitation. Reviews a selection of approaches with emphasis on motor learning. Focuses on early behavioral approaches, more recent neurophysiological and imaging approaches, and rehabilitation. Discusses selected representative papers, including seminal historical papers and more recent studies reflecting the current discussion in the field.

BIOT 5040. Fundamentals of Biochemistry for Biotechnology. 4 Hours.
Covers the fundamentals of biochemistry for biotechnology applications, including protein structure and function, DNA technologies, bioenergetics, and biosynthesis. Requires permission of instructor for those students not majoring in biotechnology.

BIOT 5050. Organic Chemistry for Biotechnology. 4 Hours.
Offers an introduction to organic chemistry that seeks to prepare students for the MS in biotechnology program. Explores the nature of and the biological aspects of organic compounds. Covers the fundamentals of the structure, nomenclature, properties, and reactions of carbon compounds. Also introduces the chemistry of biological molecules, including amino acids, proteins, carbohydrates, and lipids, as well as spectroscopic structure determination known as nuclear magnetic resonance (NMR). Requires prior completion of chemical principles 2/ general chemistry 2 with lab; restricted to biotechnology students or by permission of instructor.

BIOT 5120. Introduction to Biotechnology. 3 Hours.
Provides an interdisciplinary, state-of-the-art introduction to biotechnology to students of the Master of Science in Biotechnology program. Covers the molecular foundations of biotechnology, molecular microbiology, receptor pharmacology, drug development processes, biotech process development and scale-up, drug approval and regulatory affairs, genomics, microarray analysis, proteomics, computational biology, molecular modeling, analytical biotechnology, and bioterrorism and biotechnology.

BIOT 5130. Team Skills in Biotechnology. 2 Hours.
Focuses on project management and leadership skills in the biotechnology industry. Emphasizes professional etiquette, teamwork, and team leadership in a diverse, multidisciplinary workplace. Also offers students an opportunity to develop their technical communication skills (scientific writing, public speaking, and technical presentations).

BIOT 5145. Basic Biotechnology Lab Skills. 1 Hour.
Introduces selected key skills and techniques central to life sciences research. Combines hands-on training in basic laboratory skills with lecture and live demonstration. Laboratory exercises highlight the importance of precision/accuracy in dispensation of liquids and in the preparation of solutions and standards, documentation and record keeping, and maintaining a safe and sterile work environment while performing scientific research.

BIOT 5219. The Biotechnology Enterprise. 2 Hours.
Exposes students to a broad spectrum of concepts and issues that are common to biotechnology companies. Provides an overview of innovation, intellectual property, planning, government regulation, and strategic alliances. Introduces biotechnology entrepreneurship; management; and the legal aspects of science, technology, and research in the biotechnology context.

BIOT 5220. The Role of Patents in the Biotechnology Industry, Past and Future. 1 Hour.
Covers the basics of patenting and the application of patents to the biotechnology industry, including the controversial area of gene patents.

BIOT 5225. Managing and Leading a Biotechnology Company. 3 Hours.
Covers managing projects and personnel in a technology-based organization Such activities are best carried out by those who combine the technical knowledge of their industry with the insight into the best practices for working with groups of highly educated, and often very experienced people. The biotechnology industry is strongly dependent on the concept that knowledge is always shared and ownership is collective. As the fundamental organizational mantra is teamwork, the principles of managing in this environment are key to achieving important goals. How to accomplish this and make decisions that drive innovation and success have common threads with other technology based industries, but with the added complexity of the scientific challenges facing the biotechnology industry. Restricted to students in the Bouvé College of Health Sciences and in the College of Science or by permission of the program office.

BIOT 5226. Biotechnology Entrepreneurship. 3 Hours.
Biotechnology by its very nature is an innovative multidisciplinary industry. This is especially true for the biopharmaceutical industry in which the process of discovering new drugs and new drug targets requires novel approaches to solving difficult questions about disease processes and human health. This course focuses on the essential nature of innovation in the biotech industry, exposes students to the basics of creating startup organizations, explains the key role of business planning in enterprise creation, describes means for assessing risks, making choices from available options and how to measure success. Various business models, outsourcing work and establishing strategic partnerships are examined. Restricted to students in the Bouvé College of Health Sciences and in the College of Science or by permission of the program office.

BIOT 5227. Economics and Marketing for Biotechnology Managers. 3 Hours.
Provides a foundation for making financial decisions in the biotechnology industry. Examines accounting methods, forecasting, corporate valuation, exit strategies and drug pipeline economics. Introduces concepts for marketing pharmaceutical products. Restricted to students in the Bouvé College of Health Sciences and in the College of Science or by permission of the program office.

BIOT 5340. Introduction to Biotherapeutic Approvals. 3 Hours.
Introduces students to biologics. The class of drugs referred to as biologics or biotherapeutics, proteins drugs, makes up a large portion of the drugs in development and on the market today. Focuses on considerations for approval for such drugs. Offers students an opportunity to learn how to be able to describe and explain both biologics and biosimilars.

BIOT 5360. Drug Stability. 2 Hours.
Focuses on stability testing of both small molecule and protein drugs. Studies the difference between small molecule and protein drug stability testing. Offers students an opportunity to learn how to explain the International Council on Harmonisation (ICH)-Quality (Q1) guidelines and how they are applied to drug development and approvals.

BIOT 5400. Scientific Information Management for Biotechnology Managers. 3 Hours.
Introduces biotechnology students to scientific information management specifically related to the biotechnology field. Covers an introduction to data sciences, its history, and how it is relevant to biotech today. Offers students an opportunity to obtain the background needed to assess and use modern data management capabilities such as "the cloud," big data, etc. Covers recent developments in origination of data, metadata, data models, data management, and organization and storage of data in biotechnology.

BIOT 5500. Introduction to Regulatory Science. 3 Hours.
Introduces the science that supports regulatory affairs in the biopharmaceutical industry. Focuses on the methods and instruments used to characterize the processes and products of biotechnology including the production, separation, purification, characterization, and formulation of biologics; the pharmacokinetics of proteins; chemical and biological equivalencies of biogenerics; stability testing; high throughput assays; cell system expression; variants; method validation; and quality control.

BIOT 5560. Bioprocess Fundamentals. 3 Hours.
Focuses on the fundamental principles and elements in the process of manufacturing biopharmaceuticals. Covers kinetics of enzymatic reactions; selected microbial and cell metabolism and relevant control mechanisms; kinetics of cell growth, cell death, substrate consumption, and product formation; mathematical modeling and representation of bioprocesses; examples of industrial bioprocesses to illustrate types and operations of upstream and downstream unit operations and mass transfers in fermentation systems—the affecting factors and the impact on process development and scale-up. Also includes an overview of economic considerations. Emphasizes bioprocesses for recombinant protein production.

BIOT 5631. Cell Culture Processes for Biopharmaceutical Production. 3 Hours.
Covers the principles and concepts involved in the development of mammalian and other types of cell culture processes for the manufacturing of biopharmaceutical products such as monoclonal antibodies and recombinant proteins. Topics include protein expression and clone generation, batch and perfusion processes and media development, bioreactor operations and scale-up, and innovations in cell culture processes. Regulatory concepts include quality assurance in a cGMP environment.

BIOT 5635. Downstream Processes for Biopharmaceutical Production. 3 Hours.
Addresses the development of recombinant protein purification processes in biotechnology. Provides an overview of the scientific principles, engineering strategies, and unit operations facilities involved in scalable protein purification processes. Also discusses viral clearance and inactivation strategies; cGMP considerations; and technological advances to improve effectiveness and efficiency, such as membrane-based disposable systems.

BIOT 5640. Drug Product Processes for Biopharmaceuticals. 3 Hours.
Covers the development and implementation of the drug product manufacturing process for biopharmaceuticals. Focuses on biologic products, specifically proteins. Covers the workflow required for the development and implementation of the production process with the scientific and engineering principles highlighted. Topics include the preformulation process for early stage product development, the selection of formulation compatible with the targeted product presentation, optimization of formulations to meet stability and usage objectives, the design of a scalable process for production, large-scale process equipment and operations, process scale-up considerations, and regulatory compliance issues for drug product manufacturing facilities and operations. Students who do not meet course prerequisites may seek permission of instructor.

BIOT 5700. Molecular Interactions of Proteins in Biopharmaceutical Formulations. 3 Hours.
Offers an up-to-date survey and review of the research and understanding of the molecular interactions of proteins in biopharmaceutical formulations, including both liquid and solid formats, during the process of drug product manufacturing. Focuses on protein-protein interactions, protein-excipients (e.g., stabilizers, surfactants) interactions, and protein at interface surfaces interactions that are critical and impactful on the stability and integrity of therapeutic proteins of interest. Emphasizes understanding the mechanistic aspect of the interactions; the approaches, methods, and techniques employed to study these phenomena; and measures considered to modulate such interactions to enhance the performance of the biopharmaceutical formulations. Students who do not meet course prerequisites may seek permission of instructor.

BIOT 5810. Cutting-Edge Applications in Molecular Biotechnology. 3 Hours.
Introduces the uses of molecular biology in a biotechnology setting. Includes a brief review of the basics and then dives into state-of-the-art molecular biology applications used in biotechnology today. These applications include stability and expression of cloned gene products, gene cloning strategies, transgenic species, mutation creation and analysis, DNA fingerprinting, PCR technology, microarray technology, gene probes, gene targeting, gene therapy, stem cell technology, antisense RNA, CAR T-cell therapy, RNA interference, and CRISPR/Cas9.

BIOT 5820. Cellular Therapies. 2 Hours.
The ever-changing landscape of the biotechnology field requires constant training. This course is designed to familiarize participants with some of the most cutting-edge topics available in molecular biology today: stem cells, RNA interference, CRISPR/CAS9, CAR T-cells, gene therapy, and more. Offers participants an opportunity to learn the theory behind these new technologies, how they are done, and their power in scientific discovery and treatment.

BIOT 5821. Introduction to Biopharmaceutical Technologies. 1 Hour.
Covers the basic techniques used to develop a modern-day biopharmaceutical product. Topics include DNA fingerprinting, PCR technology, microarrays, gene probes and targeting, expression of cloned gene products, gene cloning strategies, transgenic species, and mutation creation and analysis. Offers students an opportunity to learn the theory and practical application behind these technologies—how they are done and their power in scientific discovery and treatment. Emphasizes the latest advances in these classic technologies.

BIOT 5850. Higher-Order Structure Analytics. 3 Hours.
Offers a comprehensive look at various aspects of higher- order protein structures in biotherapeutics and their implications on biological drug design. Focuses heavily on protein aggregation, a type of HOS, and analysis of those aggregates including functional implications. Topics include a review of protein structure, protein aggregation, functional aspects, and techniques to reduce HOS using protein expression and purification strategies, protein folding in disease, macromolecular crystallography, nuclear magnetic resonance, analytical ultracentrifugation, circular dichroism, light scattering, electron spin labelling, cryo-EM, WAXS, and HDX-MS. Highlights experimental design and application to the biotechnology industry in identifying and reducing HOS.

BIOT 5976. Directed Study. 1-4 Hours.
Offers independent work under the direction of members of the department on chosen topics. May be repeated without limit.