Biology (Graduate)

Graduate Biological Sciences Education

The Division of Biology and Medicine offers multiple programs of advanced graduate study leading to the degrees of A.M., Sc.M., and Ph.D. These programs are thematically based: Biotechnology; Computational Biology; Ecology, Evolution, & Organismal Biology; Molecular Biology, Cell Biology, and Biochemistry; Neuroscience; Pathobiology; Therapeutic Sciences; and Biomedical Engineering.

The research network at Brown features advanced facilities situated on campus and at partner institutions which encourages discovery and innovation with state-of-the-art equipment and resources including: Genomics Core (http://www.brown.edu/Research/CGP/core/equipment/)and Proteomics Facility (http://biomed.brown.edu/epscor_proteomics/), Bioimaging facility (http://www.brown.edu/Facilities/Leduc_Bioimaging_Facility/), Transgenic and Gene Targeting Facility (http://www.brown.edu/Departments/Molecular_Biology/transgenic/), Center for Animal Resources and Education (http://biomed.brown.edu/ancare/), Plant Environmental Center (https://www.brown.edu/academics/ecology-and-evolutionary-biology/about-us/facilities/plant-environmental-center/), Water Flume (http://www.brown.edu/Departments/EEB/research/morphology.htm), RI BioBank (http://biomed.brown.edu/rhode-island-biobank/), Molecular Pathology Core (https://www.brown.edu/research/projects/superfund/cores/core-d/), Center for Computational Molecular Biology (https://www.brown.edu/academics/computational-molecular-biology/home/) . More information about the Division's Research Facilities can be found here: https://www.brown.edu/academics/biomed/research/core-facilities (https://www.brown.edu/academics/biomed/research/core-facilities/)

Students entering graduate programs generally have appropriate preparatory course work as well as significant research experience. Courses are chosen with the advice of program counselors, and may include, in addition to divisional offerings, courses offered by other university departments. As a part of the doctoral training most students will be required to participate in the teaching of one or more courses related to the program.

Biotechnology Graduate Program

The Biotechnology masters program offers Master of Arts (A.M.) and Master of Science (Sc.M) degrees and is designed for students interested in a range of topics related to the field of biotechnology and therapeutics including drug discovery, drug & gene delivery, cell therapy, and biotechnology business.

The educational objectives of the program are to promote an understanding of: 1.) the designs and materials used in novel cell and drug delivery systems; 2.) the molecular, cellular and animal sciences of drug discovery & drug development; and 3.) the development and testing of cell-based therapies for the treatment of diseases. We also offer courses on the business and management of biotechnology. Active areas of research include: cancer therapeutics, bioadhesive drug delivery systems, mesenchymal stem cells, alternatives to animal testing, nerve guidance channels, cartilage regeneration, cardiac arrhythmias, micro-vesicles, anti-microbials, insulin regulation, neuroactive & neuroprotective agents and cell delivery & encapsulation strategies.

For further information on admission and program requirements, please visit: https://www.brown.edu/academics/biotechnology-graduate-program/masters-degree-programs (https://www.brown.edu/academics/biotechnology-graduate-program/masters-degree-programs/) and for additional information: http://www.brown.edu/academics/gradschool/programs/biomed-biotechnology-0 (http://www.brown.edu/academics/gradschool/programs/biomed-biotechnology-0/)

Ecology, Evolution, and Organismal Biology Graduate Program

The graduate program in Ecology, Evolution and Organismal Biology (EEOB) is intended for highly qualified students who plan to pursue a career that includes research and/or teaching in areas of ecology, evolution, and organismal biology. EEOB is committed to an inclusive community that benefits from the diverse backgrounds, experiences and motivations of all our members. We tailor our training programs to meet each student's needs and interests, providing a customized curriculum that supports their own intellectual growth and goals. All students are expected to attain proficiency in ecological and evolutionary theory, quantitative research methods, statistical analysis, writing, and oral presentation. Depending on the student's interests, they may also be expected to demonstrate proficiency in other areas such as functional morphology or genetics and genomics. This proficiency may be attained through coursework, seminars, independent reading, and laboratory and field programs. The Ecology, Evolution, and Organismal Biology program offers a Doctor of Philosophy (Ph.D.) degree as well as a 5th year Master of Science (Sc.M.) degree for students who would like to continue the research they started as an undergraduate at Brown. The Master of Science degree is also available for participants in Brown's Open Graduate Education Program.

For further information on admission and program requirements, please visit: http://www.brown.edu/academics/gradschool/programs/biomed-ecology-and-evolutionary-biology (http://www.brown.edu/academics/gradschool/programs/biomed-ecology-and-evolutionary-biology/)

Pathobiology Graduate Program

The Pathobiology Graduate Program is an interdisciplinary and interdepartmental program broadly devoted to understanding mechanisms of human disease. The program offers a Doctor of Philosophy (Ph.D.) degree as well as a 5th year Master of Science (Sc.M.) or Master of Arts (A.M.) degree. The four major research and teaching thematic areas are: I) Immunology & Infectious Disease, II) Environmental Pathology, III) Cancer biology, and IV) Aging. Training may be obtained in diverse areas of immunology, infection biology, cancer biology, toxicology, pulmonology, hepatology, and aging.

For further information on admission and program requirements, please visit: http://www.brown.edu/academics/gradschool/programs/biomed-pathobiology (http://www.brown.edu/academics/gradschool/programs/biomed-pathobiology/)

Molecular Biology, Cell Biology, and Biochemistry Graduate Program

The graduate program in Molecular Biology, Cell Biology, and Biochemistry (MCB) is intended for highly qualified students who plan to pursue a career that includes research in biology or medical sciences. The MCB Program offers a Doctor of Philosophy (Ph.D.) degree as well as 5th Year Master of Arts (A.M.) and Master of Science (Sc.M.) degrees. The program is interdisciplinary focusing on genetics, genomics and gene expression, signal transduction, biochemistry, structural biology, proteomics, cell signaling, molecular modeling, DNA/RNA protein interactions and epigenetics. Trainees use these skills to address questions relevant to cancer, immunology, aging, neuroscience, virology, plant biology and other biological topics.

For further information on admission and program requirements, please visit: http://www.brown.edu/academics/gradschool/programs/biomed-molecular-biology-cell-biology-and-biochemistry (http://www.brown.edu/academics/gradschool/programs/biomed-molecular-biology-cell-biology-and-biochemistry/)

Molecular Pharmacology and Physiology Graduate Program

The graduate program in Molecular Pharmacology and Physiology offers advanced training appropriate for academic and research

careers in the fields of biology and medical sciences that include: 1) neuropharmacology, neurophysiology and neural circuit function; 2) receptor and ion channel pharmacology, physiology and signal transduction; 3) structures and interactions of biological molecules and their roles in disease; 4) translational and clinical applications of pharmacology & physiology; 5) chemical biology, biophysics and their applications; and 6) cancer biology and therapeutics. Programs of study and research are developed individually in consultation with the student's advisor and advisory committee and are designed to ensure expertise in the student's principal field. The Molecular Pharmacology & Physiology Program offers a Doctor of Philosophy (Ph.D.) degree, as well as a 5th-Year Master of Science (Sc.M.) degree for students who would like to continue the research they started as undergraduates at Brown.

The Molecular Pharmacology & Physiology Program will no longer accept applications effective 2022. We ask you to consider the Therapeutic Sciences Graduate Program for those interested in the Ph.D degree as well as the 5th Year Master of Science degree for Brown students who would like to continue their research and pursue the Masters degree.

For more information on the program in Therapeutic Sciences, please visit: (https://www.brown.edu/graduateprograms/biomed-therapeutic-sciences-phd/)https://www.brown.edu/graduateprograms/biomed-therapeutic-sciences-phd (https://www.brown.edu/graduateprograms/biomed-therapeutic-sciences-phd/) and https://www.brown.edu/academics/tsgp/

Biomedical Engineering Graduate Program

The Biomedical Engineering (BME) graduate program provides cutting-edge, interdisciplinary, graduate-level education at the interface of engineering, biology, and medicine. The program features an interdisciplinary approach in multiple complementary research areas: diagnostics, biomaterials, mechanobiology, regenerative engineering, and neuroengineering. Research in these areas is advancing fundamental biological, medical, and engineering knowledge while innovating to improve the human condition. The program is distinguished by its quantitative rigor and strong collaborative connections among academic science, clinical medicine, and industry. The BME graduate program is designed for students with backgrounds in engineering, physics, or applied mathematics that seek additional education and training in the field of biomedical engineering

The Biomedical Engineering program offers both the Master of Science (Sc.M) degree and the Doctor of Philosophy (Ph.D) degree.

For more information on admission and program requirements, please visit: http://www.brown.edu/academics/gradschool/programs/biomedical-engineering (http://www.brown.edu/academics/gradschool/programs/biomedical-engineering/) and https://www.brown.edu/academics/biomedical-engineering/academics/graduate-program (https://www.brown.edu/academics/biomedical-engineering/academics/graduate-program/)

Therapeutic Sciences Graduate Program

The Therapeutic Sciences Graduate Program (TSGP) consists of a Therapeutic Sciences PhD program and a Biotechnology Master's program (ScM and AM). TSGP also includes MD/PhD students and 5th-year masters students from Brown, and shared activities and courses promote a sense of community within all of TSGP. The Therapeutic Sciences PhD program was recently developed to be an expansion and replacement of our longstanding PhD programs in Molecular Pharmacology & Physiology (MPP) and Biotechnology (Biotech). The Therapeutic Sciences PhD focuses on pharmacology, physiology and biotechnology, as well as additional scientific fields that are part of the broader area of therapeutic sciences, such as studies of drug targets in the immune system that are important in treating infectious diseases, characterization of brain mechanisms of addiction with an eye toward therapy, studies of molecular interactions in disease processes, understanding and preventing cancer growth and metastasis, and applications of cell- and tissue-based therapies. Thus, TSGP provides advanced training appropriate for academic and research careers in the fields of biology and medical sciences with a focus on determining disease mechanisms and drug actions, and developing novel therapies. The PhD program is funded in part by an NIH training grant (T32) through the NIGMS Program in Pharmacological Sciences

For further information on admission and program requirements, please visit: https://www.brown.edu/graduateprograms/biomed-therapeutic-sciences-phd (https://www.brown.edu/graduateprograms/biomed-therapeutic-sciences-phd/)

Courses

BIOL 2000A. Current Topics in MCDB - RNA Regulation: Beyond the Central Dogma.
The central dogma of molecular biology has long held that the primary role of RNA is to serve as an intermediary to convert the information stored in DNA into functioning proteins. However, it is now clear that RNA does not merely play a passive role in the information transfer process from DNA to protein. This course will focus on the many roles played by RNA molecules in both normal cellular processes and disease states. Papers from the primary literature will be chosen to explore this topic, primarily through student-led discussions. Course is limited to graduate students or advanced undergraduates with permission of the instructors.

BIOL 2000B. Topics in MCDB: How Protein Structure Informs Biological Function.
This course covers various aspects of structural and functional biology from primary to quatemary structure and deals with the 3D structure of proteins and nucleic acids and 3D structure determination. Course will be a mixture of lecture and class discussion/presentations. Students typically have taken an advanced undergraduate-level course in biology or biochemistry. Advanced undergraduates with permission. Enrollment limited to 20 students.

BIOL 2000C. Molecular Recognition and Signaling in Self and Non-self Interactions.
This course will cover cell signaling mechanisms that allow discrimination between self and non-self interactions in various biological contexts. Self/non-self signaling pathways from several model systems will be examined and their relevance to development and defense will be considered. Topics will include signaling in intra- and inter-species reproductive interactions, signaling in the establishment of symbioses, signaling upon predator attack, signaling in pathogen interactions, and co-evolution of pathogenic and resistance effectors. After one introductory lecture/discussion session led by the instructors, the remaining meetings will be student led and will focus on current primary literature. Open to advanced undergraduates with appropriate coursework.

Spr	BIOL2000C	S01	25364	W	3:00-5:30(10)	(M. Johnson)

BIOL 2000E. Topics in MCDB: The Genomics Revolution and its Impact on Genetics, Medicine and Society.
A technological revolution in genomics has exponentially increased our ability to gather biological data. A host of new methods and types of analysis has arisen to accommodate this dramatic shift in data collection. The broad scope of inquiry has ushered in an era of “system-wide” approaches and brute-force strategies where rare signals can be detected and studied. In this seminar we will cover papers that embody this new approach. Enrollment limited to 20 graduate students. Advanced undergraduates with appropriate course preparation and permission from instructor.

BIOL 2010A. Introduction to Molecular Research in the Life Sciences.
In this practical skill-building course, entering PhD students in the Molecular Biology, Cell Biology, and Biochemistry Graduate Program (MCBGP) will participate in an immersive laboratory experience. Students will practice foundational molecular methods for analysis of nucleic acids and proteins. Students will also develop key professional skills including workflow and time management, record keeping, experimental rigor and reproducibility, working in a team, and communication of experimental results. In addition, students will learn about experimental technologies and model organisms used in the molecular life sciences through interactive modules led by MCBGP trainer laboratories. Enrollment is restricted to first-year MCBGP PhD students.

Fall	BIOL2010A	S01	16233	MTWThF	10:30-12:00(16)	(M. Dawson)
Fall	BIOL2010A	S01	16233	M	10:30-12:00(16)	(M. Dawson)
Fall	BIOL2010A	S01	16233	F	10:30-12:00(16)	(M. Dawson)
Fall	BIOL2010A	S01	16233	TWTh	10:30-12:00(16)	(M. Dawson)
Fall	BIOL2010A	S01	16233	WThF	10:30-12:00(16)	(M. Dawson)
Fall	BIOL2010A	S01	16233	TWThF	10:30-12:00(16)	(M. Dawson)

BIOL 2010B. Introduction to Data Science in Molecular Biology.
In this course, second year PhD students in the Molecular Biology, Cell Biology, and Biochemistry Graduate Program (MCBGP) will learn about the basic methodologies to analyze and interpret omics datasets. This course combines lectures with hands-on workshops on data science applied to molecular research for the analysis of nucleic acids and proteins. Student will acquire knowledge of the data generated by modern molecular biology, and of the computational methods used to analyze and interpret these datasets. The hands-on workshop will teach students how to utilize the state-of-the-art computational workflows to create reproducible pipelines for data analysis. Students will also learn the best practices in data management, organization and sharing, with a focus on the big data generated by modern sequencing techniques in the life sciences. Enrollment is restricted to second year MCBGP PhD students. This is a half credit course.

Spr	BIOL2010B	S01	25001	T	10:00-1:00(16)	(N. Neretti)
Spr	BIOL2010B	S02	25365	T	10:00-1:00(16)	(N. Neretti)

BIOL 2015. Conservation in the Genomics Age.
The course will introduce students to the rapidly developing field of molecular ecology, emphasizing its importance for conservation biology. Students will explore key principles in evolutionary ecology based on readings, lectures, and discussions. Participants will also gain practical experience with ecological, genomic, and computational methods in the lab. This course is intended for advanced undergraduate and graduate students. Suggested prerequisites include Principles of Ecology (0420); Evolutionary Biology (0480) or Genetics (0470); the Lab Techniques Workshop for Biology Students provided by MDL; or similar with permission. Students will obtain permission from the professor to enroll.

BIOL 2018. Management Strategies in Biotechnology.
This course, taken the second semester, goes in depth into the numerous strategies in biotechnology. Significant differences in the strategies of small companies versus large companies, and device companies versus drug companies will be discussed with ample use of biotechnology case studies. At the end of this course, the successful student will: Understand the process of managerial decision making in the pharma/biotech industry Understand the basic principles of Decision Science, the application of quantitative analysis (modeling) to inform managerial decision making Gain exposure to basic frameworks and tools used by management consultants to define strategic options

Spr	BIOL2018	S01	25223	M	5:00-7:30(13)	(Y. Jong)

BIOL 2020. Biotechnology Science and Industry.
This course provides a comprehensive overview of the primary functional roles and steps involved in developing and commercializing a novel technology/scientific breakthrough within the biotechnology industry. This course is particularly suitable for students interested in pursuing a career within a biotechnology company, or for those interested in developing an in-depth knowledge of how the science of biotechnology becomes real world products. Pre Requisites: Foundations of Living Systems (BIOL0020), Principles of Physiology (BIOL0080), and Principles of Economics (ECON0110)/equivalent or instructor's permission is required.

Fall	BIOL2020	S01	17210	Th	5:00-7:30(04)	(E. Huang)

BIOL 2030. Foundations for Advanced Study in the Life Sciences.
BIOL2030 is a graduate-level course focused on multidisciplinary approaches to biological questions. The mechanisms and regulation of basic cellular processes involving nucleic acids (synthesis, structure, maintenance and transmission) and proteins (synthesis, maturation, function) and integration of those processes into more complex circuits (signaling, cell cycle control, development) will be presented through examples from the primary scientific literature. There are no prerequisites for this course. Enrollment is limited to graduate students. BIOL2030 is required for Ph.D. students in the MCB Graduate Program. All other students must obtain instructor permission.

Fall	BIOL2030	S01	16234	TTh	9:00-10:20(05)	(A. DeLong)

BIOL 2040. Ultrastructure/Bioimaging.
This course examines microscopy and image analysis in the life sciences. Theoretical and practical aspects of microscopy will be discussed. Students will obtain hands-on experience with electron microscopy, light microscopy, fluorescence microscopy, and confocal microscopy. Students will learn to display images in 3D. For graduate students and advanced undergraduates. Instructor permission required.

Spr	BIOL2040	S01	24989	M	2:00-5:00(13)	(G. Williams)

BIOL 2050. Biology of the Eukaryotic Cell.
(Undergraduate students should register for BIOL 1050.)

BIOL 2075. Evaluation of Health Information Systems.
This course covers the field of evaluation of health information systems (HIS) in a range of roles and environments, in the US and worldwide. It includes topics in health information system (HIS) design and deployment, healthcare workflow, quantitative and qualitative evaluation methods and socio-technical environment for HIS. Emphasis is given to understanding the range of evaluation questions that can be asked, identifying the key stakeholders, understanding available evaluation techniques, and designing rigorous but achievable studies. Examples will include Open Source systems, medical Apps, and economic evaluation, the role of evaluation frameworks and theories, and notable HIS successes and failures.

Fall	BIOL2075	S01	16217	TTh	1:00-2:20(06)	(H. Fraser)

BIOL 2089. The Importance of Intellectual Property in Biotechnology.
This course delves into the various roles of intellectual property in biotechnology. In addition to providing a solid foundation in the fundamentals of intellectual property, the course will use case studies in biotechnology to explore in depth the interplay between specific scientific breakthroughs and intellectual property. An understanding of the science of biotechnology is critical for advanced understanding of the value and possibilities of biotechnology intellectual property.

Fall	BIOL2089	S01	16597	W	4:00-6:30(10)	(D. Holmander)

BIOL 2091. Responsible Conduct of Research.
Responsible Conduct of Research is a course to develop, foster and maintain a culture of integrity in science and to empower researchers to hold themselves and others accountable to high ethical standards. Participants will be given the opportunity to review and discuss the most current and pressing matters related to research integrity with experts in the field. This course is restricted to first year PhD students within BioMed and overrides will be given to certain students outside of the BioMedical Division

BIOL 2110. Drug and Gene Delivery.
Topics in drug delivery systems including history of the field, advantages of controlled release technology, stabilization and release of proteins, fabrication methods, regulatory considerations, economic aspects, patents and intellectual property rights, and more. Prepares students for research in industry and academia, and offers information for consultants in the field. Expected: BIOL 1090, 1120; CHEM 0350, 0360.

BIOL 2117. Human Physiology.
For Brown-Pfizer Master of arts Program students. Provides an introduction to basic human physiological concepts along with more advanced coverage of selected systems. We'll start with topics of diffusion, cell physiology and the basis of cell membrane potential and then cover the nervous, endocrine, musculoskeletal, cardiovascular, respiratory, renal and gastrointestinal systems. We'll focus on normal human physiology and at times incorporate discussions of exercise physiology, pathophysiology, and specific physiologic scenarios to build toward the goal of understanding complex integration of function between cells, tissues and organ systems. Readings will consist of textbook chapters along with primary literature covering selected topics.

BIOL 2121. The Biochemistry of Signaling and Regulation from Prokaryotes to Eukaryotes.
Proteins are the engines of life. Determining how they function from a biophysical and biochemical perspective enables us to understand how they work and how we can direct and alter their activities. Proteins participate in cellular signaling pathways that are important regulators of cellular function and are often misregulated in disease. This course introduces various aspects of biochemistry involved in the analysis of cellular signaling pathways that regulate disease. Open to 12 graduate students and advanced undergraduates. Prerequisite: Students must have taken several advanced undergraduate-level courses in biology.

BIOL 2125. Bioinformatics for Evidence to Improve the Discovery, Development and Use of Medicines.
This course explores evidence used in decisions for discovery, development and use of medicines. Goals are i) learn issues and decision criteria for stakeholders in biomedical innovation, ii) understand challenges and emerging opportunities to improve the evidence used to make decisions over the life of a therapeutic, iii) apply this learning to develop a novel call for proposals for multi-stakeholder projects that integrate molecular and clinical knowledge for improving discovery, development and/or use of medicines for Parkinson’s disease or pancreatic cancer. Preference is given to graduate students in MPPB, Biotechnology and BME. Other qualified students may enroll with instructor's permission.

BIOL 2130. Techniques in Molecular and Cell Science.
This course provides hands-on laboratory training in state-of-the-art techniques in molecular and cellular sciences, and reinforces this training with didactic lectures that stress key principles, the quantitative approach and the most exciting applications of these technologies in the context of current research. Areas covered include cell culture, tissue engineering, DNA cloning, gene therapy, quantitative assays, microscopy and image analysis.

Enrollment is limited to 12; written permission required. Permission will be granted after the first class. Students MUST register for the lecture section and a lab.

BIOL 2135. Pharmacokinetics and Drug Design.
Consists of the absorption, distribution, metabolism, and elimination of drugs. These factors, including dosage, determine the concentration of drugs at its sites of action, and intensity of effects. Will examine models describing the relationship between plasma drug concentrations and therapeutic drug effect. Will acquire biologic sampling techniques, analytic methods for measurement of drugs and metabolites, and procedures facilitating data used in designing drugs and dosage regimens. Prerequisite: BIOL 0800 or equivalent. Enrollment limited to 20. Preference given to graduate students in Biotechnology and BME, especially Masters students. Graduate students (PhD and ScM) from other programs enroll if permission of instructor is granted.

Spr	BIOL2135	S01	25242	T	3:00-5:30(11)	'To Be Arranged'

BIOL 2140. Principles in Experimental Surgery.
An introduction to the principles and practice of surgery, sterile technique, anesthesia, and laboratory animal care. Intended to provide highly supervised, hands-on experience in techniques for humane handling and surgical management of experimental animal subjects. Emphasizes surgical technique, anesthesia technique, and laboratory animal medicine. Prerequisite: BIOL 0800. Limited to five (5) Graduate students only. Instructor permission required. Students MUST register for the lecture section and the lab.

BIOL 2145. Molecular Targets of Drug Discovery.
This course emphasizes the role of cell physiology in the identification of drug targets and the development of novel drugs. Specific protein drug targets such as G-protein coupled receptors will be examined in detail from identifying a target to development of drugs for that target and the physiological consequences. Prerequisite: BIOL 0800. Enrollment limited to 20. Preference is given to graduate students in Biotechnology and BME, especially Masters students. Graduate students from other programs may enroll if permission of the instructor is granted. Students must request an override code through C@B.

Spr	BIOL2145	S01	25493	T	10:00-12:30(09)	(D. Horrigan)

BIOL 2150. Scientific Communication.
Focused on the effective dissemination of scientific information in biological and biomedical research disciplines. Students will develop the skills necessary to effectively communicate scientific ideas, experiments, and results relating to their PhD dissertation projects through activities common to the profession including writing a grant proposal and presenting research work orally. Each of the activities will be dissected into key components and developed through interactive discussions and peer review. Required for most second-year PhD students in the MCB and Computational Biology Graduate Program. Other qualified PhD students may enroll with instructor's permission.

Fall	BIOL2150	S01	16235	Arranged		(G. Valdez)
Fall	BIOL2150	S02	16236	W	9:00-12:00(14)	(S. Ramachandran)

BIOL 2160. Analytical Methods in Biotechnology.
This course will cover principles and practical applications of important analytical tools used in the field of Biotechnology. Topics covered include spectroscopy, chromatography, and physical and chemical methods of characterization of a variety of molecules used for therapeutic applications. The molecules will range in size from traditional drugs with molecular weights of less than 1000, peptides and proteins as well as SiRNA and industrial polymers. This course is suitable for students intending on pursuing a career in biomedical research in academia or industry. Prerequisites: BIOL 0280, BIOL 1120, CHEM 0350/0360, or equivalent course. Enrollment limited to 20 Masters students in Biotechnology and BME.

BIOL 2167. In Vitro Models for Disease.
This course will use case studies to examine high burden diseases, their pathophysiology, treatment, and the models used to study the disease. Literature will be used to discuss the current models for the disease and the associated limitations of each of these models. The course will also cover the use of animals in research and how new in vitro models could be used to decrease their use. This course is intended for graduate students in biology, engineering, or related fields. Prerequisites: BIOL 0200 and 0800, or equivalent. Enrollment limited to 20 graduate students.

Spr	BIOL2167	S01	25495	M	10:00-12:30(03)	(J. Schell)

BIOL 2170. Molecular Pharmacology and Physiology.
Fundamental concepts in pharmacology and physiology from the cellular/molecular level to organ systems. Required of first-year graduate students in Molecular Pharmacology and Physiology. Students must request an override code through C@B.

Spr	BIOL2170	S01	25494	MWF	10:00-11:30(03)	(D. Horrigan)

BIOL 2180. Experiential Learning Industry, ELI.
Experiential Learning in Industry is restricted to biomedical engineering (BME) Sc.M. and biotechnology (Biotech) Sc.M. students, permission also required. The course is an extended in-depth learning experience in an industry environment related to the discipline of BME and Biotech. Industry environments include; medical device, pharmaceutical or biotechnology and industries that provide BME and Biotech relevant services to the aforementioned companies including patent law, licensing, regulatory and consulting. Students will pursue Experiential Learning in Industry during one summer plus one semester or during two semesters for which they will receive credit towards their degree. This course is restricted to BME and Biotech Masters students only. Students must have successfully completed the first year of the BME Masters Program. Slots are limited so permission is required.

Fall	BIOL2180	S01	16598	Arranged		(J. Schell)
Spr	BIOL2180	S01	25224	Arranged		(J. Schell)

BIOL 2190. MPP Professional Development Seminar.
Professional development seminar required of all first year graduate students in the Molecular Pharmacology and Physiology Graduate Program, and open to graduate students in other programs. Topics include grants and funding, effective oral presentation skills, alternative careers in science, and others. All students will be required to present a research seminar during the scheduled class time.

Instructor permission required for graduate students outside the Molecular Pharmacology and Physiology Graduate Program. Not intended for undergraduate students.

BIOL 2200D. Current Topics in Biochemistry: Biochemical Genomics.
A critical evaluation of current research in biochemistry and molecular biology focusing on the mechanism and regulation of transcription. Intensive reading, critical analysis, and discussion of the relevant literature in the context of student presentations in seminars. Advanced undergraduates with permission of the instructor. Enrollment limited 20 students. Instructor permission required.

BIOL 2210C. Current Topics in Molecular Biology: Cellular Quality Control Mechanisms.
Protein synthesis is a fundamental cellular process that is dependent upon the rapid and accurate synthesis of ten to twenty thousand ribosomes per generation to carry out the equally rapid and accurate synthesis of protein. Progress in understanding Ribosome structure and function, Ribosome evolution, Ribosome biogenesis and coordination of cell growth with cell division will be explored using the current literature with weekly student seminars and a final research proposal.

BIOL 2220. Topics in Signal Transduction.
Signal transduction is one of the most rapidly developing fields in biomedical sciences. Defects in signaling pathways can be responsible for diseases such as cancer, diabetes, cardiovascular disorders and psychoses. This course offers students an overview of the molecular pathways that allow cells to receive and process signals from their external environment, with an emphasis on the emerging state-of-the-art techniques used to study signal transduction events. The course will cover the basic molecular steps of receptor-mediated pathways used in signal transduction and a series of applications that will allow students to understand the complexity of this rapidly developing field of research. We will discuss new ideas, mechanisms of disease, and unsolved problems in signal transduction primarily through reading and critical analysis of recent primary literature. Expected background: BIOL 0200, 0280, 0470, or 0500 or other classes that cover similar content.

Fall	BIOL2220	S01	18511	W	3:00-5:30(10)	(E. Oancea)

BIOL 2222B. Current Topics in Functional Genomics.
A technological revolution in genomics has exponentially increased our ability to gather biological data. A host of new methods and types of analysis has arisen to accommodate this dramatic shift in data collection. The broad scope of inquiry has ushered in an era of “system-wide” approaches and brute-force strategies where rare signals can be detected and studied. In this seminar we will cover papers that embody this new approach. Students typically have taken an advanced undergraduate-level course in biology.

Spr	BIOL2222B	S01	25472	W	3:00-5:30(10)	(W. Fairbrother)

BIOL 2230. Biomedical Engineering and Biotechnology Seminar.
Biomedical engineering and biotechnology are interdisciplinary fields that incorporate progress in biomedical sciences, the physical sciences, and engineering. To achieve success in these fields requires facility with interdisciplinary oral communication – this is the specific and practical focus of this course. Each week, doctoral students in the Biomedical Engineering and Biotechnology Graduate Programs will give research presentations and receive feedback from the audience to help improve their public speaking skills.

Fall	BIOL2230	S01	16214	T	4:30-7:00(02)	(E. Darling)

BIOL 2240. Biomedical Engineering and Biotechnology Seminar.
See Biomedical Engineering and Biotechnology Seminar (BIOL 2230) for course description.

Spr	BIOL2240	S01	24945	T	4:00-6:30(16)	(J. Morgan)

BIOL 2245. Blood Substitutes: Principles and Therapeutics Development.
Blood serves many critical functions including respiratory gas transport, hemostasis and host defense. Plasma and cellular components of blood, their functional mechanisms, pathophysiologic consequencies when deficient and current treatments will be reviewed. Finally, development of blood component substitutive therapeutics (blood substitutes) based on protein and cellular engineering technologies (biotherapeutics) will be discussed. Open to Graduates students and Juniors and Seniors who meet the pre-requisites BIOL 0800 and BIOL 0280 or with instructor's permission.

BIOL 2250. Survey of Modern Therapeutics.
Survey of Modern Therapeutics examines the process of drug discovery, development, and approval from target selection to commercialization. The course will provide students with a broad overview of central background concepts in drug development including cellular physiology, target-drug interactions, and pharmacokinetics/pharmacodynamics. The course will examine the preclinical stages of the traditional small molecule drug discovery process, from initial target identification and validation, through assay development, high throughput screening, hit identification, lead optimization and the selection of a candidate drug. The course will also go through the process of bringing a therapeutic into clinical trials, through FDA approval, and to the market. Students will study some of the modern approaches in therapeutics including small molecules, biologics, vaccines, anti-infectives, and cell therapies and their applications. There are no prerequisites, but a background in biology, chemistry, or a related field is strongly encouraged. Students must request an override code through C@B.

Fall	BIOL2250	S01	18915	TTh	9:00-10:20(05)	(D. Horrigan)

BIOL 2260. Physiological Pharmacology.
The objective of this course is to present drugs in the context of the diseases they are used to treat. A list of the Common medically prescribed drugs will be discussed in terms of their fundamental modes of action and clinical importance. Pertinent background biochemistry, physiology, and pathology is provided, e.g., the electrophysiology of the heart is discussed as a background to anti-arrhythmic drugs. Course is relevant for students interested in medicine journalism, law, government, precollege teaching, biomedical research, and pharmacy. Expected: background in physiology. For graduate students ONLY register for BIOL 2260; all others BIOL 1260.

Fall	BIOL2260	S01	16922	Th	10:30-11:50(13)	(J. Marshall)
Fall	BIOL2260	S01	16922	TTh	10:30-11:50(13)	(J. Marshall)

BIOL 2270. Advanced Biochemistry.
(Undergraduate students should register for BIOL 1270.)

Fall	BIOL2270	S01	16229	TTh	2:30-3:50(12)	(A. Deaconescu)

BIOL 2290B. Mechanisms of Protein Synthesis and Impact on Human Disease.
This course will examine mechanisms central to the regulation of protein synthesis in both prokaryotes and eukaryotes. Targeting protein synthesis through ribosomes is a proven drug target commonly used to treat many infectious diseases. The regulation of protein synthesis in eukaryotes is critical for myriad human conditions including aging and cancer, including the recently discovered role of microRNAs. This course will explore the common and unique mechanisms of regulation of protein synthesis between prokaryotes and eukaryotes and the importance of understanding these mechanisms for human health. For graduate students and advanced undergraduates with permission.

BIOL 2290E. Signal Transduction.
This seminar course will provide a broad introduction to basic mechanisms of cell signaling from the extracellular environment to the nucleus of a cell, and to the mechanisms that regulate signal transmission. Topics of discussion will include: processing and modification of signaling molecules; signal recognition/ligand binding; co-receptors and receptor trafficking; intracellular relays; transduction to the nucleus; regulation of signal intensity and duration; feedback controls. Signal transduction pathways from several model systems will be examined and their relevance to development and disease will be considered. Senior undergraduates with permission of the instructors. Enrollment limited to 20.

BIOL 2300. Biomolecular Interactions: Health, Disease, and Drug Design.
Interactions between the molecules of life-proteins, RNA, DNA, membrane components-underlie all functions necessary for life. This course focuses on how nature controls these interactions, how these interactions can go awry in disease, and how we can learn the rules of these interactions to design drugs to treat disease. Students will review the physical basis of molecular interactions, learn classic and state-of-the-art high-resolution and high-throughput tools used to measure interaction, and survey the experimental and computational strategies to harness these interactions using a case study in rational drug design. Prerequisite: Introductory Biochemistry. Enrollment limited to 20; instructor permission.

BIOL 2310. Developmental Biology.
Covers the molecular and cellular events of development from fertilized egg to adult. Genetic basis of body form, cell fate specification and differentiation, processes controlling morphogenesis, growth, stem cells and regeneration are examined. Differential gene regulation, intercellular signaling and evolutionary conversation are central to discussion of mechanisms governing developmental processes. Additional topics: developmental plasticity, impact of epigenetic and environmental factors, and basis of disease gleaned from developmental biology research. Live embryos complement and reinforce concepts covered in class. Expected: BIOL0200 (or equivalent), and one course in genetics, embryology, cell biology or molecular biology. Enrollment limited to 36. (Undergraduate students register for BIOL 1310.)

Fall	BIOL2310	S01	16925	TTh	9:00-10:20(05)	(K. Wharton)

BIOL 2320E. Genetic Control of Cell Fate Decisions.
A cell's fate is acquired in a process whereby largely uncommitted progenitor cells are instructed down a committment path that ultimately results in a specific cell type with distinct molecular and physiological properties. This process is critical for the establishment of all cell types and tissues and is poised to be a critical topic in cell-based therapeutic strategies. We will investigate the intrinsic and extrinsic mechanisms that manifest at the genetic level to impart cell fate decisions on progenitors. Advanced undergraduates with permission of the instructor.

BIOL 2340. Neurogenetics and Disease.
Genetic mutations provides a powerful approach to dissect complex biologic problems. We will focus on fascinating discoveries from "forward genetic" studies – moving from nervous system phenotype to genetic mutation discovery. There will be an emphasis of neurologic disease phenotypes and the use of novel genomic methods to elucidate the central molecular and cellular causes for these conditions. The course will emphasize the use of "reverse genetics" – engineered mutations in model systems – to dissect nervous system function and disease mechanisms. Disorders to be covered include autism, intellectual disability, schizophrenia, epilepsy. Enrollment limited to 20. Instructor permission required.

BIOL 2350. The Biology of Aging.
Aging is a fundamental biological process. It is the major risk factor for age-related diseases such as cancer, cardiovascular disease, stroke, osteoporosis, arthritis and Alzheimer's, just to name a few. As life expectancy has increased in the 20th century, these diseases have become the leading causes of death. Recent research has identified universal mechanisms that regulate organismal aging and impact all organ systems. Several gene networks that can regulate the rate of aging and multiple age-related diseases have already been discovered. These mechanisms are conserved throughout evolution and many key insights have been garnered from simple model organisms. Manipulation of these networks has been achieved by diet, genetic engineering, and most recently, with drugs. The goal of modern medicine is to increase healthy survival, as opposed to simply longevity. It is now generally acknowledged that increasing health span – the fraction of our life spans free of frailty and debilitating chronic disease – has become a realistic goal. This course will examine the new concept of "geroscience" – the molecular, cellular, and genetic foundations of the biology of aging, and how this knowledge can be applied to therapies for age-associated diseases. Course material will be based on the primary research literature. Prerequisites are a background in cell biology, molecular biology and genetics - such as BIOL0470, BIOL0280, BIOL0200, and BIOL0800.

Spr	BIOL2350	S01	25002	Th	2:00-5:00(11)	(M. Tatar)

BIOL 2430. Topics in Ecology, Evolution and Organismal Biology.
Current literature in ecology, behavior, and evolutionary biology is discussed in seminar format. Topics and instructors change each semester. Representative topics have included: structuring of communities, biomechanics, coevolution, quantitative genetics, life history strategies, and units of selection. Expected: courses in advanced ecology and genetics.

Fall	BIOL2430	S01	16289	M	3:00-5:30(03)	(M. Fuxjager)
Fall	BIOL2430	S02	17398	F	1:30-4:00(11)	(M. Fuxjager)

BIOL 2440. Topics in Ecology, Evolution and Organismal Biology.
See Topics In Ecology And Evolutionary Biology (BIOL 2430) for course description.

Spr	BIOL2440	S01	25025	M	3:00-5:30(13)	'To Be Arranged'
Spr	BIOL2440	S02	26272	F	1:30-4:00(13)	'To Be Arranged'

BIOL 2450. Exchange Scholar Program.

Fall	BIOL2450	S01	16083	Arranged		'To Be Arranged'
Fall	BIOL2450	S02	16084	Arranged		'To Be Arranged'
Spr	BIOL2450	S01	24839	Arranged		'To Be Arranged'

BIOL 2528. Innovation and Commercialization in Medical Devices, Diagnostics, and Wearables.
This course provides a comprehensive overview of concepts and steps involved in developing and commercializing novel technology/scientific breakthroughs for medical devices, diagnostics and wearables. This course is particularly suitable for students interested in pursuing a career within a medical device segment, or creating innovation-based companies, as well as for those interested in developing an in-depth knowledge of evolution of medical devices from research concepts to products in the market.

Spr	BIOL2528	S01	25225	Th	9:30-12:00(05)	(M. Analoui)

BIOL 2530. Immunology.
In this course, we will explore the biology of the mammalian immune system to gain an understanding and appreciation of its importance and complexity. Together, we will learn the experimental and theoretical foundations of immunology. Topics include innate and adaptive immunity; anatomy of immune organs and tissues, structure/function of antibody molecules and T cell receptors; cytokine response, development and maturation of immune cells, and regulation of immune responses through cellular interactions. We will investigate the cells and chemicals that make up each branch of the immune system and learn how cells communicate with each other. Clinically significant issues such as vaccinations, transplantation, inflammation, autoimmunity, cancer, and immunodeficiency like HIV/AIDS infection will be discussed. This course will introduce students to primary literature where interpretative analysis of experimental data will be emphasized.

BIOL 2540. Molecular Genetics.
Even in this era when whole genome DNA sequencing has become routine, there are still thousands of eukaryotic genes with unknown functions. Genetic screens for mutations that alter pathways of interest remain the premier approach to understanding gene function in the context of the organism. In Molecular Genetics students will learn the key concepts involved in designing and interpreting genetic screens using the powerful tools available in model animal, plant, and fungal organisms. Students will also learn how to understand and analyze results presented in the primary scientific literature. Furthermore, students will gain an appreciation of how the field of genetics has changed through discoveries and technological advances made over the past 50 years. Undergraduate students should register for BIOL 1540.

Spr	BIOL2540	S01	24997	TTh	2:30-3:50(11)	(Y. Huang)

BIOL 2545. Human Genetics and Genomics.
This course will exemplify the power of genetically informed approaches to understanding human biology. It is intended for advanced undergraduate students and graduate students; prerequisites include BIOL0470 or equivalent. The course is based in lectures, reading material (textbook and primary literature), and in-class discussions. Course topics include: medical genetics and genomics; methods to study human genotypes and related phenotypes; industry-related topics; and ethical and societal implications of genome science. It will benefit students with career interests in basic science, medicine, biotechnology, or science policy. Enrollment is limited to 20 students; selection will be based on seniority, prerequisites, and registration order.

Spr	BIOL2545	S01	24999	W	3:00-5:30(10)	(E. Morrow)

BIOL 2560. Advanced Virology.
The emphasis of this course will be on understanding the molecular mechanisms of viral pathogenesis. It will begin with a general introduction to the field of virology, a basic review of the immune response to viruses, and then focus primarily on the molecular biology of specific viruses that are associated with clinical human disease. Lectures will be based on the current literature and provide historical context. Students will become familiar with primary literature and produce their own original research proposal by the end of the semester.

Fall	BIOL2560	S01	16207	MWF	9:00-9:50(09)	(A. Jamieson)

BIOL 2565. Advanced Virology for Biotechnology.
The emphasis of this course will be on understanding the molecular mechanisms of viral pathogenesis. It will begin with a general introduction to the field of virology, a basic review of the immune response to viruses, and then focus primarily on the molecular biology of specific viruses that are associated with clinical human disease. The format will be 100% online and consist of both lectures and in-class work in small groups. Lectures will be based on the current literature and provide historical context. Students will become familiar with primary literature and produce their own original final project by the end of the semester.

Fall	BIOL2565	S01	18873	Arranged		(A. Jamieson)

BIOL 2595. Artificial Intelligence in Biomedicine.
This course will teach the fundamental theory and methods of artificial intelligence (AI) alongside their application to the biomedical domain. It will give a representative overview of traditional methods as well as modern developments in the areas of (deep) machine learning, natural language processing and information retrieval. The course is designed to be accessible to non-computer science audiences and will not require extensive prior programming experience. The course will be accompanied by practical assignments applying the discussed techniques in a biomedical context. Understanding of formal theoretical knowledge will be assessed in a final exam.

BIOL 2640A. Viral Immunology.
Viral Immunology is an advanced topics course in Microbiology and Immunology which will be focused on viral immunology. Weekly meetings will cover different issues concerning defense against viral infections and pathology related to viral infection, with focus on viral-host interactions. Topics will be selected to present either important basic concepts in the context of immune responses and/or major challenges in controlling viral infections. Recent advances in understanding virus-host interactions, host responses to viruses, cytokine regulation of immune responses or cytokine-mediated pathology during viral infections will be emphasized. The 2020 organizational meeting is set for Wednesday, Jan. 22 at 3:00PM (BMC 6th Floor Conference Room - Room 603). There is also a requirement for a previous immunology course.

BIOL 2640B. Microbial Pathogenesis.
Examines microbial pathogens and the underlying mechanisms by which infectious organisms cause diseases. Bacterial, fungal, protozoal and viral pathogens will be studied using tools of modern biology. Also examined are the host's immune responses to infection and disease. Areas covered include mechanisms of pathogen internationalization and survival, immune responses, signal transduction and pathophsiology. Expected: BIOL 0510, 0530, or 1550.

BIOL 2640C. The Immune System.
Introduction to the experimental and theoretical foundations of immunology and the function of the mammalian immune system. Focuses on concepts, landmark experiments and recent advances. Topics include innate and adaptive immunity; structure/function of antibody molecules and T cell receptors; and regulation of immune responses through cellular interactions. Application of concepts to medically significant issues (vaccines, transplantation, hypersensitivity, autoimmunity, cancer, immunodeficiency) is discussed. Interpretative analysis of experimental data is emphasized. Activities include written assignments that analyze a hypothetical immune system and a final paper addressing an immunological topic of the student's choosing. For Pfizer students only.

BIOL 2850. Introduction to Research in Pathobiology.
Introduces incoming pathobiology graduate students with research opportunities in the laboratories of program faculty. Consists of seminars with individual faculty members in the graduate program in pathobiology. Required background reading of recent papers lead to a discussion of current research in the faculty member's laboratory. Additional discussions include safety and ethical issues in research. Open only to first-year graduate students in the program in pathobiology.

BIOL 2860. Molecular Mechanisms of Disease.
Dr. Bartnikas' goal for this class is to teach first-year graduate students what he wishes he would have been taught and what he wished he would have known as a first-year graduate student. This will be accomplished by studying several human diseases and designing experiments to better understand their mechanistic and molecular basis. (Diseases will be chosen out of a series of options by students early in the semester.) The class will consist of didactic lectures, discussions, small group work, and group presentations. Active participation by all students will be encouraged. Students should have a solid background in the life sciences with an understanding of the fundamental principles of molecular biology, genetics, biochemistry, and cell biology. Readings will be assigned from Robbins Basic Pathology (2018), Junqueira's Basic Histology Text & Atlas (2018), primary literature, and reviews. Both textbooks are available online through the library website. Upper-level undergraduates require permission to take the course and will be admitted to the class if space allows.

Fall	BIOL2860	S01	16215	MW	1:00-2:30(08)	(T. Bartnikas)

BIOL 2865. Toxicology.
Toxicology is the science that describes the adverse biological effects of exogenous chemical and physical stressors, including environmental, industrial, and agricultural chemicals and pharmaceuticals. This course will introduce the principal biological processes that determine an organism's response to a toxicant, including absorption, distribution through a biological system, metabolism, elimination, and effects at the site(s) of action. We will discuss modern challenges in toxicology, such as assessing toxicity of mixtures and testing some of the thousands of untested chemicals in commerce. The material will be presented in lecture and student-led discussions, with readings from the toxicology literature.

Spr	BIOL2865	S01	24944	TTh	1:00-2:20(08)	(D. Spade)

BIOL 2970. Preliminary Examination Preparation.
For graduate students who have met the tuition requirement and are paying the registration fee to continue active enrollment while preparing for a preliminary examination.

Fall	BIOL2970	S01	16085	Arranged		'To Be Arranged'
Spr	BIOL2970	S01	24840	Arranged		'To Be Arranged'

BIOL 2980. Graduate Independent Study.
Independent study projects at the graduate level. Section numbers vary by instructor. Please check Banner for the correct section number and CRN to use when registering for this course.

BIOL 2985. Graduate Seminar.
Section numbers vary by instructor. Please see the registration staff for the correct section number to use when registering for this course.

BIOL 2990. Thesis Preparation.
For graduate students who have met the residency requirement and are continuing research on a full time basis.

Fall	BIOL2990	S01	16086	Arranged		'To Be Arranged'
Spr	BIOL2990	S01	24841	Arranged		'To Be Arranged'

BIOL 2995. Thesis.
Section numbers vary by instructor. Please see the registration staff for the correct section number to use when registering for this course.