

# BIOLOGY (BIOL)

## **BIOL 101. Biological Concepts. 3 Hours.**

Semester course; 3 lecture hours (delivered online, face-to-face or hybrid). 3 credits. A topical approach to basic biological principles. Topics include molecular aspects of cells, bioenergetics, photosynthesis, cellular respiration, cellular and organismal reproduction, genetics and evolution, and ecology. Not applicable for credit toward the major in biology.

## **BIOL 103. Global Environmental Biology. 3 Hours.**

Semester course; 3 lecture hours (delivered online). 3 credits. This course engages students in understanding biological systems through aspects of global change in the Earth's environment. Global change is explored through the perspective of a biologist in association with social and economic concepts. Topics include climate change, population biology, ecosystems, urbanization, renewable and nonrenewable energy, air and water resources and sustainability goals. Assessments and applied activities reinforce major course concepts. Not applicable as a prerequisite for any biology course at the 200 level or higher nor for credit toward the B.S. in Biology.

## **BIOL 151. Introduction to Biological Sciences I. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 139, MATH 141, MATH 151, MATH 200, MATH 201 or a satisfactory score on the math placement exam; and CHEM 100 with a minimum grade of B, CHEM 101 with a minimum grade of C or a satisfactory score on the chemistry placement exam. Introduction to core biological concepts including cell structure, cellular metabolism, cell division, DNA replication, gene expression and genetics. Designed for biology majors.

## **BIOL 152. Introduction to Biological Sciences II. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151 and CHEM 101, both with a minimum grade of C. Focuses on evolutionary principles, the role of natural selection in the evolution of life forms, taxonomy and phylogenies, biological diversity in the context of form and function of organisms, and basic principles of ecology. Designed for biology majors.

## **BIOL 200. Quantitative Biology. 3 Hours.**

Semester course; 3 lecture hours (delivered online or hybrid). 3 credits. Prerequisites: BIOL 151 and BIOZ 151 with minimum grades of C; and MATH 151, MATH 200, MATH 201, STAT 210 or satisfactory score on the VCU Mathematics Placement Test within a one-year period immediately preceding the beginning of the course. Enrollment is restricted to biology majors and biology minors. An introduction to the application of the scientific method, experimental design and quantitative aspects of biology.

## **BIOL 201. Human Biology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 101, 151, or 152, or BIOL/ENVS 103. Fundamentals of human biology, including the structure, function and disorders of human body systems, principles of human genetics and inheritance, human evolution, and the interaction of humans with the environment. Not applicable for credit toward the B.S. in Biology.

## **BIOL 205. Basic Human Anatomy. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours (delivered online or face-to-face, plus an online component). 4 credits. Prerequisites: BIOL 101 and BIOZ 101, BIOL 151 and BIOZ 151, or BIOL 152 and BIOZ 152, each with a minimum grade of C. Enrollment is restricted to students majoring in communication arts, health and physical education, exercise physiology, health, physical education and exercise science; pre-health majors in medical laboratory sciences, clinical radiation sciences, dental hygiene and nursing; students enrolled in the health sciences certificate program; and students in pre-occupational therapy, pre-physician assistant, pre-pharmacy, pre-physical therapy, pre-dentistry and pre-optometry minors. Human specimens, models and other in-person and online resources are used to study the human body using a regional approach in order to integrate functions across organ systems. Not applicable for credit toward the B.S. in Biology.

## **BIOL 209. Medical Microbiology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 101 and BIOZ 101, BIOL 151 and BIOZ 151, or BIOL 152 and BIOZ 152, each with a minimum grade of C. General principles of microbiology and immunology to provide a thorough understanding of the host-microbe relationship in disease. Not applicable for credit toward the B.S. in Biology.

## **BIOL 217. Principles of Nutrition. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 101, 151 or 152 with a minimum grade of C, or BIOL/ENVS 103 with a minimum grade of C. An introduction to basic principles of nutrition and their application in promoting growth and maintaining health throughout the life cycle. Not applicable for credit toward the B.S. in Biology.

## **BIOL 284. Laboratory Assistant Experience. 0 Hours.**

Semester course; 0 hours. 0 credits. Enrollment is restricted to students with permission of the departmental chair and limited to students for whom a laboratory supervisor has agreed to mentor their laboratory assistantship. Helps facilitate student involvement in research laboratories within the Department of Biology. Students will assist with components of the laboratory's operation and gain experience working in a laboratory setting. Students will gain hands-on experience in performing tasks related to specific research areas based on the laboratory in which they are accepted to work. Graded as pass/fail.

## **BIOL 291. Topics in Biology. 1-4 Hours.**

Semester course; variable hours. Variable credit. Prerequisites: BIOL 151, 152 and BIOZ 151, 152, with minimum grades of C. A study of a selected topic in biology. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

## **BIOL 300. Cellular and Molecular Biology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151 and 152; BIOZ 151 or LFSC/BNFO 251; BIOZ 152 or LFSC/BNFO 252; CHEM 101 and CHEZ 101, all with a minimum grade of C; BIOL 200, MATH 200, MATH 201, STAT 210, STAT 212 or STAT 314. Biology majors must have completed BIOL 200. Pre- or corequisites: CHEM 102 and CHEZ 102. A study of the molecular biology of the cell as it relates to gene expression, cell signaling, and cell growth and differentiation.

## **BIOL 303. Microbiology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 300 with a minimum grade of C. The morphological, biochemical, taxonomic, genetic and evolutionary characteristics of microorganisms with a primary focus on bacteria. Focuses on the structural, mechanical and biochemical adaptations employed by microorganisms in their interactions with host cells and substrates.

**BIOL 304. Biology Skills. 3 Hours.**

Semester course; 1 lecture, 3 laboratory and 1 recitation hour (delivered face-to-face or hybrid). 3 credits. Prerequisites: BIOL 151 and BIOZ 151. The course provides hands-on experience in laboratory-based research using current biological and/or biomedical research topics to aid in development of critical thinking and problem-solving.

**BIOL 307. Aquatic Ecology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 317, CHEM 102 and CHEZ 102, with minimum grades of C. The physical, chemical and especially the biological aspects of freshwater ecosystems.

**BIOL 308. Vertebrate Histology. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisite: BIOL 300 with a minimum grade of C. Microanatomy of vertebrate cells, tissues and organs and the relationship of structure to function. Laboratory work involves an in-depth study of vertebrate microanatomy at the light microscope level as well as an introduction to techniques used for the preparation of materials for histological study.

**BIOL 309. Entomology. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisites: BIOL 151 and BIOZ 151; BIOL 152 and BIOZ 152, all with minimum grades of C. A field-based course that focuses on insect diversification, identification, natural history and basic biology.

**BIOL 310. Genetics. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151 and 152; BIOZ 151 or LFSC/BNFO 251; BIOZ 152 or LFSC/BNFO 252; BIOL 300; CHEM 101; and CHEZ 101, each with a minimum grade of C; and BIOL 200, MATH 200, MATH 201, STAT 210, STAT 212 or STAT 314. Biology majors must have completed BIOL 200. Concurrent prerequisites: CHEM 102 and CHEZ 102. The basic principles of molecular and applied genetics of plants, animals and microorganisms.

**BIOL 312. Invertebrate Zoology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151 and BIOZ 151; BIOL 152 and BIOZ 152, all with minimum grades of C. An integrative survey of the invertebrate animals with emphasis on systematics and natural history.

**BIOL 313. Vertebrate Natural History. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151, 152 and BIOZ 151, 152, with minimum grades of C. The natural history of vertebrates with emphasis on the species native to Virginia.

**BIOL 314. Animal Reproduction. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL and BIOZ 151, BIOL and BIOZ 152, and BIOL 300, each with a minimum grade of C. Introduction to basic reproductive anatomy and physiology. Examination of the basic factors that affect reproductive performance and how these factors are used to regulate the reproductive processes of domestic animals and humans.

**BIOL 317. Ecology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151 and 152; BIOZ 151 or LFSC/BNFO 251; BIOZ 152 or LFSC/BNFO 252; CHEM 101 and CHEZ 101, all with a minimum grade of C; BIOL 200, MATH 200, MATH 201, STAT 210, STAT 212 or STAT 314. Biology majors must have completed BIOL 200. An introduction to the basic principles of ecology, including interactions among organisms and influences of the physical environment.

**BIOL 318. Evolution. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151 and 152; BIOZ 151 or LFSC/BNFO 251; BIOZ 152 or LFSC/BNFO 252; CHEM 101 and CHEZ 101, all with a minimum grade of C; BIOL 200, MATH 200, MATH 201, STAT 210, STAT 212 or STAT 314. Biology majors must have completed BIOL 200. An exploration of the theoretical and empirical foundations of evolutionary biology with a focus on the processes driving evolutionary change across all of life.

**BIOL 320. Biology of the Seed Plant. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisites: BIOL 151 and BIOZ 151; and BIOL 152 and BIOZ 152, all with minimum grades of C. The physiology, structure and adaptation of seed plants.

**BIOL 321. Plant Development. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 300 with a minimum grade of C. This course will discuss the mechanisms underlying plant development. Lectures and readings will explain the patterns in plant development from a morphological and molecular standpoint.

**BIOL 322. Plants, People and Culture. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151, BIOZ 151, BIOL 152 and BIOZ 152, or equivalents, with minimum grades of C. Plant-human interactions are deeply intertwined and have significant impact on our societies, environment and future. Plants are harnessed to provide us with clothing, food, housing, medicine, recreation, jobs, clean air, clean water, etc. This course provides basic understanding of plant morphology, anatomy and growth by examining the biology, ecology, history and current events of economically useful plants. Students read primary literature, communicate scientific findings and synthesize information from multiple sources verbally and in written format.

**BIOL 324. Medicinal Botany. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151 and BIOZ 151; BIOL 152 and BIOZ 152; and BIOL 300, all with a minimum grade of C. Topics include plant anatomy, morphology and reproduction; traditional plant medicine such as Ayurveda and traditional Chinese medicine; plant defense systems and secondary metabolites; and plant-derived drugs for various illnesses/ailments including cancer, arthritis, depression and diabetes.

**BIOL 325. Fungal Biology. 3 Hours.**

Semester course; 2 lecture and 3 laboratory hours. 3 credits. Prerequisite: BIOL 300 with a minimum grade of C. The basic biology of fungi, including growth, structure, genetics, diversity, the commercial uses of fungi and their importance as model organisms. Also discusses the interactions between fungi and plants and fungi and humans.

**BIOL 330. Community Science: \_\_\_\_\_. 3 Hours.**

Semester course; 1 lecture hour (delivered online) and 4 laboratory hours. 3 credits. May be repeated with a different topic for a maximum of six credits. Prerequisites: BIOL 152, BIOZ 152 and BIOL 200, each with a minimum grade of C. A comprehensive study of select topics that is integrated with community science. Students will contribute to local, national and/or global community science projects while gaining experience in data collection, data analysis and topic-specific protocols.

**BIOL 332. Environmental Pollution. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: eight credits in biology. The study of pollution in the environment with emphasis on the procedures for detection and abatement. Crosslisted as: ENV 330.

**BIOL 333. Evolution of the Angiosperms. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151, 152 and BIOZ 151, 152, all with minimum grade of C. Application of evolutionary concepts to flowering plants. Topics include speciation concepts, evolution of vegetative and sexual characteristics and an overview of angiosperm diversity to the level of family.

**BIOL 335. Global Change Biology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151, BIOL 152, BIOZ 151 and BIOZ 152, all with minimum grade of C. Examines how humans influence biological systems and explores what can be done to adapt to or to mitigate future global change, emphasizing anthropogenic climate change.

**BIOL 340. Development and Stem Cells. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 300 and CHEM 102, each with a minimum grade of C. Basic principles of developmental biology and stem cells of vertebrates, pinpointing the underlying cellular and molecular mechanisms that guide development and stem cell biology. Significant emphasis on medical aspects of development such as human birth defects, cloning, properties of stem cells and their medical uses, and careers in developmental and stem cell biology.

**BIOL 341. Human Evolution. 4 Hours.**

Semester course; 3 lecture and 2 laboratory hours (delivered online of face-to-face). 4 credits. Prerequisite: UNIV 200 or HONR 200 with a minimum grade of C. Introduces the range of human diversity as well as a broad understanding of evolution and evolutionary biology, particularly as it applies to hominid evolution. Specific topics include basic genetics, primatology, paleontology and the hominin fossil record. Crosslisted as: ANTH 301.

**BIOL 351. Introduction to Bioinformatics. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BNFO 201 and BNFO 300 or permission of instructor. The course will present a practical and theoretical introduction to the tools and techniques needed to obtain and interpret a variety of genome-related data types. The course will include several bioinformatic methods underlying nucleotide and protein sequence alignment, statistical methods for data visualization in R, the types of experimental results commonly encountered in bioinformatics data analysis and the public databases where these data can be accessed. Crosslisted as: BNFO 301.

**BIOL 391. Topics in Biology. 1-4 Hours.**

Semester course; 1-4 lecture hours. 1-4 credits. Prerequisites: BIOL 152 and BIOZ 152; and BIOL 300, BIOL 310, BIOL 317 or BIOL 318, each with a minimum grade of C. A study of a selected topic in biology. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

**BIOL 392. Introduction to Research. 2 Hours.**

Semester course; 2 lecture hours. 2 credits. Prerequisites: BIOL 151, BIOZ 151, BIOL 152 and BIOZ 152, each with a minimum grade of C. Dive into the dynamic world of scientific research with this engaging and interactive course! Through a project-based approach, students will craft their own research proposal while gaining a deep understanding of the research process. By the end of the course, students will be adept at critically evaluating scientific information and grasp the intricate, interdisciplinary nature of science. While developing critical thinking skills and exploring the ethical dimensions of research, students will gain insights from guest speakers who bring real-world research careers to life. This course will illuminate how science intersects with and impacts society, preparing students to begin their own research journey with a faculty mentor. Ideal for sophomores and juniors, the course also fulfills the NSF and NIH guidelines for Responsible Conduct of Research training for undergraduates.

**BIOL 395. Directed Study. 1-2 Hours.**

Semester course; 3-6 independent study hours. 1-2 credits. May be repeated for a maximum of two credits. Prerequisites: BIOZ 151 and BIOZ 152, each with a minimum grade of C. Enrollment is restricted by permission of the Department of Biology and faculty mentor. A maximum of two credits may be earned between BIOL 395 and BIOZ 395; a maximum total of six credits for all research and internship courses (BIOL 395, BIOL 451, BIOL 453, BIOL 492, BIOL 493, BIOL 494, BIOL 495, BIOZ 395 and/or BIOZ 493) may be applied to the 40 credits of biology required for the major. Additional credits from these courses may be applied to upper-level and open elective credits toward the degree. Students undertake a biologically relevant project in collaboration with a VCU faculty member. The nature of the project is defined through an agreement between the student and the mentor. It must involve hands-on learning and may include directed readings, experimental work or advanced guided inquiry, all under the faculty member's supervision. Students will develop a final deliverable showcasing their project's scope and outcomes, with the form and content varying according to the project's focus. To receive credit, students must engage in a minimum of three hours of supervised activity per week, per credit hour. Graded as pass/fail.

**BIOL 401. Applied and Environmental Microbiology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 152, BIOZ 152 and BIOL 300, each with a minimum grade of C. Introduction to the diversity of microorganisms in natural environments and the ways they can be manipulated and controlled for human advantage. Students gain foundational knowledge of microbial energetics, growth and community dynamics, which is then applied to understanding microbial roles in biogeochemical cycling, climate change, agriculture, public health, wastewater treatment and landfills. The course also covers applied topics such as biotechnology, pollution control and food production.

**BIOL 402. Comparative Vertebrate Anatomy. 5 Hours.**

Semester course; 3 lecture and 4 laboratory hours. 5 credits. Prerequisites: BIOL 300 and BIOL 318, each with a minimum grade of C. The evolution of vertebrate forms as demonstrated by anatomical studies of selected vertebrate types.

**BIOL 403. Primatology. 4 Hours.**

Semester course; 3 lecture and 2 laboratory hours (delivered online or face-to-face). 4 credits. Prerequisite: ANTH 210 or ANTH 301/BIOL 341. Primatology investigates the taxonomic relationships among primates through comparative anatomy, comparative behavior and comparative biochemistry. Study of primate evolution, demography, subsistence, reproduction, social organization, communication systems and ecology. Crosslisted as: ANTH 403.

**BIOL 411. Physiology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 300 and CHEM 301, each with a minimum grade of C. Focuses on the characterization and understanding of the function and mechanisms of major physiological systems, primarily using human physiology as a model. Emphasis is placed on understanding how different physiological systems work together to maintain homeostasis and predicting the consequences of damaging or deleting system components that can occur in diseases and injuries.

**BIOL 413. Parasitology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 300 with a minimum grade of C. The epidemiology and pathological effects of eukaryotic parasites, including parasite life cycles and host-parasite relationships.

**BIOL 415. Mangrove Avian Field Ecology. 4 Hours.**

Semester course; two weeks abroad in Panama (or other tropical location with mangrove forests) followed by class meetings two days per week throughout most of spring semester. 4 credits. Prerequisite: BIOL 317. An immersive study of tropical ecology with a focus on bird ecology and conservation of mangrove ecosystems through a unique blend of rigorous science and community engagement. Two weeks of study abroad, including engagement with local conservation organizations and participation in education outreach with local schools, followed by discussion, data analysis and presentation of progress and research in a public symposium on campus.

**BIOL 416. Ornithology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 317 with a minimum grade of C. Provides an integrative study of birds, including avian evolution and diversity, general anatomy and physiology, behavior, and ecology.

**BIOL 417. Mammalogy. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisites: BIOL 218 and 317 with minimum grades of C. Study of the characteristics, adaptive radiation and distribution of mammals, with emphasis on North American forms.

**BIOL 420. Yeast and Fermentation. 3 Hours.**

Semester course; 2 lecture and 3 laboratory hours. 3 credits. Prerequisite: BIOL 300 with a minimum grade of C. Concurrent prerequisites: BIOL 303 and BIOL 310. Addresses the basic biology of yeast used in brewing beer and briefly in wine production. Topics will include yeast properties such as growth, structure, genetics, biodiversity and natural habitats. The process of wine and beer production will be discussed. Laboratory sessions include basic microbiology techniques, yeast isolations and characterization using DNA and biochemical methods, as well as the study of factors that affect fermentation. At the end of the course the students will give a presentation on other fermentation products of their interest such as vinegar, bread, etc., providing an expanded version of this important process.

**BIOL 422. Forest Ecology. 4 Hours.**

Semester course; 3 lecture hours and 3 laboratory hours. 4 credits. Prerequisite: BIOL 317 with a minimum grade of C. Covers the fundamentals of forest ecology, with a particular emphasis on Virginia's diverse forest ecosystems. Students gain an understanding of the principal controls on forest structure, growth and distribution and relate these principles to sustainable forest management.

**BIOL 423. Plant Physiology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151 and BIOZ 151; BIOL 152 and BIOZ 152; and BIOL 300 or equivalents, all with minimum grades of C. Physiology of higher plants at molecular, cellular and organism level. Topics include transport processes, metabolism, growth, stress responses and plant-soil interactions.

**BIOL 425. Field Botany. 3 Hours.**

Semester course; 1 lecture hours and 4 laboratory hours (40 percent online, 60 percent field/laboratory). 3 credits. Prerequisites: BIOL 152, BIOZ 152 and BIOL 200; and BIOL 300, BIOL 310, BIOL 317 or BIOL 318. Online discussions, reflections and assessments in conjunction with field experience. Explores the effects of environmental conditions on plant morphology and adaptations, with emphasis on plant anatomy, plant physiology and plant diversity.

**BIOL 430. Invasion Biology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151, BIOL 152, BIOZ 151, BIOZ 152 and BIOL 317, all with minimum grade of C. A comprehensive view of the ecology and impacts of invasive species. Integrates the effects of historical human demography, ecological disturbance, natural history, species interactions, barriers to invasion, invasive species management and impacts on natural communities and ecosystems.

**BIOL 431. Introduction to Marine Biology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 317, CHEM 102 and CHEZ 102, with minimum grades of C. An introduction to physical, chemical and geological oceanography and a more detailed treatment of the organisms and ecological processes involved in the pelagic and benthic environments of the world's oceans and estuaries.

**BIOL 435. Herpetology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 317 with a minimum grade of C. The evolution, ecology, structure, taxonomy and behavior of reptiles and amphibians.

**BIOL 438. Forensic Molecular Biology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 310 with a minimum grade of C. Provides an understanding of molecular biology testing methodologies as applied to analysis of forensic samples. Current topics in forensic DNA analysis will include quality assurance, DNA databanking, contemporary research and population genetics. Crosslisted as: FRSC 438.

**BIOL 440. Developmental Biology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 300 and 310, each with a minimum grade of C. Basic principles of developmental biology focused on vertebrate model organisms with an emphasis on the underlying cellular and molecular mechanisms that guide development.

**BIOL 445. Neurobiology and Behavior. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisite: BIOL 317 with a minimum grade of C. The study of animal behavior stressing ecological, evolutionary and neurobiological approaches.

**BIOL 448. Neuroscience. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 300 with a minimum grade of C. Concurrent prerequisite: BIOL 310. An examination of the basic structure of the nervous system, nervous system operation on a cellular and molecular level and the formation of the nervous system during development.

**BIOL 449. Stem Cells in Disease and Therapy. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 152, BIOZ 152 and BIOL 300, each with a minimum grade of C. BIOL 310 and BIOL 340 recommended. Advanced stem cell biology with emphasis on the role of stem cells in human disease and regenerative medicine. Topics include the history of stem cell research; the generation of pluripotent stem cells; the role of adult stem cells in disease and genetic disorders; the use of genetic engineering in stem cell-based curative gene therapy; and discussions of the ethical issues related to stem cell use in regenerative medicine.

**BIOL 450. Biology of Cancer I. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 300 with a minimum grade of C or PHIS 309. An examination of the cellular, molecular and clinical aspects of cancer development, progression and treatment.

**BIOL 451. Biology of Cancer II. 4 Hours.**

Semester course; 1 lecture and 12 research hours. 4 credits. Prerequisite: BIOL 450. Enrollment is restricted by permission of the instructor and faculty mentor. A maximum of six credits for all research and internship courses (BIOL 395, BIOL 451, BIOL 453, BIOL 492, BIOL 493, BIOL 494, BIOL 495, BIOZ 395 and/or BIOZ 493) may be applied to the 40 credits of biology required for the major. Additional credits from the courses may be applied to upper-level and open elective credits toward the degree. Under the mentorship of a VCU faculty member, students will engage in an examination of the cellular, molecular and clinical aspects of cancer development, progression and treatment.

**BIOL 452. Biology of Drugs. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 300 with a minimum grade of C. Explores how drugs modulate biological signaling pathways to study, cure, enhance and intoxicate organisms. An introduction to basic pharmacology that largely focuses on human pathways and diseases. Topics include major drug classes (cardiovascular, gastrointestinal, etc.) and drugs of abuse (alcohol, marijuana, etc.).

**BIOL 453. Cancer Biology Thesis. 4 Hours.**

Semester course; 1 lecture and 12 research hours. 4 credits. Prerequisite: BIOL 451. Enrollment is restricted by permission of the instructor and faculty mentor. A maximum of six credits for all research and internship courses (BIOL 395, BIOL 451, BIOL 453, BIOL 492, BIOL 493, BIOL 494, BIOL 495, BIOZ 395 and/or BIOZ 493) may be applied to the 40 credits of biology required for the major. Additional credits from the courses may be applied to upper-level and open elective credits toward the degree. Students will benefit from invaluable learning opportunities in cancer research including hands-on learning, direct mentorship from a VCU faculty member, scientific writing skills, time and research project management, and exposure to and training in various laboratory techniques. In addition, students will gain experience in preparation of a cancer research proposal and thesis.

**BIOL 454. Biology of Aging and Diseases. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 300 and BIOL 310 each with a minimum grade of C. A study of the molecular biology of aging as it relates to evolution of life span, model organisms, diseases and genetic regulation of aging.

**BIOL 455. Immunology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 300 with a minimum grade of C or PHIS 309. A comprehensive introduction to the vertebrate immune system emphasizing the molecular and cellular basis of innate and adaptive immune mechanisms, interactions and regulation.

**BIOL 456. Virology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 152, BIOZ 152 and BIOL 300, each with a minimum grade of C. BIOL 310 is recommended. Exploration of concepts related to the basic molecular and cellular biology of viruses with emphasis on the structure, genetic material and replication strategies of viruses, and the different mechanisms of infection and prevention measures. Importance of viruses as agents of evolution and their role in ecosystems and geological processes will also be discussed.

**BIOL 459. Infectious Disease Ecology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 151, BIOL 152, BIOZ 151, BIOZ 152 and BIOL 317, all with minimum grade of C. A comprehensive and up-to-date overview of the causes and consequences of infectious disease at levels from individual organisms to global scale. Examines the history of infectious disease ecology in human and nonhuman populations. Students learn about the roles of transmission and coevolution in infectious disease ecology and how population models are used to inform management of epidemics and emerging infectious diseases.

**BIOL 460. Human Evolutionary Genetics. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 318 or BIOL 341 with a minimum grade of C. The origin and genetic history of modern humans, our historic colonization and migration, the utility of the Human Genome Project, our differences from other primates, adaptation to our environment and disease, and the ethical implications of genetic research in our society.

**BIOL 475. Biology Capstone Seminar. \_\_\_\_\_. 1-3 Hours.**

Semester course; 1-3 seminar hours. 1-3 credits. Prerequisites: BIOL 300, BIOL 310, BIOL 317 and BIOL 318, each with a minimum grade of C. Enrollment is restricted to biology majors with senior standing. Students read assigned topical papers before class, prepare critical analyses, discuss and debate selected positions. See Schedule of Classes for specific topics.

**BIOL 477. Biology Capstone Experience. 0 Hours.**

Semester course; variable hours. 0 credits. Prerequisites: BIOL 300, BIOL 310, BIOL 317 and BIOL 318, each with a minimum grade of C; and 90 hours of undergraduate course work. The following courses qualify as a capstone experience if taken concurrently with this course: BIOL 492, BIOL 493, BIOL 495, BIOL 497 or other courses, including topics courses, which include the core competencies required for a capstone experience and are approved by the chair of the Department of Biology. Graded as pass/fail.

**BIOL 480. Animal-Plant Interactions. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 317 or BIOL 318 with a minimum grade of C, or permission of the instructor. Ecological and evolutionary consequences of interactions among animals and plants.

**BIOL 482. Preceptor Experience. 0 Hours.**

Semester course; 0 hours. 0 credits. Enrollment is restricted to students who have completed the relevant course for which they will be a teaching assistant with a minimum grade of B and who have a minimum cumulative GPA of 3.0. Permission of instructor and departmental chair also required prior to registration. Teaching assistants will enhance their knowledge of course content and develop skills that are natural to an instructional role, an understanding of the learning process within a discipline and the ability to explain the importance and value of course content to a novice audience. Graded as pass/fail.

**BIOL 484. Research Assistant Experience. 0 Hours.**

Semester course; 0 hours. 0 credits. Enrollment is restricted to students with permission of the departmental chair and limited to students for whom a research supervisor has agreed to be a mentor. Helps facilitate student involvement in research laboratories within the Department of Biology. Students will gain hands-on experience including data collection and analysis, learning field and/or laboratory techniques, and/or mastering experimental procedures, all under the direct supervision of a faculty member. Graded as pass/fail.

**BIOL 489. Research Writing. 1 Hour.**

Semester course; 1 lecture hour. 1 credit. Prerequisite: BIOL 392. Corequisite: BIOL 494. Enrollment is restricted by permission of the faculty mentor and Department of Biology. An opportunity for students to develop skills necessary for effectively communicating their research in writing. Activities include a variety of seminar discussions and activities, including preparing figures for publication and crafting a research paper that correctly uses the primary literature. Students will use this as an opportunity to aid the writing of their thesis for BIOL 494.

**BIOL 490. Presenting Research. 1 Hour.**

Semester course; 1 lecture hour. 1 credit. Concurrent prerequisite: BIOL 492. Corequisite: BIOL 495. Enrollment is restricted to students with senior standing and by permission of the faculty mentor and Department of Biology. Opportunity for students to develop skills necessary for effective oral presentation of their research work. This includes a variety of seminar discussions and activities such as the preparation of visual materials and the statistical analysis of data. Students will make several oral presentations directly related to their specific BIOL 492 or 495 projects.

**BIOL 491. Topics in Biology. 1-4 Hours.**

Semester course; variable hours. Variable credit. Prerequisite: BIOL 300. A study of a selected topic in biology. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

**BIOL 492. Undergraduate Research. 1-4 Hours.**

Semester course; 3-12 research hours. 1-4 credits. May be repeated for a maximum of 18 credits. Prerequisites: BIOZ 151 and BIOZ 152, each with a minimum grade of C. Enrollment is restricted by permission of the Department of Biology and faculty mentor. A maximum total of six credits for all research and internship courses (BIOL 395, BIOL 451, BIOL 453, BIOL 492, BIOL 493, BIOL 494, BIOL 495, BIOZ 395 and/or BIOZ 493) may be applied to the 40 credits of biology required for the major. Additional credits from the courses may be applied to upper-level and open elective credits toward the degree. A minimum of two credits is required for the course to count as a laboratory experience. Students will immerse themselves in biologically relevant primary research under the mentorship of a VCU faculty member. Students will actively participate in projects that involve data collection and analysis, mastering field and/or laboratory techniques and executing experimental procedures. The course will culminate in the submission of a written research report. The course emphasizes hands-on learning through mentorship. The experience is designed to enhance students' practical skills, critical thinking and application of research methodologies while contributing to cutting-edge science. A minimum of three hours of supervised activity per week per credit hour is required.

**BIOL 493. Biology Internship. 4 Hours.**

Semester course; 0-4 field experience hours. 0-4 credits (one credit per 50 hours of supervised work experience). May be repeated for a maximum of 18 credits. Prerequisites: BIOL 151, BIOZ 151, BIOL 152 and BIOZ 152, each with minimum grade of C. Enrollment is restricted by permission of the chair of the Department of Biology and institution where the internship will be performed. Students may take a maximum of four credits per semester; maximum total of six credits for all research and internship courses (BIOL 395, BIOL 451, BIOL 453, BIOL 492, BIOL 493, BIOL 494, BIOL 495, BIOZ 395 and/or BIOZ 493) may be applied to the 40 credits of biology required for the major. Additional credits from the courses may be applied to upper-level and open elective credits toward the degree. Internship is designed to provide laboratory, field or work experience in an off-campus professional biology setting. In addition to an internship proposal and professional practices/reflection assignments, a final report/reflection must be submitted during the course of the internship.

**BIOL 494. Research and Thesis I. 1-4 Hours.**

Semester course; 3-12 research hours. 1-4 credits. May be repeated for a maximum of four credits. Corequisite: BIOL 489. Enrollment is restricted by permission of the faculty mentor and Department of Biology. A maximum total of six credits for all research and internship courses (BIOL 395, BIOL 451, BIOL 453, BIOL 492, BIOL 493, BIOL 494, BIOL 495, BIOZ 395 and/or BIOZ 493) may be applied to the 40 credits of biology required for the major. A minimum of two credits is required for the course to count as a laboratory experience. Additional credits from the courses may be applied to upper-level and open elective credits toward the degree. Research and thesis is a comprehensive two-semester course sequence designed for students to immerse themselves in a substantial research project and produce a high-quality research thesis. First in the two-course sequence, students will engage in rigorous research activities collecting, analyzing and reporting their data. At the culmination of the course students will prepare a first draft of a research thesis. The course is highly recommended for students pursuing advanced degrees such as M.S., Ph.D., M.D.-Ph.D. or other dual degrees. A minimum of three hours of supervised activity per week per credit hour is required.

**BIOL 495. Research and Thesis II. 1-4 Hours.**

Semester course; 3-12 research hours. 1-4 credits. May be repeated for a maximum of four credits. Prerequisite: BIOL 494. Corequisite: BIOL 490. Enrollment is restricted by permission of the faculty mentor and Department of Biology. Students may take a maximum of four credits per semester; maximum total of six credits for all research and internship courses (BIOL 395, BIOL 451, BIOL 453, BIOL 492, BIOL 493, BIOL 494, BIOL 495, BIOZ 395 and/or BIOZ 493) may be applied to the 40 credits of biology required for the major. Additional credits from these courses may be applied to upper-level and open elective credits toward the degree. A minimum of two credits is required for the course to count as a laboratory experience. A minimum of four credits is required for honors in biology. Additional credits from the courses may be applied to upper-level and open elective credits toward the degree. Research and thesis is a comprehensive two-semester course sequence designed for students to immerse themselves in a substantial research project and produce a high-quality research thesis. Second in the sequence, students will continue to engage in rigorous research activities collecting, analyzing and reporting their data. The culmination of the course will be the creation of a detailed and well-crafted research thesis. The course is highly recommended for students planning to pursue advanced degrees such as M.S., Ph.D., M.D.-Ph.D. or other dual degrees. A minimum of three hours of supervised activity per week per credit hour is required.

**BIOL 496. Biology Preceptorship: \_\_\_\_\_. 2 Hours.**

Semester course; 2 practicum hours. 2 credits. May be repeated with a different course for credit. Enrollment restricted to students who have completed the relevant course with a minimum grade of B and who have a minimum cumulative GPA of 3.0. Permission of instructor is required prior to registration. Preceptors assist instructors in lecture (BIOL) or laboratory (BIOZ) courses. Responsibilities vary and may include, but are not limited to, attending class, conducting review sessions and preparing course study/review materials. Graded as pass/fail. A maximum of four combined credits from BIOL 496 and BIOL 499 may be applied to degree requirements.

**BIOL 497. Ecological Service Learning. 1 Hour.**

Semester course; 1 lecture hour. 1 credit. Prerequisite: BIOL 317 with a minimum grade of C. A service-learning course coupled to course content and material taught in BIOL 317. Students will seek out ecologically relevant opportunities with local, state and federal community partners who will provide experiences to enhance academic enrichment and personal growth and will help foster a sense of civic responsibility. Students must complete a minimum of 20 service-learning hours with community partner(s).

**BIOL 498. Insects and Plants Service-learning. 2 Hours.**

Semester course; 2 field experience hours. 2 credits. Prerequisites: BIOL 317 or BIOL 318 with a minimum grade of C, and permission of the instructor. A service-learning course related to insect-plant interactions. Field experience with community partners, including public parks, botanical gardens and organic farms. Designed to expand academic instruction, enhance personal growth and foster a sense of civic responsibility. Students must complete a minimum of 40 service-learning hours with a community partner.

**BIOL 499. Biology Lead Preceptorship. 2 Hours.**

Semester course; 2 practicum hours. 2 credits. Prerequisite: BIOL 496 in the same course with a grade of Pass. Enrollment is restricted to students who have completed the relevant course with a minimum grade of B and who have a minimum cumulative GPA of 3.0. Permission of the instructor is required prior to registration. Lead preceptors assist instructors in lecture (BIOL) or laboratory (BIOZ) courses. Responsibilities cumulate beyond those required in the prerequisite course. Responsibilities vary and may include, but are not limited to, organizing preceptor teams for large enrollment courses, preceptor mentorship, data entry of course materials, execution of group work, etc. Graded as pass/fail. A maximum of four combined credits from BIOL 496 and BIOL 499 may be applied to degree requirements.

**BIOL 502. Microbial Biotechnology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: MICR/ BIOC 503 or BIOC 530, 531, 532 and 533 or equivalent, and MICR/ BIOC 504 or equivalent. Open to qualified seniors and graduate students only. Discussion of the application of basic principles to the solution of commercial problems. The course will cover the historical principles in biotransformations as related to primary and secondary metabolism, as well as recombinant DNA technology and monoclonal antibodies and products resulting from the application of recombinant DNA technology.

**BIOL 503. Fish Biology. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisite: BIOL 317 or equivalent. Open to qualified seniors and graduate students only. Classification, behavior, physiology and ecology of fishes. Laboratories will emphasize field collection of fish and identification of specimens.

**BIOL 507. Aquatic Microbiology. 4 Hours.**

Semester course; 2 lecture and 4 laboratory hours. 4 credits. Prerequisites: BIOL 303 and 307 or equivalents. Open to qualified seniors and graduate students only. This course will involve a practical approach to the methods used to culture, identify and enumerate specific microorganisms that affect the cycling of elements in aquatic systems and those that affect or indicate water quality.

**BIOL 508. Barrier Island Ecology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 317 or equivalent, or permission of instructor. A study of the physical factors affecting the formation of barrier islands, adaptations of plants and animals for colonization and persistence in these harsh environments, and how coastal ecological processes conform to general ecological theory. Examples and problems pertaining to Virginia and the southeastern United States are emphasized.

**BIOL 509. Microbial Ecology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 317 or equivalent with a grade of C or better. Open only to qualified seniors and graduate students. Explores the interactions of microorganisms and their environment, including discussion of microbial diversity, nutrient cycling, symbiosis and selected aspects of applied microbiology.

**BIOL 510. Conservation Biology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Open to qualified seniors and graduate students only. Explores the accelerated loss of species due to increasing human population pressure and the biological, social and legal processes involved in conserving biodiversity.

**BIOL 511. Coastal Ecology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 317. Enrollment is restricted to seniors and graduate students who have passed the VCU prerequisite or an equivalent general ecology course at another university. This course will provide students with an introduction to the topics of coastal ecosystems, drivers shaping these systems and the organisms that live in these environments. As 80 percent of the world's population (and 50 percent of Americans) lives within 50 miles of the coastline and humans use coastal areas extensively, understanding the natural roles and services provided by coastal ecosystems and their constituent organisms is fundamental for addressing management, conservation and response to climate change.

**BIOL 512. Plant Diversity and Evolution. 4 Hours.**

Semester course; 3 lecture and 4 laboratory hours. 4 credits. Prerequisites: BIOL 300 and 310 or equivalents, or permission of instructor. Taxonomy, diversity and evolutionary history of vascular plants (including ferns, gymnosperms and flowering plants). Lecture emphasis on evolutionary relationships; laboratory emphasis on plant recognition and identification, especially of the Virginia flora, including some field trips to areas of local botanical interest.

**BIOL 514. Stream Ecology. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisite: BIOL 317. Open to qualified seniors and graduate students only. A study of the ecology of streams and rivers. Laboratory emphasis is on the structure and functioning of aquatic communities in mountain to coastal streams.

**BIOL 516. Population Genetics. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: STAT 543 or BIOS 543 or ENV 543 or FRSC 580. Theoretical and empirical analyses of how demographic and evolutionary processes influence neutral and adaptive genetic variation within populations.

**BIOL 518. Plant Ecology. 4 Hours.**

Semester course; 3 lecture and 2 laboratory hours. One three-day field trip is required. 4 credits. Prerequisite: BIOL 317. Open to qualified seniors and graduate students only. A lecture, field and laboratory course concerned with the development, succession and dynamics of plant communities and their interrelations with climate, soil, biotic and historic factors.

**BIOL 519. Forest Ecology. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisite: BIOL 317 or equivalent. Enrollment restricted to graduate students and upper-level undergraduates. Covers advanced topics in forest ecology, with a particular emphasis on Virginia's diverse forest ecosystems. Students gain an understanding of the principal controls on forest structure, growth and distribution and apply these principles to the development and execution of a graduate-level field research project.

**BIOL 520. Population Ecology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 310 and BIOL 317 or permission of instructor. Open to qualified seniors and graduate students only. Theoretical and empirical analysis of processes that occur within natural populations, including population genetics, population growth and fluctuation, demography, evolution of life history strategies and interspecific interactions. Quantitative models will be used extensively to explore ecological concepts.

**BIOL 521. Community Ecology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 317 or equivalent. Open to qualified seniors and graduate students only. Theoretical and empirical analysis of the structure and function of natural communities, ecosystems and landscapes.

**BIOL 522. Evolution and Speciation. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 310 or equivalent. Open to qualified seniors and graduate students only. Evolutionary principles, with emphasis on genetic and environmental factors leading to changes in large and small populations of plants and animals, and the mechanisms responsible for speciation.

**BIOL 524. Endocrinology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 300 and CHEM 301-302 and CHEZ 301L, 302L or equivalent. Open to qualified seniors and graduate students only. Hormonal control systems at the organ, tissue and cellular level. Although the major emphasis will be on vertebrate endocrine systems, some discussion of invertebrate and plant control systems will be covered.

**BIOL 530. Introduction to Human Genetics. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Enrollment restricted to qualified seniors and graduate students. Basic knowledge of genetics is recommended. Provides a comprehensive examination of the fundamentals of human genetics. Explores topics including Mendelian and non-Mendelian inheritance, pedigree analysis, cytogenetics, aneuploid syndromes, cancer, gene structure and function, epigenetics, gene expression, biochemical genetics, and inborn errors of metabolism.

**BIOL 535. Wetlands Ecology. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisite: BIOL 317 or equivalent or permission of instructor. A study of the ecology of freshwater and coastal wetlands, including the physical and biological aspects of these systems, wetland functions at local, landscape and global scales, and wetland regulations and restoration. Students will acquire skills with analytical techniques used in laboratory settings and in field-based applications for purposes of identifying and delineating wetland ecosystems.

**BIOL 540. Fundamentals of Molecular Genetics. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 310 or consent of instructor. The basic principles and methodologies of molecular biology and genetics are applied to genome organization, replication, expression, regulation, mutation and reorganization. Emphasis will be placed on a broad introduction to and integration of important topics in prokaryotic and eukaryotic systems. Crosslisted as: BNFO 540.

**BIOL 541. Laboratory in Molecular Genetics. 2 Hours.**

Semester course; 1 lecture and 4 laboratory hours. 2 credits. Concurrent prerequisite: BIOL 540 or equivalent. Experiments are designed to apply advanced techniques and concepts of molecular biology and genetics using prokaryotic and eukaryotic systems. Emphasis will be placed on experimental design, integrating results throughout the semester, making use of relevant published literature, scientific writing and providing hands-on experience with advanced equipment and methodologies. Crosslisted as: BNFO 541.

**BIOL 545. Biological Complexity. 3 Hours.**

Semester course; 2 lecture and 2 laboratory hours. 3 credits. Prerequisites: physics and calculus, or permission of instructor. Open only to graduate students and qualified seniors. An introduction to the basis of complexity theory and the principles of emergent properties within the context of integrative life sciences. The dynamic interactions among biological, physical and social components of systems are emphasized, ranging from the molecular to ecosystem level. Modeling and simulation methods for investigating biological complexity are illustrated. Crosslisted as: LFSC 510.

**BIOL 548. Bioinformatic Technologies. 2 Hours.**

Semester course; 2 lecture hours. 2 credits. Prerequisite: BIOL 545/ LFSC 510 or permission of instructor. Introduction to the hardware and software used in computational biology, proteomics, genomics, ecoinformatics and other areas of data analysis in the life sciences. The course also will introduce students to data mining, the use of databases, meta-data analysis and techniques to access information. Crosslisted as: LFSC 520.

**BIOL 550. Ecological Genetics. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Open to qualified seniors and graduate students only. Introduces the principles of ecological genetics, especially those with foundations in population and quantitative genetics, and illustrates conceptual difficulties encountered by resource stewards who wish to apply genetic principles. Explores various types of biological technologies employed by conservation geneticists and provides means for students to gain experience in analyzing and interpreting ecological genetic data.

**BIOL 560. Conservation Medicine. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Introduces students to key elements of wildlife diseases, zoonoses, emerging infectious diseases associated with wildlife and humans, and both the conservation and health impacts of these topics. Included are discussions of the interactions among environmental quality and wildlife and human diseases and health. Topics include diseases of fish, amphibians, reptiles, birds and mammals, the effects of environmental contaminants and climate on those diseases, and their interaction with human health.

**BIOL 565. Advances in Cell Signaling. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 300 or equivalent. Topical course focusing on advances in cellular communication by cytokines, hormones and neurotransmitters. Each semester, the course focuses on a different topic. Past topics have included cancer biology, allergy and asthma, and autoimmunity.

**BIOL 580. Eukaryotic Biotechnology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 300 and BIOL 310, both with a minimum grade of C, or graduate standing in biology or a related field. Enrollment is restricted to graduate students and senior undergraduates. Discussion of principles, concepts, techniques, applications and current advances in cellular and molecular biology aspects of biotechnology for animal and plant cells. The course will cover molecular construction of foreign genes; DNA cloning; technologies for DNA, RNA and protein analyses; nonvector and vector-mediated genetic transformation; gene regulation in transgenic cells; cell and tissue culture; cell fusion; and agricultural, medical and other industrial applications.

**BIOL 591. Special Topics in Biology. 1-4 Hours.**

Semester course; 1-4 credits. An in-depth study of a selected topic in biology. See the Schedule of Classes for specific topics to be offered each semester and prerequisites. If several topics are offered, students may elect to take more than one.

**BIOL 601. Integrated Bioinformatics. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits. Enrollment requires permission of instructor. Presents major concepts in bioinformatics through a series of real-life problems to be solved by students. Problems addressed will include but not be limited to issues in genomic analysis, statistical analysis and modeling of complex biological phenomena. Emphasis will be placed on attaining a deep understanding of a few widely used tools of bioinformatics. Crosslisted as: BNFO 601.

**BIOL 602. Professional and Career Development in Biology. 1 Hour.**

Semester course; 1 lecture hour. 1 credit. Enrollment is restricted to students with graduate standing. This course will equip students early in their graduate experience with the knowledge, resources and skills to rapidly and successfully complete the requirements for an M.S. in Biology while enhancing their communication and planning skills in several critical formats and areas, as well as exploring alternative career paths based on their personal goals and values.

**BIOL 603. Fundamentals of Scientific Leadership. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing. The purpose of this course is to prepare students to successfully work as members and leaders of diverse scientific teams during their graduate studies and in multiple scientific career paths. Students will be familiarized and gain experience with key concepts of teams and leading teams, including values-based missions and goals, effective communication and feedback, stages of team development and leadership, diversity and inclusivity, mentoring and coaching, resolving conflict, project management, leading change, leaving a legacy, and assessment.

**BIOL 604. Research Integrity. 1 Hour.**

Semester course; 1 lecture hour. 1 credit. Enrollment is restricted to students with graduate standing. This course is designed to provide a discussion-based approach to research integrity. By the end of the course students will be acutely aware of how science interacts with and informs society. They will have digested an array of topical issues relating to responsible conduct of research and be able to clearly articulate ethical and legal solutions to problems posed. This course addresses issues across a broad biosciences background including laboratory and field studies. This course targets master's- and entry-level Ph.D. students. Graded as pass/fail.

**BIOL 605. Diversity and Inclusion in Science. 1 Hour.**

Semester course; 1 lecture hour. 1 credit. Enrollment is restricted to students with graduate standing. This course will familiarize and engage students with multiple forms of diversity in science through presentations, diverse guest speakers, class discussions and student assignments, preparing them to recognize and leverage this diversity by employing inclusiveness throughout their scientific careers and lives.

**BIOL 606. Quantitative Ecology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Principles and applications of mathematical ecology at the community level, including experimental design; sampling techniques, assumptions and limitations; and the use of cluster analysis, gradient analysis and ordination to evaluate, summarize and compare large data sets.

**BIOL 607. Science Communication: Fundamentals. 2 Hours.**

Semester course; 2 lecture hours. 2 credits. Enrollment is restricted to students with graduate standing. The goal of this course is to provide training in science communication to diverse audiences from scientific and nonscientific backgrounds and across diverse career paths. The course covers fundamental rules of writing, the writing process, technical writing, visual presentation, oral presentation, engaging audiences and communication with the public. Students will attain science communication skills through writing exercises, videotaped oral exercises and peer review to prepare them for graduate school and beyond.

**BIOL 608. Science Communication: Research Proposals. 2 Hours.**

Semester course; 2 lecture hours. 2 credits. Enrollment is restricted to students with graduate standing. The goal of this course is to provide training in writing competitive research proposals. Students will learn the necessary skills for the proposal-writing stage of scientific research preparatory stage, including reference managers, annotated bibliographies, selling the idea, mock review panels, short-form proposals, long-form proposals and thesis/dissertation proposals. Students will learn proposal-writing skills that will provide an edge in applications for a diversity of funding sources.

**BIOL 609. Scientific Communication: Public Discourse. 1 Hour.**

Semester course; 1 lecture hour. 1 credit. Prerequisite: BIOL 607. Enrollment is restricted to students with graduate standing. The mission of this course is to train students nearing completion of a thesis/dissertation to apply skills they learned in the prerequisite course to effectively communicate their own thesis/dissertation research, and its relevance to global issues in biology, to nonscientific audiences. Students successfully completing this course will be able to effectively communicate the science and relevance of their own research in verbal and written formats with non-scientists in the lay public, government and nongovernment institutions and the media. Graded as satisfactory/unsatisfactory.

**BIOL 610. Conservation Applications. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Covers the implementation of conservation techniques including monitoring, planning, education, habitat management and combining conservation with human development strategies. Focuses on how to make conservation work where biodiversity and human livelihoods must be reconciled. Students will utilize a number of computer programs to analyze and interpret management strategies.

**BIOL 618. Ecosystems Ecology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 317 or equivalent or permission by instructor. Introduction to the structure and functioning of aquatic and terrestrial ecosystems. The course complements other offerings in the graduate program by considering ecological processes at higher orders of organization and in the context of abiotic factors. Students will gain discipline-specific knowledge through lectures and readings while building quantitative and critical thinking.

**BIOL 620. Biogeochemistry. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Enrollment restricted to graduate students. This course will examine the biogeochemical cycles of carbon, nitrogen, phosphorus, sulfur and iron on Earth from both a historical perspective and in the context of global environmental change, considering the cycles individually while also acknowledging that there are significant interactions between these cycles. Examples of biogeochemical processes will be drawn from multiple ecosystems, ranging from terrestrial soils to the deep ocean.

**BIOL 626. Physiological Ecology. 4 Hours.**

Semester course; 4 lecture hours. 4 credits. Prerequisite: BIOL 317 or equivalent. This course examines the physiological adjustments and adaptations made by organisms in response to their environment.

**BIOL 630. Patterns of Mammalian Reproduction. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. A comprehensive ecological and evolutionary study of specializations and adaptive radiation in mammalian reproductive anatomy, the reproductive cycle, seasonality of reproduction and factors affecting litter size and developmental state of neonates. Human reproductive biology is included when pertinent.

**BIOL 631. Biology Integration: From Molecules to Organisms. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Enrollment is restricted to students with graduate standing that have completed at least a minor in biology or equivalent. This course will expose students to the recent advances in the biology subdisciplines that span from molecules to organisms, by examining how molecular and cellular processes scale and culminate to affect organisms. Students will focus on understanding experimental approaches and practical applications critical to evaluate research in molecular, cellular, developmental and organismal biology. The course is the first of two courses with the goal of equipping the students with the conceptual framework that will allow them to make sense and integrate the broad biological information they will be exposed to during their careers. The overall approach reflects the broad multidisciplinary, multi-scale reality of modern/contemporary biological sciences and will help students identify themes, patterns and processes that transcend the scales of biological organization from molecules to organisms.

**BIOL 632. Biology Integration: From Organisms to Landscapes. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: BIOL 631. Enrollment is restricted to students with graduate standing that have completed at least a minor in biology or equivalent. This course will expose students to the recent advances in the biology subdisciplines that span from organisms to landscapes by examining how the spatial patterns of organisms, populations, communities and landscapes impact ecological processes. Students will focus on understanding experimental approaches and practical applications critical to evaluate research in evolutionary biology and the ecology subdisciplines. The course will also highlight the impact of human activities on the global environment. The course is the second of two courses with the goal of equipping the students with the conceptual framework that will allow them to make sense and integrate the broad biological information they will be exposed to during their careers. The overall approach reflects the broad multi-disciplinary, multi-scale reality of modern/contemporary biological sciences and will help students identify themes, patterns, and processes that transcend scales of biological organization from organisms to landscapes.

**BIOL 640. Evolution and Molecular Markers. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Methodologies and applications of molecular biology as they pertain to the study of evolution, with a focus on systematics, speciation and biogeography. The course provides proficiency in the understanding, interpretation and choice of appropriate molecular markers for evolutionary research, with particular attention to current methods and recent literature. Designed to benefit students of both natural history (ecologists, systematics, evolutionary biologists) and molecular biology.

**BIOL 650. Conservation Genetics. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Covers the application of molecular genetics to biodiversity conservation. Essential topics include molecular measures of genetic diversity, estimating loss of genetic diversity in small populations, detecting inbreeding, resolution of taxonomic uncertainties, genetic management of T&E species, captive breeding and reintroduction. Students will utilize a number of computer programs to analyze and interpret molecular genetic data.

**BIOL 654. Environmental Remote Sensing. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: ENVS 602, or permission of the instructor. This course provides a basic and applied understanding on the use of digital remote sensor data to detect, identify and characterize earth resources. Students are required to demonstrate an understanding of the spectral attributes of soils, vegetation and water resources through various labs involving both image- and non-image-based optical spectral data. Crosslisted as: ENVS 654/URSP 654.

**BIOL 660. Developmental Biology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: biochemistry or cell biology or their equivalent. Molecular and cellular principles of developmental biology in model systems, including flies, worms, fish and mammals. Understanding of morphogen gradients, transcription, cell movements and signaling in development. Advanced methods are taught enabling students to interpret and present findings from the primary literature.

**BIOL 676. Plant and Animal Cell Biology. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: biochemistry or cell biology or permission of instructor. Molecular and cellular principles of cell behavior and function in plant and animal cells. Topics include intracellular transport, cell cycle control, signaling and cell motility. Advanced methods are taught enabling students to interpret and present findings from the primary literature in this field.

**BIOL 690. Biology Seminar. 1 Hour.**

Semester course; 1 credit. May be repeated for credit. Presentations by faculty and visiting lecturers, and discussions of research and developments in biology and related fields. Graded as S/U/F.

**BIOL 691. Special Topics in Biology. 1-4 Hours.**

Semester course; variable hours. 1-4 credits. An advanced study of a selected topic in biology. See the Schedule of Classes for specific topics to be offered each semester and prerequisites. If several topics are offered, students may elect to take more than one.

**BIOL 692. Independent Study. 1-4 Hours.**

Semester course; 1-4 independent study hours. 1-4 credits. May be repeated for a maximum of four credits. Enrollment is restricted by credit hours earned and permission of the instructor, adviser and department chair. A course providing independent study through research or internship in biology.

**BIOL 693. Current Topics in Biology. 1 Hour.**

Semester course; 1 lecture hour. 1 credit. May be repeated for credit. Designed to develop skills in preparing and delivering oral presentations in conjunction with an in-depth study of a current topic in biology. Students present talks and lead discussions on the selected topic.

**BIOL 698. Thesis. 1-16 Hours.**

Semester course; hours to be arranged. Credits to be arranged. Independent research by students in areas of systematics, environmental, developmental, behavioral, cellular and molecular biology, and comparative physiology.