

BIOLOGY: REQUIREMENTS

Natural Sciences Division

The biology curriculum structures learning based on the scientific process of discovery: observation, interpretation, experimentation, analysis, and the formation of new hypotheses. Through exploration of recent developments in the broad range of biological fields, students examine details in the context of basic principles. They experience the dynamic nature of biological science by participating in laboratory work and research projects that form the backbone of the program. The curricular design offers many choices to students, allowing non-majors to explore any one field of biology in depth or to examine biology in the context of human issues having sociological, economic, and political importance, such as health care, biotechnology, and the environment.

The Biology Curriculum

Biology majors must take both foundation courses (BIOL 115 and 116 unless specifically exempted by AP exams or IB credit) and the year-long introductory laboratory sequence, BIOL 109Y-110Y. The foundation courses must be completed within the first four semesters. Advanced courses may be taken after completion of the prerequisite foundation course, so students can begin advanced courses while completing the introductory series. A year of introductory chemistry lecture or the equivalent is also required of all majors.

Upper-level courses are offered at the 200 and 300 levels. Courses at the 200 level are designed for sophomores and juniors who have completed at least part of the introductory-level curriculum. Reading assignments include textbooks, primary literature, and other advanced sources. Courses at the 300 level are designed for juniors and seniors who have completed the entire introductory-level curriculum and at least one 200 level course. Primary literature and other advanced sources form a substantial portion of the reading, and extensive student-directed work is expected.

In addition to the biology major, major programs in biochemistry and in molecular biology are available. These programs combine work in biology and chemistry to prepare students for graduate work or employment entailing research on the molecular basis of biological systems. Information on course requirements for these major programs is detailed in the biochemistry and molecular biology section.

Non-majors can choose innovative topical courses that approach biological issues in a human context (BIOL 103, 104, 105, 106, 107). These courses are designed for students with minimal backgrounds in biology. The foundation courses--BIOL 115 and 116--allow more in-depth study. Several courses also serve the interdisciplinary concentration in environmental studies.

For students considering medical, dental, nursing, or veterinary postgraduate programs, there is usually a requirement of a minimum of two semesters of biology with the corresponding laboratory work. BIOL 115 and 116 plus the laboratory sequence BIOL 109Y-110Y satisfy this requirement.

Students can involve themselves in the department through the Biology Student Advisory Group, which meets with the chair and faculty members, or as employees ranging from laboratory teaching proctors to research assistants.

Majors are encouraged to participate in the department through research with faculty members and by their active role in hiring faculty, suggesting curriculum changes, inviting seminar speakers, and planning social events.

Requirements for the Biology Major

The following requirements apply to students who declare a major in biology.

- BIOL 115 and 116 (or specific exemption), to be completed within four semesters of starting this series.
- BIOL 109Y-110Y, to be completed by the end of the sophomore year.
- Six upper-division lecture courses, including at least one 300-level course. MATH 258 counts toward this requirement.
- Four upper-division laboratory courses (.5 unit of credit earned in Research in Biology or Senior Honors can serve as one .25-unit laboratory course requirement).
- One year of Introductory Chemistry lecture (or equivalent).

In order to fulfill the diversification requirements for upper-level courses, biology majors will need to take at least one upper-level lecture course in each of the following three categories to graduate:

- Environmental biology: BIOL 228, 241, 251, 253, 261, 272, 328, 352, and 362.
- Organismal biology/physiology: BIOL 233, 238, 243, 245, 336, and 358.
- Cellular and molecular biology: BIOL 238, 255, 263, 266, 321, 333, 351 and 375.

We strongly encourage majors to take at least one year of mathematics and physics. Students planning graduate studies in any area of biology should also include organic chemistry. We encourage majors to seek opportunities for independent research with faculty members, through Research in Biology, honors research, and the Summer Science Scholars Program.

Senior Exercise

The Senior Exercise for all biology majors consists of a detailed analysis of a research field, focusing on a critique of a particular research article. In addition, all majors must attend a specified number of guest lectures in the Biology Seminar Series and take a standardized assessment exam.

Advanced Courses Offered in Biology

Many courses and laboratories are offered in alternating years, so care should be taken in planning the major to suit individual goals. The following list indicates which courses are normally taught on alternating-year schedules. Please note that the schedule can vary from these

guidelines; students should consult the department chair or course instructor if particular courses are needed.

Courses that may be offered in alternating years include: BIOL 233, 234, 241 , 245, 246, 251, 255, 256, 266, 321, 322, 328, 333, 336, 346, 349, 351, 352, 353, 358, 359, 362, and 375.

Honors

The Honors Program in biology is an exciting opportunity for students to perform research in collaboration with a faculty member of the Department of Biology. Prior to enrollment in senior honors, students are ordinarily expected to complete at least one semester of Research in Biology (BIOL 385, 386) and participate in the Summer Science Scholars Program. Two semesters of Research in Biology are recommended. Students must have an overall GPA of at least 3.33 and a GPA of 3.33 in biology.

Requirements for the Biology Minor

The minor in biology requires a minimum of 2.75 units of credit earned in the major curriculum; these must include the foundation courses (BIOL 115 and 116), the introductory laboratory, BIOL 109Y-110Y , and at least one upper-level laboratory. One year of BIOL 385, 386 would satisfy the upper-level laboratory requirement and one year of BIOL 393, 394 would satisfy one upper-level lecture course requirement in the area minor.

Transfer Credit Policy

All transfer credit must be approved in advance by the chair.

CROSS-LISTED COURSES

The following courses are cross-listed with the biology offerings to satisfy natural-sciences diversification:

ENVS 112 Introduction to Environmental Studies
MATH 258 Mathematical Biology

COURSES:

BIOL 103 Biology in Science Fiction

Credit: 0.5 QR

Science-fiction literature and film extend our awareness of the natural world in amazing ways, as in the film *Avatar*. Yet real biology is often more amazing than science fiction. The impact of evolution on human existence is examined through Wells's *The Time Machine* and Vonnegut's *Galapagos*, while bizarre living creatures are explored through Herbert's *Dune* and Crichton's *Jurassic Park*. Quantitative reasoning in biology is introduced through problem sets applying calculation to extrapolate present and future biological phenomena. Exponential functions are

used to explore whether human populations will explode, as in *Star Trek*, "The Trouble with Tribbles," or decline as in *The Time Machine*. Hardy-Weinberg equilibria and computer modeling show how bizarre mutant traits spread through populations, as in *Galapagos*. Acid-base titrations show how global warming acidifies the ocean, disrupting the marine ecosystem as in Slonczewski's *A Door into Ocean*. Students create their own interactive projects on the Web. May be offered in alternating years. No prerequisites. Does not count toward the major or minor.

Instructor: Slonczewski

BIOL 104 Biology of Female Sexuality

Credit: 0.5

This course examines the human female body with respect to sexual response, menstruation, reproduction, menopause, and contemporary health issues. Students work in cooperative learning groups for leading discussions and for the class praxis project, which focuses on constructive alliances with men to promote healthy relationships and reduce the sexual objectification and rape of women. The underlying goals of the course are to provide an anatomical appreciation of the human body, to improve our capacity to act as informed health-care consumers, to forge a feminist understanding of women's health concerns in a social context, and to learn skills for bridging differences and for networking among women in their diversity, in order to provide better health care for all. Texts vary from year to year. This course no longer has a laboratory component. There are no prerequisites. Men are welcome. This course counts toward the women's and gender studies major but does not count toward the biology major or minor.

BIOL 105 Biology of Exercise

Credit: 0.5

This is an introductory biology class that will examine human physiology by considering the response of the human body to exercise. We will ask basic questions about human exercise performance and seek to understand the biological mechanisms that are relevant to these questions. Questions that may be considered include: What limits human exercise performance? How does nutrition influence exercise? What are the mechanisms involved in increased performance during training? How does exercise influence the overall health of humans? Students will learn to directly evaluate the scientific basis of knowledge about physiology through the analysis of experimental methodology and data. May be offered in alternating years. No prerequisites. Does not count toward the major or minor.

Instructor: C. Gillen

BIOL 106 Conservation Biology

Credit: 0.5

Conservation Biology introduces students to subjects in biology that are central to questions about sustaining species and ecosystems. Students will use a series of case studies to learn the scientific methodology and fundamental principles that must be applied to issues of conserving biological diversity. Case studies will illustrate: aquatic and terrestrial habitats; population and ecosystem levels of organization; and principles of evolution, population biology, and ecosystem biology. Biology 106 is appropriate for first-year students and it is an alternative core course for the Environmental Studies Concentration. There are no prerequisites. Offered every other year.

Instructor: R. Heithaus

BIOL 107 Scaling in Biology: Why Size Matters

Credit: 0.5 QR

While biologists seek general principles that explain the common characteristics of all organisms, we too often ignore that most obvious of traits: an organism's size. We will explore how size determines the form, function, pace, and complexity of life. Our questions will span realms from the miniscule (can bacteria see?) to the gigantic (how many species are there on Earth?) to the fantastic (what would it cost to feed King Kong?) Living things span an amazing range of sizes, and by studying the importance of size in the living world, we will develop a quantitative framework for comparing not just apples and oranges, but bacteria and blue whales. Surreal perspectives on biology such as Swift's *Gulliver's Travels*, and Kafka's *Metamorphosis*, as well as films like *A Fantastic Voyage* and *Destroy All Monsters*, will further highlight the truly amazing nature of biological reality. This course has no prerequisites.

Instructor: Kerkhoff

BIOL 109Y Introduction to Experimental Biology

Credit: 0.25 QR

This is the first laboratory course a student takes and is a prerequisite for all upper-division laboratory courses. Students are introduced to the processes of investigative biology and scientific writing. It is not designed to accompany any particular core lecture course. Laboratories cover topics presented in the core lecture courses, BIOL 115 and 116, and introduce a variety of techniques and topics, including field sampling, microscopy, PCR, gel electrophoresis, enzyme biochemistry, physiology, evolution, and population biology. The course emphasizes the development of inquiry skills through active involvement in experimental design, data collection, statistical analysis, integration of results with information reported in the literature, and writing in a format appropriate for publication. The year culminates in five-week student-designed investigations that reinforce the research skills developed during the year. Evaluation is based on short reports, quizzes, lab performance, and two scientific papers, as well as oral and written presentations based on the independent project. Prerequisite or corequisite: BIOL 115. Enrollment is limited to sixteen students in each section.

BIOL 110Y Introduction to Experimental Biology

Credit: 0.25 QR

See course description for BIOL 109Y.

BIOL 115 Energy in Living Systems

Credit: 0.5

Energy flow is a unifying principle across a range of living systems, from cells to ecosystems. With energy flow as a major theme, this course covers macromolecules, cells, respiration and photosynthesis, physiology and homeostasis, population and community interactions, and ecosystems. Throughout the course, the diversity of life is explored. The course also introduces students to the process of scientific thinking through discussion of research methodology and approaches. Majors and nonmajors may enroll. Biology majors should take this class prior to the junior year. No prerequisites. This course will be offered every year.

BIOL 116 Information in Living Systems

Credit: 0.5

How is information generated, transmitted, stored, and maintained in biological systems? The endeavor to understand the flow of biological information represents a fundamental undertaking of the life sciences. This introductory course examines the mechanisms of heredity, the replication and expression of genetic information, and the function of genes in the process of evolution, with an emphasis on the tools of genetics and molecular biology to address research questions in these areas. Majors and nonmajors may enroll. Biology majors should take this class prior to the junior year. Prerequisites: BIOL 115, AP score of 5, or permission of instructor. This course will be offered every year.

BIOL 228 Ecology

Credit: 0.5

Ecology is the study of the distribution and abundance of organisms and the structure and dynamics of biosphere. Topics will include physiological ecology, population ecology, competition, predator-prey systems, mutualism, succession, energy and nutrient dynamics, and the ecology of communities, ecosystems, and the biosphere. We will explore the influence of humans on natural systems. Students will use theoretical models and primary literature to supplement the text, lectures, and discussions. Prerequisite: BIOL 115 or permission of instructor. BIOL 229 is highly recommended.

BIOL 229 Ecology Laboratory

Credit: 0.25

This course examines techniques for studying ecological principles in the field and laboratory, with primary emphasis on terrestrial systems. Students will learn experimental design, sampling protocols, and quantitative methods including spatial analysis with geographic information systems. Topics include limits to distribution, interactions with the physical environment, population dynamics, species interactions, carbon sequestration, and biodiversity. Studies will include physically demanding field work in local habitats in varying weather conditions. Prerequisite: BIOL 109Y-110Y and BIOL 115 or permission of the instructor. Prerequisite or corequisite: BIOL 228.

BIOL 233 Plant Biology

Credit: 0.5

This course presents an introductory examination of flowering plant form and function in evolutionary and ecological contexts. As the foundation for our examination of flowering plants, we will conduct an overview of plant evolution, focusing on plants important to evolutionary concepts. Photosynthesis is examined as a model for structure/function relationships that are ever-evolving. Physiological and genetic features of morphology, growth, reproduction, and abiotic and biotic interactions are considered as well. Prerequisite: BIOL 116 or permission of the instructor.

Instructor: Edwards

BIOL 234 Laboratory Experience in Plant Biology

Credit: 0.25

This course explores plant anatomy and morphology through a course-long project in growing and studying unknown plants from seed to flower. Students categorize their unknown plants using traditional descriptive methods of form and anatomy of leaves, roots, and flowers. We also utilize molecular methods to identify unknown plants through DNA analysis. Experiments involving growth and hormone regulation offer students the opportunity to design their own hypotheses and experiments. The course may be offered in alternating years. Prerequisite: BIOL 109Y-110Y. Prerequisite or corequisite: BIOL 233.

Instructor: Edwards

BIOL 238 Microbiology

Credit: 0.5

Microbes inhabit the most extreme environments on earth, ranging from superheated sulfur vents on the ocean floor to alkaline soda lakes. In medicine, newly discovered bacteria and viruses cause a surprising range of diseases, including heart disease; they may even hold the key to human aging. Yet other species live symbiotically with us, keeping us healthy; still others, such as nitrogen fixers, are essential to the entire biosphere. This course covers microbial cell

structure and metabolism, genetics, nutrition, microbial communities in ecosystems, and the role of microbes in human health and disease. Prerequisite: BIOL 116.

Instructor: Slonczewski

BIOL 239 Experimental Microbiology

Credit: 0.25

We learn the classic techniques of studying bacteria, protists, and viruses in medical science and in ecology. We practice microbial culture and examine life cycles, cell structure and metabolism, and genetics. High-throughput methods of analysis are performed, such as use of the microplate UV-VIS spectrophotometer. For the final project, each student surveys the microbial community of a particular habitat, using DNA analysis and biochemical methods to identify microbial isolates. May be offered in alternating years. Prerequisite: BIOL 109Y-110Y or a chemistry lab course. Corequisite: BIOL 238.

Instructor: Slonczewski

BIOL 241 Evolution

Credit: 0.5

Evolution is the major unifying theory of biology; the unity of fundamental processes, species diversity, and adaptive characteristics of organisms are consequences of evolution, and can be fully understood only in this light. Evolutionary processes also have major impacts on humans. This course introduces the processes of evolution, most of which can be examined in contemporary time through experiment, theory, and simulation, and by examining pattern in nature. The class format will combine lecture and discussion. Topics will include basic Darwinian arguments, modern population genetics, adaptation, speciation, reconstructing phylogenetic history, macroevolution, and the consequences of evolution for conservation and human health. Examples will be drawn from all levels of biology, from molecular to ecological studies. Students will read and discuss original literature, utilize computer simulations, and prepare a final paper and presentation. Prerequisites: BIOL 116 or permission of the instructor.

Instructor: R. Heithaus

BIOL 243 Animal Physiology

Credit: 0.5

Animal physiology examines the processes of animal cells, tissues, and organ systems. In this class, we will seek to understand how physiological processes relate to the survival of an animal in its environment. We will use three primary approaches: (1) comparative, contrasting animals that live in different environments; (2) environmental, exploring how animals survive in challenging environments; and (3) structure-function, examining how the anatomy of a system

relates to its function. Each of the primary animal organ systems (nerve, muscle, cardiovascular, respiratory, gastrointestinal, renal, and excretory) will be covered in detail. Readings from the primary research literature will be assigned. This course replaces BIOL 341. Prerequisites: BIOL 109Y-110Y and BIOL 115, or permission of instructor.

BIOL 244 Experimental Animal Physiology

Credit: 0.25

This laboratory class explores the techniques, equipment, and experimental designs common to animal physiology. Topics to be studied may include muscle physiology, cardiac physiology, salt and water balance, metabolism, and exercise physiology. A variety of experimental techniques will be used. Students will participate in experimental design, perform experiments, and present results in oral and written form. Students will also read and analyze relevant papers from the primary literature. Prerequisite: BIOL 109Y-110Y. Prerequisite or corequisite: BIOL 243.

Instructor: C. Gillen

BIOL 245 Environmental Plant Physiology

Credit: 0.5

Plants, like all life forms, survive in community with a diversity of organisms and in a changing and demanding environment. Plant life benefits from and is challenged by relationships with other species and by the environment. Plants have evolved a fundamentally different pattern of living from organisms of other kingdoms; the physiological strategies that have evolved to meet the challenges of a predominantly stationary life that relies on resources of the immediate environment are marvelous, intriguing, and enlightening. Our focus is on flowering plants and the structural and physiological processes (molecular, cellular, and systemic) that manage the intersections with the environment and with other organisms. The subject is presented through examination of experimental design and data analysis. May be offered in alternating years. Prerequisites: BIOL 116 and CHEM 121/122 and CHEM 124 or CHEM 125.

Instructor: Bickford

BIOL 246 Environmental Plant Physiology Lab

Credit: 0.25

This course will examine techniques for investigating plant physiological responses to environmental stimuli in both laboratory and field settings. Students will learn to use instrumentation to measure processes related to CO₂ acquisition and loss (photosynthetic CO₂ assimilation, electron transport, and respiration) and plant water status (water potential). Using these methods and an experimental approach, we will explore topics such as plant resource-use physiology, environmental impacts on leaf physiology, and resource impacts on growth and allocation. These topics and processes will be examined in the context of natural and

agroecosystem responses to climate change. During the semester students will become familiar with the primary literature in the field, design and conduct experiments, and communicate their results in written and oral form. Prerequisites: BIOL 115, CHEM 121/123 and CHEM 124 or permission of instructor. Corequisite: BIOL 245.

BIOL 251 Marine Biology

Credit: 0.5

This course applies ecological principles to the field of marine biology. Topics are organized to explore the diversity of marine habitats. We will study the basics of oceanography that create diverse conditions for marine organisms, the special adaptive pressures on organisms, and the ecological influences on biological diversity. Topics will include chemical properties of seawater, ocean currents, tides, animal and plant communities in the oceans and estuaries, the importance of the sea to humans (through fisheries and influences on global climate), and the problems of pollution in marine ecosystems. May be offered in alternating years. Prerequisite: BIOL 115.

BIOL 253 Paleobiology

Credit: 0.5

This course examines the use of fossils as tools for interpreting Earth's ancient oceans and the life they once supported. Methods for inferring physical and chemical aspects of marine settings (e.g., oxygen levels, salinity variation) and the use of major marine fossil taxa as past analogues of modern organisms, will allow for the reconstruction of paleoenvironments. We will explore techniques used to infer how organisms functioned within their life environments and how they interacted with other life forms, and we will survey major events in the history of Earth's oceans and marine biota, including some significant fossil locations (i.e., lagerstätten), as a means of introducing major ecological principles. Laboratories and exercises involving fossil specimens will constitute a significant portion of the final grade, and at least one field trip will be required. Prerequisite: BIOL 116 or permission of the instructor. This class fulfills the environmental biology diversity requirement for the biology major.

BIOL 255 Genetic Analysis

Credit: 0.5

This course introduces both principles and experimental approaches related to heredity in a wide variety of organisms from bacteria to humans. Topics will include classical transmission genetics, chromosomal structure, extranuclear heredity, epigenetics, population and evolutionary genetics, and molecular analysis of genes and chromosomes. As genetic analysis can be used to dissect many biological processes, we will also address how geneticists approach problems and advance scientific understanding, focusing our discussions around primary literature. May be offered in alternating years. Prerequisite: BIOL 116.

Instructor: Hicks

BIOL 256 Experimental Genetic Analysis

Credit: 0.25

This laboratory course introduces both genetic concepts and genetic approaches commonly used to understand biological processes. We will cover fundamental techniques including mutant screens, double mutant analysis, linkage mapping, and map-based cloning of genetic loci. We will use the model plant *Arabidopsis thaliana* as our experimental organism, although the approaches taken in this course can be used in any organism amenable to genetic analysis. May be offered in alternating years. Prerequisite: BIOL 109Y-110Y. Prerequisite or corequisite: BIOL 255.

Instructor: Hicks

BIOL 261 Animal Behavior

Credit: 0.5

The evolution and ecology of animal behavior is explored in detail. The diversity of behavior and the ecological consequences of behavior will be studied, with emphasis on how research programs are designed to answer questions. Topics include the genetics and physiology of behavior, perceptual systems, integration and storage of information, the ecology of reproduction, feeding behavior, habitat selection and migration, and social behavior. Prerequisite: BIOL 116 or permission of the instructor.

Instructor: Mauck

BIOL 262 Experimental Animal Behavior

Credit: 0.25

This laboratory applies the principles of experimental design and inference to the study of animal behavior. There will be both laboratory and field components. Students should be aware that animals do not always "behave" in discrete, three-hour time periods, and that some work may have to be arranged outside of the regularly assigned class period. Prerequisites: BIOL 109Y-110Y. Prerequisite or corequisite: BIOL 261.

Instructor: Mauck

BIOL 263 Molecular Biology and Genomics

Credit: 0.5

The molecular and genomic basis of life is at the heart of modern biology. In BIOL 263, we will learn techniques and explore research questions at the forefront of molecular research, focusing on the mechanisms by which the information of the genome is expressed to form the functional molecules of living cells and organisms. The processes of DNA replication, recombination, and repair, transcription of RNA from DNA templates, and translation of RNA into protein are discussed in the context of current research, frequently using primary literature. The function of genes and the regulation and measurement of gene expression are treated in depth. Students analyze and publish interactive tutorials on the structure and function of key macromolecules. This intermediate-level course presumes a strong background in the basics of protein structure/function, central dogma processes, fundamental molecular techniques for manipulating nucleic acids and proteins, and general chemistry. Prerequisites: BIOL 116 and one year of chemistry (Intro or Honors Intro). Recommended prerequisite or corequisite: CHEM 231 and 232 (Organic Chemistry). Note: For further study of the function of proteins, membranes, and cellular processes, the complementary course BIOL 266 (Cell Biology) is recommended.

BIOL 264 Gene Manipulation

Credit: 0.25

This course teaches advanced methods of gene isolation, manipulation, and characterization. An assortment of the following techniques will be covered: the isolation of DNA and RNA from tissues and cells; recombinant DNA technique; expression of genes in heterologous systems; the polymerase chain reaction (PCR); measurement of gene expression, and bioinformatics and sequence analysis. Prerequisite: BIOL 109Y-110Y. Prerequisite or corequisite: BIOL 263, one year of chemistry with labs, or permission of instructor.

BIOL 266 Cell Biology

Credit: 0.5

This course is designed to introduce the student to the wide variety of questions being asked by researchers in this exciting field and the approaches they are taking to answer these questions. This course complements BIOL 263 (Molecular Biology) in content, concentrating on the nongenomic aspects of the cell. We will cover topics such as biological membranes and ion channels, cell organelles and their function, cell regulation, and intercellular and intracellular communication. May be offered in alternating years. Prerequisite: BIOL 116. Prerequisite or corequisite: CHEM 121.

Instructor: Itagaki

BIOL 267 Experimental Cell Biology

Credit: 0.25

This laboratory course is designed to complement BIOL 266. The topics covered in the laboratory will expose the student to some of the standard techniques used in modern cell

biology. The laboratories will also illustrate some of the fundamental ideas of the field. Instead of covering a wide variety of techniques and preparations superficially, we will concentrate on a select few, covering them in greater depth. Some topics that will be covered are protein and lipid separation, cell permeability, cell motility, and mitochondrial function. May be offered in alternating years. Prerequisites: BIOL 109Y-110Y. Prerequisite or corequisite: BIOL 266.

Instructor: Itagaki

BIOL 321 Developmental Biology

Credit: 0.5

This course concerns the mechanisms responsible for building multicellular eukaryotic organisms, with examples from vertebrates, invertebrates, and plants. The processes of fertilization, embryonic axis formation, morphogenesis, organogenesis, and cellular differentiation will be examined at the molecular and cellular levels. Particular attention will be devoted to the experimental basis for current models of these processes. Students will read original research literature as well as standard texts. May be offered in alternating years. Prerequisites: BIOL 116 and any 200-level BIOL course.

Instructor: Hicks

BIOL 322 Experiments in Developmental Biology

Credit: 0.25

This laboratory course introduces students to both classical and modern experimental approaches for discovering developmental mechanisms, using model systems including sea urchin, chick, *Xenopus*, *Drosophila*, *Caenorhabditis*, and zebrafish. Students document major cellular and developmental events in embryogenesis of these organisms, and conduct experiments to investigate the cellular, molecular, and genetic bases of morphogenesis, pattern development, and developmental determination. May be offered in alternating years. Prerequisite: BIOL 109Y-110Y. Prerequisite or corequisite: BIOL 321.

Instructor: Hicks

BIOL 328 Global Ecology and Biogeography

Credit: 0.5

This is a comprehensive course in the large-scale history and dynamics of the biosphere. The course will begin with a focus on biogeography and macroecology, with the goal of describing and understanding very general patterns in the distribution, abundance, and functioning of organisms. Special attention will be given to patterns of biodiversity and their basis in both ecological (dispersal, competition) and evolutionary (speciation, extinction) processes. The second phase of the course will examine current attempts to model dynamic ecological processes

at the global scale, with a focus on feedbacks between ecosystems and the atmosphere, and the relationship between biodiversity and ecosystem function. The conclusion of the course will examine the large-scale interactions between *Homo sapiens* and the rest of the biosphere, including recent attempts to quantify both human impacts and the value of global ecosystem services. The course will be conducted seminar-style, and most of the reading will be drawn from recent primary literature. The development of research methods using published data, Internet databases, and model output to address ecological questions at continental to global scales will be an integral part of this course. May be offered in alternating years. Prerequisites: At least one of BIOL 228, 241, 251, or 261, or permission of the instructor.

Instructor: Kerkhoff

BIOL 333 Environmental Toxicology

Credit: 0.5

This course examines the effects of chemical contaminants on molecular, organismal, and ecological systems. Topics include sources and movement of contaminants in the environment, basics of toxicity testing, molecular mechanisms of contaminant effects, and ecological risk assessment. The course will use readings from standard texts, the popular press, and primary literature, placing particular emphasis on current experimental approaches and problem-solving methods. Rather than surveying a wide variety of topics superficially, the course will concentrate on selected issues and stories that illustrate important contemporary issues in environmental toxicology. May be offered in alternating years. This course fulfills the cellular and molecular diversity requirement for the biology major. Prerequisite: BIOL 116 and at least one biology lecture course at the 200 or 300 level.

Instructor: Powell

BIOL 336 Integrative Biology of Animals

Credit: 0.5

This course will seek to understand general principles in animal biology through a topics-based approach. We will develop integrative understandings of animals, studying them from genetic, molecular, biochemical, physiological, organismal, evolutionary, and environmental frameworks. Although both invertebrate and vertebrate animals will be studied, invertebrates will be the primary focus because of the large number and spectacular diversity of invertebrate species. Emphasis will be placed upon understanding the experimental evidence that has led to the current understanding of animal biology, and controversial topics in animal biology will be explored. Prerequisite: at least one biology lecture course at the 200 or 300 level.

Instructor: C. Gillen

BIOL 346 Introduction to Microscopy and Image Analysis

Credit: 0.25

This laboratory is designed to give students a theoretical background in microscopy and an opportunity to use the power of microscopy as an investigative tool. We first learn about the mechanics and physics of optics and light. We learn how to manipulate the microscope to create amazing contrast in cells with apparently no contrast. Later, we will investigate questions pertaining to the physiology or structural biology of eukaryotic organisms, from protists to plants and animals. Techniques covered will include: bright, dark-field, phase-contrast, polarized light, epifluorescence, and differential interference microscopy. Students will learn how to prepare and view living and fixed cells and tissues. We will compare confocal, digital deconvolution, and electron microscopy, and we will explore some of the groundbreaking results that light microscopy has delivered to our understanding of biology. The course may be offered in alternating years. Prerequisite: BIOL 109Y-110Y.

Instructor: Edwards

BIOL 349 Evolutionary Modeling

Credit: 0.25

With the increasing use of computer modeling of complex systems, evolutionary algorithms have become a useful tool in exploring questions in evolutionary biology. This course introduces students to evolutionary algorithms, computer models of evolutionary processes. Through readings, lectures, guided exercises and independent work, students will gain familiarity with the advantages and disadvantages of using computer models to explore questions in evolutionary biology. Primary focus will be on one research platform, Avida, and on its strengths and limitations as a research tool to study fundamental principles of evolution. Issues accessible to study using Avida include the topography of fitness landscapes and selective environments, the relative effects of mutations of various kinds and rates, the emergence of complexity in evolving populations and the "transfer" of complexity from environment to genome via evolutionary processes, and so on. Prerequisite: junior or senior standing and at least one biology lecture course at the 200 or 300 level or permission of instructor. No particular computer expertise is required. Can be used to fulfill a lab requirement for the Biology major.

BIOL 352 Aquatic Systems Biology

Credit: 0.5

This course is designed to introduce students to the study of freshwater ecosystems, including lakes, streams, and wetlands. Human activities have had profound impacts on freshwater life and an understanding of the dynamics of freshwater systems is instrumental in determining how to protect and restore these habitats. We will examine the physical, chemical, and biological factors influencing biological diversity and productivity, and will emphasize the application of ecological principles to study these systems. Possible topics include the effects of agricultural run-off and eutrophication; erosion resulting from human development; the introduction of non-native species; toxic contaminants; and restoration techniques. Standard texts as well as primary

literature will be used. May be offered in alternating years. Prerequisite: BIOL 115 and at least one biology lecture course at the 200 or 300 level.

Instructor: Fennessy

BIOL 353 Aquatic Systems Lab

Credit: 0.25

In this laboratory course, students will employ methods used in the study of freshwater ecosystems. It is designed to complement either BIOL 251 or BIOL 352. Students will learn to identify freshwater organisms, quantify biological, chemical, and physical parameters that affect these organisms, and design ecological experiments. Throughout the course, laboratories will emphasize hypothesis testing, quantitative methods, and experimental design. Field trips will be taken to local natural habitats, and many lab periods will be spent doing fieldwork. May be offered in alternating years. Prerequisites: BIOL 109Y-110Y. Prerequisite or co-requisite: BIOL 251 or 352 or permission of instructor.

Instructor: Fennessy

BIOL 358 Neurobiology

Credit: 0.5

The study of the nervous system is a field that has experienced explosive growth in the past few decades. This course is designed to introduce the student to modern neurobiology by covering the basic foundations as well as the latest results from current research. Subject matter will range from the biophysics of membranes and ion channels, through sensory integration and simple behaviors, to the development of the nervous system. Rather than cover a wide variety of topics superficially, we will concentrate more time on selected topics that illustrate the current thinking of neurobiologists. May be offered in alternating years. Prerequisites: BIOL116 and at least one biology lecture course at the 200 or 300 level. Experience in math and/or physics is strongly recommended.

Instructor: Itagaki

BIOL 359 Experimental Neurobiology

Credit: 0.25

This is a laboratory designed to complement the lecture course. We will concentrate on the different intracellular and extracellular electrophysiological recording techniques commonly used in the field to illustrate both motor and sensory aspects of nervous-system function. We will also use molecular techniques to define the distribution of some neurotransmitters in the central nervous system. We will conclude with a series of independent projects that will bring together

the ideas covered earlier in the course. May be offered in alternating years. Prerequisites: BIOL 109Y-110Y. Prerequisite or corequisite: BIOL 358.

Instructor: Itagaki

BIOL 362 Ecological and Evolutionary Physiology

Credit: 0.5

Students will read the current primary literature in the fields of physiological ecology and evolution. The seminar is constructed around student-led discussion. Students will read and critique important papers ranging from life history evolution to techniques for assessing age-related changes on the cellular level. Not offered in most years. Prerequisites: at least one biology lecture course at the 200 or 300 level and permission of the instructor.

Instructor: Mauck

BIOL 375 Virology

Credit: 0.5

In this course, students examine the form and function of viruses through current research papers and through documentaries on viral disease. Specific viruses are examined in depth, exemplifying their roles in human and animal health, biotechnology, and global ecology. Topics may include: human papillomavirus, a DNA virus causing cancer, including its molecular biology as well as controversies over vaccination; Ebola virus, an RNA virus with extraordinary virulence; influenza virus, an RNA virus of humans and animals with pandemic potential; human immunodeficiency virus, the cause of AIDS, including its molecular biology and regulation, chemotherapy development, and epidemiology; and the use of viral vectors for gene therapy. May be offered in alternating years. Prerequisites: BIOL 238, 243, 263, 266 or 358. Prerequisite or corequisite: CHEM 231.

Instructor: Slonczewski

BIOL 385 Research in Biology

Credit: 0.25

This combined discussion and laboratory course aims to develop abilities for asking sound research questions, designing reasonable scientific approaches to answer such questions, and performing experiments to test both the design and the question. We consider how to assess difficulties and limitations in experimental strategies due to design, equipment, organism selected, and so on. The course provides a detailed understanding of selected modern research equipment. Students select their own research problems in consultation with one or more biology faculty members. This course is designed both for those who plan to undertake honors research in their senior year and for those who are not doing honors but want some practical research

experience. A student can begin the course in either semester. If a year of credit is earned, it may be applied toward one laboratory requirement for the major in biology. Prerequisites: BIOL 109Y-110Y and 116, and permission of instructor.

BIOL 386 Research in Biology

Credit: 0.25

See course description for BIOL 385.

BIOL 393 Independent Study in Biology

Credit: 0.25-0.5

This course provides the student with the opportunity to pursue an independent investigation of a topic of special interest not covered, or not covered in depth, in the current curriculum. The investigation, designed in consultation with the chosen faculty mentor, may be designed to earn .25 or .5 unit of credit in a semester. BIOL 393 is ordinarily a library-oriented investigation. (For laboratory-oriented independent research, see BIOL 385 and 386.) Normally, students receive credit for no more than two semesters of independent study. Independent study does not count toward diversification requirements for the biology major. Prerequisite: permission of the department.

BIOL 493 Independent Study in Biology

Credit: 0.25-0.5

Individual study in biology, typically pursued by juniors or seniors, provides an opportunity to pursue an independent investigation of a topic of special interest not covered, or not covered in depth, in the curriculum. The investigation, designed in consultation with the chosen faculty mentor, may be designed to earn .25 or .5 unit of credit in a semester and may be continued in the second semester. BIOL 393 ordinarily involves literature-oriented investigations. (For laboratory-oriented independent research, see BIOL 385 and 386). Normally, students receive credit for no more than two semesters of individual study. Such study cannot be used to fulfill either the natural science diversification requirement or the requirements for the major. To enroll in individual study, a student must identify a member of the Biology Department willing to mentor the project and, in consultation with him or her, draft a syllabus, including readings, a schedule, and assignments, which must be approved by the department chair. The student should meet regularly with the instructor for at least one hour per week or the equivalent. The amount of graded work should approximate that required, on average, in 300-level biology courses, at a minimum. In the case of group individual studies, a single course syllabus may be submitted, assuming that all group members will follow the same syllabus. Students are urged to begin discussion of their proposed work well in advance, preferably the semester before, so that they can devise a syllabus and seek departmental approval before the registrar's deadline.

BIOL 497 Senior Honors

Credit: 0.5

This course offers an in-depth research experience. Prior to enrollment in Senior Honors, students are expected to complete at least one semester of BIOL 385-386 (Research in Biology) and participate in the Summer Science Scholars program. Two semesters of BIOL 385-386 are recommended. Emphasis is on completion of the research project. Students are also instructed in poster production and produce one or more posters of their honors work for presentation at Kenyon and possibly at outside meetings. There will be oral progress reports. The letter grade is determined by the instructor and project advisor in consultation with the department. Students must have an overall GPA of at least 3.33 and a GPA of 3.33 in biology. Prerequisites: BIOL 385 or 386 and permission of the project advisor and the department.

BIOL 498 Senior Honors

Credit: 0.5

This course continues the honors research project and gives attention to scientific writing and the mechanics of producing a dissertation. A dissertation is required and is defended orally to an outside examiner. The letter grade is determined by the instructor and project advisor in consultation with the department. Prerequisites: BIOL 385 or 386, and 497.