Biology

Natural Sciences Division

The biology curriculum structures learning based on the scientific process of discovery: observation, interpretation, experimentation, analysis, and the formation of new theory. 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.

Faculty

Karen A. Hicks, Chair, Associate Professor
Kathryn L. Edwards, Professor
M. Siobhan Fennessy, Professor
Christopher M. Gillen, Associate Professor
Kathy M. Gillen, Assistant Professor
E. Raymond Heithaus, Jordan Professor of Environmental Science
Patricia A. Heithaus, Instructor
Haruhiko Itagaki, Professor
Andrew J. Kerkhoff, Assistant Professor of Biology and Mathematics
Robert A. Mauck, Associate Professor (on leave)
Wade H. Powell, Associate Professor
Joan L. Slonczewski, Professor

Emeritus Faculty

Robert D. Burns, Professor Emeritus
Dorothy E. Jegla, Professor Emerita
Thomas C. Jegla, Professor Emeritus

The Biology Curriculum (beginning fall 2009/class of 2013)

Biology majors must take both foundation courses, BIOL 115 and 116 (unless specifically exempted by AP exams or by departmental placement exams during orientation), 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 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. For additional information, see the chair of either the biology or chemistry department.

Non-majors can choose innovative topical courses that approach biological issues in a human context (BIOL 103, 104, 105, 107). These courses are designed for students with minimal backgrounds in biology. The foundation courses—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 109-110Y 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 (starting with the class of 2013)

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.
- One year of Introductory Chemistry lecture (or AP placement).
- 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).
- Six upper-division lecture courses, including at least one 300-level course. MATH 258 counts toward this requirement.

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, 261, 272, 328, and 352.
- Organismal biology/physiology: BIOL 233, 238, 243, 245, 336, and 358.
- Cellular and molecular biology: BIOL 238, 255, 263, 266, 321, and 333.

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.

Requirements for the Biology Major (through the class of 2012)

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

- BIOL 112, 113, 114 (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.
- One year of Introductory Chemistry lecture (or AP placement).
- 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).
- Five upper-division lecture courses. MATH 258 counts toward this requirement.

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, 261, 272, 328, and 352.

- Organismal biology/physiology: BIOL 233, 238, 243, 245, and 358.
- Cellular and molecular biology: BIOL 238, 255, 263, 266, 321, and 333.

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.

Substitution Policy (through the class of 2012)
Biology majors may petition to substitute a 200-level course for one of the introductory lecture courses (BIOL 112, 113, 114) if the following conditions are met:

1. Students must have completed two introductory lecture courses (or they must have completed one and be currently enrolled in a second). Placement out of BIOL 113 with AP credit of 5 may be used towards this requirement.

2. Students must have consulted with a member of the biology department. Since this policy applies to students planning on majoring in biology, students who have advisors in other disciplines are encouraged to declare the biology major and choose an advisor in biology.

3. Students must have the permission of the 200-level course instructor to enroll without the 100-level prerequisite.

Allowed substitutions:
- For BIOL 112: BIOL 228 (Ecology) or BIOL 241 (Evolution)
- For BIOL 113: BIOL 233 (Plant Biology), BIOL 243 (Comparative Animal Physiology), or BIOL 245 (Environmental Plant Physiology)
- For BIOL 114: BIOL 238 (Microbiology), BIOL 255 (Genetic Analysis), or BIOL 263 (Molecular Biology and Genomics)

Important: This is a course substitution policy. The substituted course counts in place of the introductory lecture and does not count as fulfilling the upper-level diversification requirement. Five additional upper-level lecture courses still must be taken.

Senior Exercise (for all class years)
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 (for all class years)
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, 238, 239, 245, 251, 255, 256, 266, 321, 322, 328, 333, 336, 346, 352, 353, 358, 359, and 367.

Honors (for all class years)
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 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 (starting with the class of 2013)
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 any of the area minors.

Requirements for the Biology Minor (through the class of 2012)
The minor in biology can be earned in one of five areas of biology, listed as A through E below. The minor requires a minimum of 3 units of credit earned in the major curriculum; these must include the introductory laboratories, 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 any of the area minors. Specific course requirements for each area minor are listed below.

Attention: Please be advised that the two 1-unit requirements below must include at least one upper-level laboratory. The 2 units mean 2 units of earned credit, not four courses per se.

A. Environmental Biology
BIOL 109Y-110Y Introduction to Experimental Biology
BIOL 112 Evolution and Ecology
2 units from:
BIOL 228 Ecology
BIOL 229 Ecology Laboratory

BIOL 241 Evolution
BIOL 251 Marine Biology
BIOL 261 Animal Behavior
BIOL 262 Experimental Animal Behavior
BIOL 272 Microbial Ecology
BIOL 328 Global Ecology and Biogeography
BIOL 352 Aquatic Systems Biology
BIOL 353 Aquatic Systems Lab
ENVS 461 Environmental Studies

B. Plant Biology
BIOL 109Y-110Y Introduction to Experimental Biology
BIOL 112 Evolution and Ecology
BIOL 113 From Cell to Organism
1.5 units from:
BIOL 233 Plant Biology
BIOL 234 Laboratory Experiences in Plant Biology
BIOL 245 Environmental Plant Physiology
BIOL 346 Introduction to Microscopy and Image Analysis

C. Molecular Biology and Genetics
BIOL 109Y-110Y Introduction to Experimental Biology
BIOL 114 Genetics and Development of Organisms
2 units from:
BIOL 238 Microbiology
BIOL 239 Experimental Microbiology
BIOL 255 Genetic Analysis
BIOL 256 Experimental Genetic Analysis
BIOL 263 Molecular Biology and Genomics
BIOL 264 Gene Manipulation
BIOL 321 Developmental Biology
BIOL 322 Experiments in Developmental Biology
BIOL 364 Principles of Gene Manipulation

D. Physiology
BIOL 109Y-110Y Introduction to Experimental Biology
BIOL 113 From Cell to Organism
2 units from:
BIOL 238 Microbiology
BIOL 239 Experimental Microbiology
BIOL 243 Comparative Animal Physiology
BIOL 244 Experimental Animal Physiology
BIOL 245 Environmental Plant Physiology
BIOL 266 Cell Biology or BIOL 366 Cell Physiology
BIOL 267 Experimental Cell Biology or
BIOL 367 Experimental Cell Physiology
BIOL 333 Environmental Toxicology
BIOL 336 Integrative Biology of Animals
BIOL 346 Introduction to Microscopy and Image Analysis
BIOL 358 Neurobiology
BIOL 359 Experimental Neurobiology

E. Biology
BIOL 109Y-110Y Introduction to Experimental Biology
BIOL 112 Evolution and Ecology
BIOL 113 From Cell to Organism
BIOL 114 Genetics and Development of Organisms
1 unit: Any upper-level courses in biology

Cross-Listed Courses

The following courses are cross-listed in the biology offerings:
ENVS 112 Introduction to Environmental Studies
MATH 258 Mathematical Biology

Biology Courses

BIOL 103 Biology in Science Fiction

Credit: .5 unit **QR**

Science-fiction literature extends our knowledge of the natural world in extraordinary ways. 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 ecosystems 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: 0.63 unit

This is an introductory biology course that considers contemporary health issues relating to the human female body. In order to better position these issues in the Western patient-medical-pharmaceutical context, we explore the Western feminist critique of science and medicine. Sexual and reproductive biology of the human female is examined as physicians/scientists and women have come to describe and understand it, along with the societal values that influence research on women. Topics may include the biological bases for understanding cancer, heart disease, reproduction and cloning, contraception, drugs and fetal development, designer drugs and performance, the place for gynecologists and midwives in women's birthing, aging, Eastern medical philosophy, herbal medicines, and better health-care systems. Attention is paid to voices of marginalized women, including black women, lesbians, and disabled women, throughout the course. Students will undertake group projects designed to learn from one another, and groups will learn to lead class discussions using a cooperative learning model. The underlying goals of the course are to improve our capacity to act as health-care consumers, to forge a feminist understanding of women's health concerns in a social context, and to learn skills for bridging differences amongst our diverse selves. Texts have included

Ethel Sloane's *Biology of Women*, Evelyn White's *The Black Women's Health Book*, and *A New View of Woman's Body*. May be offered in alternating years. No prerequisites.

BIOL 105 Biology of Exercise

Credit: .5 unit

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 107 Scaling in Biology: Why Size Matters

Credit: .5 unit **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. This class is based on the idea that you can learn an awful lot of biology just by asking that fundamental question: "Is it bigger than a breadbox?" We will explore how size determines the form, function, pace, and complexity of life. Our questions will span 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, and could he actually feed himself, or walk for that matter?). Living things span an amazing range of sizes, and by studying the size extremes of the living world, we will develop a framework for comparing not just apples and oranges, but bacteria and blue whales. Surreal perspectives on biology such as Swift's *Gulliver's Travels*, Kafka's *Metamorphosis*, and films like A *Fantastic Voyage* and *Destroy All Monsters*, will further highlight the truly amazing nature of biological reality. This course has no prerequisites or enrollment limits. This course will be offered every other year.

Instructor: Kerkhoff

BIOL 109Y Introduction to Experimental Biology

Credit: .25 unit **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 of five sections.

BIOL 110Y Introduction to Experimental Biology

Credit: .25 unit **QR**

See course description for BIOL 109Y.

BIOL 115 Energy in Living Systems

Credit: .5 unit

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: .5 unit

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 or permission of instructor. This course will be offered every year.

BIOL 228 Ecology

Credit: .5 unit

This course will study mechanisms that influence the distribution and abundance of organisms. Topics will include physiological ecology, population ecology, competition, predator-prey systems, mutualism, succession, energy and nutrient dynamics, and the ecology of communities, ecosystems, and landscapes. We will explore the influence of humans on natural systems. Students will use simulation models and original 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: .25 unit

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 geopgraphic information science. Topics include limits to distribution, interactions with the physical environment, population dynamics, species interactions, productivity, and biodiversity. Studies will include field trips to local habitats in varying weather conditions. Prerequisite: BIOL 109Y-110Y and BIOL 115 or permission of the instructor.

BIOL 233 Plant Biology

Credit: .5 unit

This course presents an introductory examination of plant function and structure. Physiological features of morphology, growth, reproduction, species interactions, and evolutionary patterns will be considered, with an emphasis on flowering plants. Comparative life cycles and structures of different divisions of plants and algae will also be discussed, as will problems with plant classification schemes. Practical issues in plant biology may be designated by the class participants for disussions. May be offered in alternating years. Prerequisite: BIOL 115 or permission of the instructor.

BIOL 234 Laboratory Experience in Plant Biology

Credit: .25 unit

This course introduces methods for analyzing plant morphology, physiology, and molecular taxonomy. Topics will include the cell, tissue, and organ structure of vascular seed plants, as well as experimental investigation of selected plant processes such as flowering, photosynthesis, and hormonal interactions in growth and development. In addition, students will carry out a semester-long independent analysis of an unknown plant. May be offered in alternating years. Prerequisite: BIOL 109Y-110Y. Prerequisite or corequisite: BIOL 233.

BIOL 238 Microbiology

Credit: .5 unit

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. May be offered in alternating years. Prerequisite: BIOL 116.

Instructor: Slonczewski

BIOL 239 Experimental Microbiology

Credit: .25 unit

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: .5 unit

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 Comparative Animal Physiology

Credit: .5 unit

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.

Instructor: C. Gillen

BIOL 244 Experimental Animal Physiology

Credit: .25 unit

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: .5 unit

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. Prerequisite: BIOL 115.

Instructor: Edwards

BIOL 251 Marine Biology

Credit: .5 unit

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 Paleomarine Biology

Credit: .5 unit

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., lagerstatten), 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 112. This class fulfills the Environmental Biology diversity requirement for the Biology major.

BIOL 255 Genetic Analysis

Credit: .5 unit

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: .25 unit

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: .5 unit

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 115 and 116 or permission of the instructor.

Instructor: Mauck

BIOL 262 Experimental Animal Behavior

Credit: .25 unit

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: .5 unit

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 115, 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: .25 unit

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: .5 unit

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 363 (Molecular Biology) in content, concentrating on the nongenomic aspects of cell function. 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 115 and BIOL 116.

Instructor: Itagaki

BIOL 267 Experimental Cell Biology

Credit: .25 unit

This laboratory course is designed to complement BIOL 366. 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 272 Microbial Ecology

Credit: .5 unit

Microbes form the foundation of our terrestrial biosphere and perhaps that of other planets as well. Most conversions of the nitrogen cycle are performed exclusively by microbes; much of the global carbon and oxygen cycle depends on them. Yet less than 0.01 percent of the microbial species detectable in our environment are known to science. This course investigates the essential roles of microbes in various ecosystems, ranging from deep-sea thermal vent communities, to Ohio wetlands, to the human digestive flora. We examine microbial mutualism in systems such as the luminescent organs of deep-sea fish, the fungal germination of orchids, and the digestion of wood by termites. The diversity of microbial flora is explored, including protists, fungi, algae, prokaryotes, and archaea. We practice methods of identification and enumeration of environmental microbes. Applications of these topics include bioremediation and water treatment. Not offered in most years. Prerequisite: BIOL 116 or permission of the instructor.

Instructor: Slonczewski

BIOL 321 Developmental Biology

Credit: .5 unit

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: .25 unit

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: .5 unit

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: .5 unit

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, 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. Prerequisite: BIOL 115 and BIOL 116 and any 200-level BIOL course.

Instructor: Powell

BIOL 336 Integrative Biology of Animals

Credit: .5 unit

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. May be offered in alternating years. Prerequisite: at least one biology lecture course at the 200 or 300 level.

Instructor: C. Gillen

BIOL 337 Experimental Animal Biology

Credit: .25 unit

This laboratory class will explore the comparative structure and function of animals. We will explore comparative anatomy, animal diversity, evolutionary relationships, and function of living animals. Laboratory work will be complemented with critical reading of recent research papers and consideration of controversies in animal biology. May be offered in alternating years. Note: The lecture course BIOL 336 is not a prerequisite for this course. Prerequisites: BIOL 109Y-110Y; prerequisite or corequisite: BIOL 243 or 336.

Instructor: C. Gillen

BIOL 346 Introduction to Microscopy and Image Analysis

Credit: .25 unit

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. To accomplish this, we will be investigating questions pertaining to the physiology of a wide range of eukaryotic organisms, including protists, plants, and animals. Techniques covered will include: bright, dark-field, phase-contrast, polarized light, epifluorescence microscopy, and differential interference microscopy (DIC). Students will learn preparation and viewing of living and fixed cells and tissues. Confocal, digital deconvolution, and electron microscopy will also be compared along with an exploration of some of the goundbreaking results that light microscopy has delivered to our understanding of biology. May be offered in alternating years. Prerequisite: BIOL 109Y-110Y.

Instructor: Edwards

BIOL 349 Evolutionary Modeling

Credit: .25 unit

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 with at least one biology course at the 200 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: .5 unit

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 or permission of the instructor.

Instructor: Fennessy

BIOL 353 Aquatic Systems Lab

Credit: .25 unit

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 corequisite: BIOL 251 or 352 or permission of instructor.

Instructor: Fennessy

BIOL 358 Neurobiology

Credit: .5 unit

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: BIOL 115 and 116. Experience in math and/or physics is strongly recommended.

Instructor: Itagaki

BIOL 359 Experimental Neurobiology

Credit: .25 unit

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: .5 unit

Students will read the current primary literature in the fields of physiological ecology and evolution while learning to use the modern tools integral to the discipline. The seminar combines student-led discussion with hands-on activities in both field and lab. In discussion modules, students will read and critique important papers ranging from life history evolution to techniques for assessing age-related changes on the cellular level. Research modules apply both field and laboratory techniques presented in the readings. Individual research projects will involve students in experimental design, field sample collection, laboratory molecular techniques, appropriate statistical analysis, and oral presentation of the data. Not offered in most years. Prerequisites: permission of the instructor and completion of the introductory biology series.

BIOL 375 Virology

Credit: .5 unit

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: the M13 bacteriophage as a tool for nanotechnology; 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; and human immunodeficiency virus, including its molecular biology and regulation, chemotherapy development, and epidemiology, as well as its applications for gene therapy. Prerequisites: BIOL 238, 243, 266, or 358. Prerequisite or corequisite: organic chemistry.

Instructor: Slonczewski

BIOL 385 Research in Biology

Credit: .25 unit

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, 115, and 116, and permission of instructor.

BIOL 386 Research in Biology

Credit: .25 unit

See course description for BIOL 385.

BIOL 393 Independent Study in Biology

Credit: .25 unit-.5 unit

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: .25 unit-.5 unit

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. 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 497 Senior Honors

Credit: .5 unit

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: .5 unit

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.