In addition, excellent opportunities exist for research and instruction off-campus at field research sites including:

- Blackwater Ecological Preserve,
- Virginia Coast Reserve-Long Term Ecological Research Site,
- Virginia Institute of Marine Sciences Eastern Shore Marine Laboratory, and
- other regional agencies and facilities.

**Admission Information**

Students who wish to enter this program should apply to the Master of Science in biology program and indicate their proposed field of study in the Statement of Interest, a required component of the application. Applications for admission can be obtained via the Internet at http://www.odu.edu/admission/graduate or from:

Office of Graduate Admissions
Old Dominion University
Norfolk, VA 23529-0050
(757) 683-3685

Requirements for regular admission to the master’s program in biology are:

1. a bachelor’s degree in biology or a related field from an accredited college or university;
2. a grade point average of at least 3.00 on a 4.00 scale;
3. Satisfactory scores on the General portion of the Graduate Record Examination (Verbal+Quantitative 1000 or 300 on the new GRE) or at least a 24 on the Medical College Admission Test
4. two letters of recommendation;
5. an essay describing the area of biology of interest for graduate study, professional goals and motivation for graduate study in biology; and
6. written acknowledgment from a Department of Biological Sciences faculty member agreeing to serve as the student’s major advisor, if the student is accepted.

The Test of English as a Foreign Language (TOEFL) is required of all applicants whose native language is not English: minimum scores are 550 for the paper-based test, 213 for the computer-based or 79 on internet-based test.

**Deadlines for application to the program are:**

- February 1 for summer admission, early fall admission and consideration for a graduate teaching assistantship;
- June 1 for fall semester admission; and
- October 1 for spring semester admission.

**Degree Requirements**

Two degree options are available — thesis and non-thesis. A minimum of 31 semester hours of graduate credit is required of thesis students and 37 of non-thesis students; three-fifths of these credits must be at the 600-level or above. Research (BIOL 698) is required of all students. All students must deliver a scientific presentation in an appropriate public forum. For thesis students, the presentation should be at a scientific meeting. Course work, including any required courses, is selected according to the interest of the student, with the guidance and approval of the student’s faculty advisory committee. All students will complete a comprehensive exam (written or oral) that covers the student’s program of study. A substantial research project and a defense of the written thesis (BIOL 699) are required of students selecting the thesis option.

**Master of Science - Biology**

Many pertinent graduate courses are offered for the Master of Science in Biology programs that can be applied toward the degree requirements. A program of study is developed by the student with approval of an advisory committee and the Graduate Program Director.

**Master of Science - Wetland Biology Concentration**

The wetland biology concentration has been structured to contain essential clusters in the following disciplines: plant identification, wetland and aquatic ecology, soils and hydrology, regulation, technical application, topical seminars, internships, and research and/or thesis. Recommended course are:

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<td>Wetland Plants</td>
<td>5</td>
</tr>
<tr>
<td>BIOL 550</td>
<td>Principles of Plant Ecology</td>
<td>4</td>
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<tr>
<td>OEAS 508</td>
<td>Introductory Soils</td>
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Many faculty combine active field research with parallel laboratory studies. Quantitative approaches are encouraged and the opportunity exists to obtain a master’s degree in statistics while pursuing a doctorate in ecological sciences. The program is enhanced by excellent on-campus resources that include a scanning electron microscopy lab, genetic sequencing facilities, herbarium, aquatics laboratory, water tunnel and flow quantification facility, GIS facilities, greenhouse, and digital imaging facilities. Field research sites have been established in:

- the Virginia Coastal Reserve,
- Blackwater Ecologic Preserve,
- Great Dismal Swamp,
- Atlantic Ocean,
- Chesapeake Bay, and
- other areas.

### Admission

Application forms for admission to the Ph.D. program in ecological sciences are available from the Office of Admissions and online (http://www.odu.edu/admission/graduate). The following should be sent to the Admissions Office:

1. the completed application form;
2. official transcripts from all universities attended;
3. Graduate Record Examination (GRE) scores;
4. test of English as a Foreign Language (TOEFL) score (from students whose native language is not English);
5. three letters of recommendation, including one from the applicant’s major advisor; and,
6. a statement of professional goals that includes specific research interests.

If an applicant is interested in requesting financial aid, an application for institutional graduate financial assistance should be completed during the application process (see Office of Admissions web page for form). The deadline for application to the program is February 1 for the subsequent fall semester. Students may be admitted during the spring and summer semesters as well, provided they obtain permission from the Graduate Program Director.

To qualify for admission, a student needs:

1. a satisfactory academic average (overall GPA score of at least 3.0 on a 4.0 scale, and overall GPA in the sciences of at least 3.0);
2. GRE scores near the 70th percentile on each of the examination sections (verbal, quantitative, and analytical) with a combined total of at least 1,000 to 1,200 preferred on the verbal and quantitative sections;
3. a TOEFL score of at least 550 (paper-based test), 213 (computer-based test), or 79 (internet-based test) for applicants whose native language is not English;
4. satisfactory letters of recommendation; and
5. a statement of professional goals as stated above.

A master’s degree is desirable but not required. The applicant is expected to have a background in the sciences, with an appropriate undergraduate degree and substantial course work in biology, chemistry or geology.

Applicants are strongly advised to contact the ODU faculty member closest to their area of interest prior to submitting an application to determine whether that faculty member is accepting new graduate students. No student, regardless of qualifications, is admitted to the Ecological Sciences Program without the approval of a specific faculty advisor. Potential applicants therefore should initiate a dialogue, preferably by email, with an appropriate member of the program faculty. Applicants should consult the list of faculty in the Department of Biological Sciences, which includes a brief description of their research interests. Applicants may also find it desirable to visit the campus for an interview with a potential advisor and the Graduate Program Director.

It is important for potential applicants to realize that many considerations enter into the decision to accept a student into the program. In addition

### Master of Science - Biotechnology Concentration

The biotechnology program is designed to enable the student to learn basic skills in cell and molecular biology, with the flexibility to develop a curriculum in the areas of infectious diseases, immunology, physiology, or environmental molecular biology.

Biotechnology students are required to take five core courses (below) in addition to the research and presentation requirements.

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The remaining coursework is selected according to the interest of the student, with the guidance and approval of the student’s faculty advisory committee.

### Doctor of Philosophy - Biomedical Sciences

Robert E. Ratzlaff, Graduate Program Director

In this interdisciplinary program all students are required to master a broad knowledge of the basic biomedical sciences. Refer to the College of Sciences (http://catalog.odu.edu/previous/2016-2017/graduate/collegesofsciences) section of this catalog for details.

### Doctor of Philosophy - Ecological Sciences

Dr. Holly Gaff, Graduate Program Director

### Program Description

The primary goal of the doctoral program in ecological sciences is to provide advanced training in ecological, evolutionary and integrative biology.

The program has notable strengths in a broad range of biological sub-disciplines, including:

- ecosystem studies,
- experimental ecology,
- community ecology,
- behavioral ecology,
- marine biology,
- molecular genetics,
- conservation biology,
- systematics,
- modeling,
- evolutionary biology,
- biomechanics,
- parasitology, and
- functional morphology.

Program faculty conduct studies in a variety of terrestrial, freshwater, and marine environments on several continents, and their research focuses on a broad spectrum of taxa, including, but not limited to:

- vascular plants,
- polychaetes,
- mollusks,
- crustaceans,
- insects,
- arachnids,
- birds,
- fishes, and
- amphibians.

Many faculty combine active field research with parallel laboratory studies. Quantitative approaches are encouraged and the opportunity exists to obtain a master’s degree in statistics while pursuing a doctorate in ecological sciences. The program is enhanced by excellent on-campus resources that include a scanning electron microscopy lab, genetic sequencing facilities, herbarium, aquatics laboratory, water tunnel and flow quantification facility, GIS facilities, greenhouse, and digital imaging facilities. Field research sites have been established in:

- the Virginia Coastal Reserve,
- Blackwater Ecologic Preserve,
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- other areas.

### Application

Application forms for admission to the Ph.D. program in ecological sciences are available from the Office of Admissions and online (http://www.odu.edu/admission/graduate). The following should be sent to the Admissions Office:

1. the completed application form;
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If an applicant is interested in requesting financial aid, an application for institutional graduate financial assistance should be completed during the application process (see Office of Admissions web page for form). The deadline for application to the program is February 1 for the subsequent fall semester. Students may be admitted during the spring and summer semesters as well, provided they obtain permission from the Graduate Program Director.

To qualify for admission, a student needs:

1. a satisfactory academic average (overall GPA score of at least 3.0 on a 4.0 scale, and overall GPA in the sciences of at least 3.0);
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3. a TOEFL score of at least 550 (paper-based test), 213 (computer-based test), or 79 (internet-based test) for applicants whose native language is not English;
4. satisfactory letters of recommendation; and
5. a statement of professional goals as stated above.

A master’s degree is desirable but not required. The applicant is expected to have a background in the sciences, with an appropriate undergraduate degree and substantial course work in biology, chemistry or geology.

Applicants are strongly advised to contact the ODU faculty member closest to their area of interest prior to submitting an application to determine whether that faculty member is accepting new graduate students. No student, regardless of qualifications, is admitted to the Ecological Sciences Program without the approval of a specific faculty advisor. Potential applicants therefore should initiate a dialogue, preferably by email, with an appropriate member of the program faculty. Applicants should consult the list of faculty in the Department of Biological Sciences, which includes a brief description of their research interests. Applicants may also find it desirable to visit the campus for an interview with a potential advisor and the Graduate Program Director.

It is important for potential applicants to realize that many considerations enter into the decision to accept a student into the program. In addition

### Master of Science - Biotechnology Concentration

The biotechnology program is designed to enable the student to learn basic skills in cell and molecular biology, with the flexibility to develop a curriculum in the areas of infectious diseases, immunology, physiology, or environmental molecular biology.

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to the strength of an applicant’s credentials (GRE scores, transcripts, and letters of recommendation), the availability of space in the appropriate faculty advisor’s lab and availability of adequate financial aid may influence the decision. Of these, space in an appropriate advisor’s lab is the most important consideration after an applicant’s academic qualifications. For this reason, applicants are strongly encouraged to contact a potential advisor directly.

**Program Requirements**

Program requirements are designed to provide a firm foundation in conceptual elements of ecological, evolutionary, and integrative biology, while moving students expeditiously toward their own research. In general, students must complete:

- 48 hours beyond the master’s degree, or
- in the absence of a master’s, 78 hours beyond the bachelor’s degree.

The student’s program of study should be broad and balanced. Coursework varies with each student, depending on background and goals. Enrollment in a weekly ecology seminar is required, on average, one semester each year. Professional experience (environmental management or teaching) is encouraged. A five-member advisory committee of faculty is selected to guide the student through his or her course of study and to provide initial approval of the dissertation research. This committee also administers the comprehensive written and oral candidacy examinations, which are taken after all required coursework is completed and the research skill requirement (proficiency in one foreign language, computer programming, or a quantitative skill approved by the advisory committee) is satisfied. The written exam must be passed before the oral exam may be taken. Once the candidacy exams are completed and a dissertation committee approves a written dissertation prospectus, the student advances to candidacy. At least three of the members of the original advisory committee, including the committee chair (student’s major advisor), will compose the dissertation committee. This committee approves a written dissertation prospectus and will supervise the research. At this time, the student’s attention turns almost exclusively to his or her own research. However, students continue to participate in seminar courses on a variety of topics, and an average of one seminar course per year of residency on campus is required. At the conclusion of their research, the student submits a dissertation to the committee and presents a public defense of this work.

**BIOLOGICAL SCIENCES Courses**

**BIOL 500. Vascular Plant Families. 5 Credits.**
An evolutionary survey of vascular plant families and the principles and methodologies that define them; emphasis on recognition and skills of identification. A field intensive hands-on course. A research project including a written paper and presentation is required. Prerequisites: A botany course.

**BIOL 501. Entomology. 4 Credits.**
A comprehensive survey of the insects, including taxonomy, morphology, physiology, reproductive and developmental biology, and ecology. Research techniques in entomology will be learned through both field and laboratory work.

**BIOL 503. Medical Microbiology. 3 Credits.**
This course integrates the disciplines of microbiology, immunology, and biochemistry with the pathophysiology of infections and the appropriate pharmacology in a problem-based learning setting. Students will learn the fundamental concepts and terminologies of infectious diseases. The material will be case studies in small group tutorials and emphasize independent learning. Prerequisites: Microbiology and Biochemistry courses, anatomy course recommended, or instructor approval.

**BIOL 504. Conservation Biology. 5 Credits.**
The application of fundamental biological principles to the preservation of biodiversity, including the role of ecological and evolutionary theory to the preservation of biotas on a regional and global basis. Lectures will cover modern approaches to conservation biology, including conservation ethics and management issues. Laboratories will include discussion of case studies, introduction to software applicable to conservation biology, presentations by regional conservation practitioners, and visits to relevant field sites.

**BIOL 508. Introduction to Pharmacology. 4 Credits.**
This is a general introductory course in pharmacology dealing with chemistry, general properties and pharmacological effects on various physiological systems, therapeutic usefulness and toxicities of drugs. The course is designed to prepare upper-level undergraduate and graduate students for more advanced courses in pharmacology.

**BIOL 509. Immunology. 3 Credits.**
A comprehensive study of the phenomena of immune resistance, the cells and tissues involved in immune responses, and the consequences of immunization. Prerequisites: permission of the instructor.

**BIOL 511. Zymology: Fermentation Science. 4 Credits.**
This is an introductory course in the theory and practice of zymology (fermentation). Edible and potable products of fermentation (beer, wine, mead, yogurt, cheese) have been known since antiquity and play an important role in today’s society. The science of fermentation touches on many biological disciplines, such as microbiology and biochemistry, and the study of yeasts has provided considerable foundation to the fields of cell biology and molecular biology. In this course, we will cover fundamentals of fermentation and its practical application to production of beer, one of the oldest beverages produced by humans. Prerequisite: BIOL 293.

**BIOL 512. Plant Physiology. 4 Credits.**
A study of the physiological processes which occur in plants. A laboratory and greenhouse oriented course stressing plant nutrients, cell metabolism-respiration, photosynthesis, nitrogen metabolism, and plant hormones.

**BIOL 515. Marine Ecology. 3 Credits.**
An introduction to ecological processes in the marine environment, with an emphasis on coastal ecosystems. The course covers synthetic topics as well as the ecology of specific marine habitats. Prerequisites: A previous course in marine biology. Pre- or corequisites: When offered during the fall semester, BIOL 542 is a corequisite.

**BIOL 516. Clinical Immunology. 3 Credits.**
A description of common immunological problems seen in the clinic. Prerequisites: BIOL 509.

**BIOL 519. Wetland Plants. 5 Credits.**
A field-oriented course on the identification and ecology of aquatic and wetland plants with emphasis on plants used to delineate wetlands following federal guidelines. Activities include the use of identification databases, apps, and traditional floras, and monographs to develop identification skills using plants from the diversity of habitats in the region. A research project including a written paper and presentation is required. Prerequisites: A botany course.

**BIOL 520. Ichthyology. 5 Credits.**
The biology of marine and freshwater fishes including morphology, physiology, evolution, distribution, ecology, and reproduction.

**BIOL 522. Field Studies in Ornithology. 4 Credits.**
A combined lecture and field study of birds with emphasis on identification, behavior, and field methods. Extensive field trips, including at least one weekend, are taken.

**BIOL 523. Cellular and Molecular Biology. 3 Credits.**
The molecular organization of eukaryotic cells is presented along with cell evolution, molecular genetics, the internal organization of the cell and the behavior of cells in multicellular organisms. Prerequisites: course background in cell biology and genetics or permission of the instructor.

**BIOL 524. Comparative Animal Physiology. 5 Credits.**
An introduction to the basic mechanisms by which different animals function. How organisms acquire and use energy, regulate their internal environment, circulate and exchange gases and wastes, receive and conduct information about their environment, and move and use muscles will be some of the topics covered. Emphasis will be on how organisms make changes in these basic mechanisms to deal with different environmental conditions.
BIOL 525. Cancer Biology. 3 Credits.
This course will examine how mutation leads to altered gene products and expression, subverted cell activity, cell immortalization, and tumor formation. Students will explore the differences between benign tumors and malignant tumors as well as the factors involved in malignancy. The course will conclude with the exploration of current cancer therapy. Prerequisites: Cell Biology and Genetics courses.

BIOL 526. Histology. 5 Credits.
The structure and function of cells, tissues and organs at both the light microscopic and ultrastructural levels.

BIOL 530. Microbial Pathogenesis. 3 Credits.
Examination of bacterium-host interactions with an emphasis on how bacteria cause disease, particularly the means by which the bacterium is able to circumvent host defense mechanisms. Prerequisites: microbiology course.

BIOL 535. Marine Conservation Biology. 3 Credits.
This highly interdisciplinary science of conserving marine biodiversity will be taught through a review of old and new literature. This will include its history, marine ecology related to conservation biology, threats to marine biodiversity, assessment of extinction risk, conservation challenges of marine habitats and regions, and methods for conserving marine biodiversity.

BIOL 536. Infectious Disease Epidemiology. 3 Credits.
This lecture/lab course will focus on concepts related to the spread and control of infectious diseases. The lectures will focus on concepts while the labs will provide quantitative skills essential to the study of infectious diseases. Prerequisites: Undergraduate coursework in statistics and biology.

BIOL 537. One Health: People, Animals and the Environment. 3 Credits.
A course that examines the interdependence between human health, animal health and environmental health. The One Health approach to the threat of emerging infectious diseases includes understanding the interconnectedness of human and animal pathogens, epidemic zoonoses and corresponding environmental factors, insights into mechanisms of microbial evolution towards pathogenicity, new technologies and approaches towards disease surveillance, and political and bureaucratic strategies. Pre- or corequisite: A Microbiology course is recommended.

BIOL 538. The Biology of Woody Plants. 4 Credits.
The study of trees and shrubs (dendrology), their identification, ecology, structure and anatomy, life, and uses are emphasized in this field-oriented course. A research project including a written paper and presentation is required. Prerequisite: A grade of "C" or higher in a botany course.

BIOL 541. Animal Behavior. 5 Credits.
Animal behavior with special attention to its evolution and ecological significance. Field and laboratory activities will emphasize observational and experimental techniques used to study behavior.

BIOL 542. Marine Ecology Laboratory. 2 Credits.
A laboratory/field course in which students gain practical experience with research techniques common to coastal marine ecology, and become familiar with the organisms and ecological conditions present in the various marine habitats visited by the class. A field trip of several days is required. Pre- or corequisite: When offered during the fall semester, BIOL 515 is a prerequisite.

BIOL 544. Field Studies in Marine Biology. 5 Credits.
An intensive study abroad field course offered during the summer at a foreign marine laboratory where students will be engaged in lectures and field studies of coastal marine environments. Check with the Director of the Marine Biology Concentration Program for details. Prerequisite: BIOL 331.

BIOL 545. Community Ecology. 3 Credits.
The goal of this course is to introduce and evaluate both classical and emerging paradigms in community ecology. This will be achieved by examining those processes (biotic and abiotic) that structure ecological communities, and by exposing students to quantitative and theoretical aspects of these paradigms. Prerequisites: Ecology course.

BIOL 546. Comparative Biomechanics. 3 Credits.
The principles of fluid and solid mechanics will be applied to a variety of plant and animal systems to understand how organisms deal with the immediate physical world and its accompanying constraints. A diverse range of topics will be covered, including aerial flight in insects, wind resistance in trees, jet propulsion in squid, flow within blood vessels, forces on intertidal organisms, viscoelasticity in biological materials, and energy storage during terrestrial movement. Prerequisites: Cell biology course and physics course recommended.

BIOL 550. Principles of Plant Ecology. 4 Credits.
Course covers the general theoretical concepts in plant ecology with statistical methods. The structure, development, processes, and history of plant communities are studied. Laboratories involve extensive fieldwork. A weekend field trip is required.

BIOL 553. Molecular Ecology. 4 Credits.
This course will explore the biology of organisms by using molecular (nucleic acid and/or protein) techniques and data. It covers a wide variety of subdisciplines within Biology, including genetics, physiology, ecology, and evolution. This course will explore basic theory in population genetics, ecology, and evolution and cover DNA, RNA, and Protein techniques and their application to biological research.

BIOL 555. Population Genetics. 3 Credits.
An introduction to the principles of population genetics that address topics such as inheritance, genetic variation, fitness, natural selection, mutation, genetic drift, gene expression, and single- and multi-locus models of different types of selection. Human disease is addressed. Students will write a mock-grant proposal. Prerequisites: A Genetics course.

BIOL 557. General Virology. 3 Credits.
A basic course covering the history of virology, viral taxonomy, genetics, and the molecular biology and host responses to the major mammalian virus groups. Examples of recent impacts of viruses on human health such as influenza pandemics will also be covered. Prerequisites: courses in cell biology and genetics.

BIOL 560. Frontiers in Nanoscience and Nanotechnology. 1 Credit.
Review of the structure, synthesis and properties of key nano-materials and their impact on living systems. Prerequisite: graduate standing.

BIOL 561. Human Cadaver Dissection. 4 Credits.
Students will dissect a human cadaver and learn all major structures. All exams will be practical tag-tests using human tissue. The major emphasis will be on head, neck, trunk, and joints with some clinical application to injuries and surgery.

BIOL 562. Microbial Genetics. 3 Credits.
This course emphasizes the fundamental concepts of microbial genetics including the study of gene structure, gene regulation, operons, DNA replication, RNA biology, protein synthesis, plasmid biology, mobile genetic elements, and recombinant DNA technology. Prerequisites: Courses in cell biology, genetics and general microbiology.

BIOL 563. Cell Signaling in Host Pathogen Interactions. 3 Credits.
This course will emphasize cell dynamics including host and pathogen induced cellular signaling, the regulation of actin cytoskeleton rearrangement, and the modulation of host transcription and translation by different pathogens. Prerequisites: A cell biology course.

BIOL 564. Biomedical Applications of Low Temperature Plasmas. 3 Credits.
This course is cross listed between ECE and Biology. It is intended for senior undergraduate students and first year graduate students. The course contents are multidisciplinary, combining materials from engineering and the biological sciences. The course covers an introduction to the fundamentals of non-equilibrium plasmas, low temperature plasma sources, and cell biology. This is followed by a detailed discussion of the interaction of low temperature plasma with biological cells, both prokaryotes and eukaryotes. Potential applications in medicine such as wound healing, blood coagulation, sterilization, and the killing of various types of cancer cells will be covered.
BIOL 565. Biotechnology. 3 Credits.
This course provides an overview of how microbes are manipulated to solve practical problems through biotechnology. Topics to be covered include basic concepts in microbial technology, industrial microbiology, microbes in drug development, food microbiology, microbial interactions, gut microbiota, and metagenomics.

BIOL 570. Diseases that Changed our World. 3 Credits.
Despite advancements in the development of antimicrobials and vaccines and in securing clear water and food supplies, modern civilizations are not immune to epidemic diseases. This course will provide insight into the role of different technologies in the struggle to attain disease control and eradication and explore the challenge of forecasting emerging plagues, describing the nature and evolution of diseases and conveying their significance in shaping Western culture and civilization, their impact, their consequences, their costs, and the lessons learned.

BIOL 571. Marine Vertebrate Ecology, Management & Conservation. 3 Credits.
Course will explore the biology, diversity and major life history patterns of a suite of marine megafauna, including sea turtles, marine mammals, seabirds and sharks. Students will determine the major drivers behind large-scale declines of many marine megafauna species and be challenged to understand and attempt to solve conservation and management issues. Prerequisite: A Marine Biology course.

BIOL 574. Mushrooms. 4 Credits.
The identification, classification ecology, culture, and uses of mushrooms and other fleshy fungi. A field oriented course.

BIOL 575. Neurobiology. 3 Credits.
This course will focus on understanding brain structure as well as the morphology and function of the central nervous system in general. Fundamental processes such as neuron morphogenesis, guidance, polarity, migration, and growth cone motility will be emphasized. The cellular and molecular basis of neurological disorders also will be discussed. Prerequisites: BIOL 250 or BIOL 293 must be passed with a grade of "C" or higher or permission of instructor.

BIOL 578. Microbial Ecology. 3 Credits.
Study of the interactions between microorganisms, particularly bacteria, and their environment. Emphasis is placed on nutrient cycling and the influence of microbes on global mineral dynamics. The effects of physical and chemical factors on distribution and activity of microbes in their environments and applications of these interactions are studied (biotechnology). Prerequisites: a general microbiology course.

BIOL 579. Microbial Ecology Laboratory. 1 Credit.
A laboratory for measurement of microbial numbers and activity in natural environments. Pre- or corequisite: BIOL 578.

BIOL 580. Advanced Human Physiology Laboratory. 2 Credits.
A study of the cardiovascular, respiratory, nervous and digestive systems using mammals.

BIOL 581. Forensic and Medical Entomology. 5 Credits.
This course provides a comprehensive survey of the insects used in legal investigations and medically important insects. Topics covered include the taxonomy, morphology, physiology, reproductive and developmental biology, and ecology of these insects along with the diseases they may vector. Research techniques in forensic and medical entomology will be learned through both field and laboratory activities.

BIOL 582. Human and Veterinary Parasitology. 3 Credits.
The course will emphasize the principles of parasitism, including biology, physiology, genetics, morphology, and phylogeny of the major parasitic groups with a specific focus on the significant parasites of humans and animals of veterinary importance. The general biology of parasites including their life cycles, diagnosis, and treatment will be included as well. Pre- or corequisite: A cell biology course.

BIOL 590. Advanced Human Physiology. 4 Credits.
All major physiological systems with emphasis on normal physiology. Some clinical applications made but not stressed.

BIOL 596. Topics in Biology. 1-3 Credits.
Prerequisites: Permission of the instructor. A specially designed course concerning specific topics in the biological, environmental, or allied health fields.

BIOL 598. Independent Study in Biology. 1-3 Credits.
Supervised (non-lab/field) project selected to suit the needs of the individual student. Requires completion of formal scientific paper documented with appropriate primary technical literature (see GPD for details). Unstructured course. Prerequisites: permission of the GPD and permission of instructor.

BIOL 609. Special Readings in Biology. 3 Credits.
Reading and discussion course designed to explore a field of specific interest.

BIOL 620. Biometry. 4 Credits.
A first course, or a refresher course, in statistical methods and experimental design for graduate students in biology and the natural sciences. The focus is on application and hypothesis testing with examples drawn from the field of biology. The course requires a significant amount of work outside the classroom on homework exercises and an independent project. Prerequisites: A Statistics course.

BIOL 640. Microbial Toxins. 3 Credits.
This course will focus on the mechanisms of action of microbial toxins, including those affecting the host's nervous system, immune function, metabolism, protein synthesis, and homeostasis. The structure and function of representatives of several toxin types will be analyzed for their potential applications to biotechnology and medicine. Prerequisites: A general microbiology course required and a microbial pathogenesis course recommended.

BIOL 661. Topics in Biology. 1-3 Credits.
1-3 credits. Supervised projects and practica selected to meet the specific objectives of the student.

BIOL 669. Internship in Biology. 3 Credits.
3 credits. With approval of Advisory Committee.

BIOL 671. Molecular and Immunological Techniques. 4 Credits.
2 cr. Lecture. Required of all graduate students admitted to Biology programs. The course will introduce students to the responsible conduct of science and scientific research.

BIOL 695. Topics in Biology. 1-3 Credits.
1-3 credits. A specially designed course concerning specific topics in the biological, environmental or allied health fields.

BIOL 698. Research in Biology. 1-3 Credits.
This course is selected with the recommendation of the faculty advisor.

BIOL 700. Cardiovascular Physiology. 4 Credits.
4 credits. This physiology course will focus solely on Cardiovascular Physiology. Lectures will focus on basic and advance cardiovascular principles. The laboratory will focus on the use of current cardiovascular research.

BIOL 701. Practical Computing for Biology. 3 Credits.
This hands-on training course emphasizes the use of general computing tools to work more effectively in the biological sciences. It integrates a broad range of powerful and flexible tools that are applicable to ecologists, molecular biologists, physicists, and anyone who has struggled analyzing large or complex data sets. Text file manipulation with regular expressions, basic shell scripting, programming in Python and R, interaction with remote devices, and basic graphical concepts will be reviewed.

BIOL 702. Biomedical Sciences Journal Club. 1 Credit.
1 credit. Review and discussion of current papers in the areas of biomedical sciences. Student presentation, discussions and readings in this field required.
BIOL 705. **Advanced Microbiology. 4 Credits.**
Lecture 2 hours; laboratory 4 hours; 4 credits. Prerequisite: A microbiology course. Investigate microbiology from historical perspectives to modern molecular microbiology; ecological and biomedical components; bacteria and viruses. Laboratory will involve designing experiments conducting and evaluating results.

BIOL 707. **Ecosystem Ecology. 5 Credits.**
Ecological principles at ecosystem level of biological organization. Discussion of energy flow, nutrient cycling, ecosystem stability and ecosystem modeling. Laboratory involves field trips and methods of measuring ecosystem parameters. Prerequisites: a general ecology course.

BIOL 708. **Ecological Sciences Seminar. 1 Credit.**
A graduate seminar course in the ecological sciences. The format of the course depends on the faculty running the seminar, but most seminars involve student-led discussions on current research articles.

BIOL 712. **Biological Microscopy. 4 Credits.**
Prerequisites: permission of the instructor. Lectures will cover theory and concepts of specimen preparation and operation of various microscopes used in the biological sciences. The laboratory experience will include specimen preparation to viewing.

BIOL 714. **Biomedical Sciences Laboratory. 2 Credits.**
2 credits. Prerequisite: approval of the program director. Three laboratory rotations (6 credits) are required by the curriculum.

BIOL 715. **Biomedical Sciences Laboratory. 2 Credits.**

BIOL 716. **Endocrinology. 5 Credits.**
The biochemical integration of hormones and related agents on vertebrate physiology with emphasis on human endocrinology. Recent literature will be stressed.

BIOL 720. **Systematic Ichthyology. 3 Credits.**
A systematic survey of fishes emphasizing life history, anatomy, identification and classification. Prerequisites: BIOL 520.

BIOL 724. **Neuromuscular Physiology. 3 Credits.**
This course will provide a comprehensive discussion of the physiological and chemical properties of nerve and muscle cells.

BIOL 730. **Emerging Infectious Diseases. 3 Credits.**
Lecture 3 hours; 3 credits. Prerequisite: A microbiology course. Discussion on current studies into new and reemerging infectious diseases with an examination of the infectious agent and factors involved in disease emergence, prevention and elimination.

BIOL 731. **Systematics and Speciation. 3 Credits.**
Principles of systematic biology and discussion of speciation theory, with emphasis on generation, analysis, and interpretation of taxonomic data and application of these data to a better understanding of classification and speciation processes. Modern theories of evolutionary biology and phylogenetics will be stressed. A research paper is required.

BIOL 732. **GIS in the Life Sciences. 3 Credits.**
This course is designed to introduce students to geographic information systems through examples and applications in the life sciences.

BIOL 745. **Advanced Immunology. 3 Credits.**
Lecture 3 hours; 3 credits. Current concepts in cellular and molecular immunology and host defense based on critical review of the primary literature.

BIOL 748. **Functional genomics and proteomics in animal models. 3 Credits.**
The purpose of this course is to show how animal models of human diseases can be created and analyzed using genomic and proteomic technologies. The course will overview high throughput methods of generating disease models in mice and describe ongoing efforts in this field. Attempts to identify molecular mechanisms of the disease will be presented with particular emphasis on drug target discovery. Pre- or corequisite: An immunology course.

BIOL 749. **Biogeography. 3 Credits.**
Emphasis on historical biogeography, utilizing both dispersal and vicariance models for explanations of the geographic distribution of organisms. Ecological explanations are also considered. Useful techniques for biogeographic analyses, such as comparison of area cladograms are discussed at length.

BIOL 750. **Marine Benthic Ecology. 4 Credits.**
Application of ecological principles at the community level to marine benthic environments. Discussion of community structure, animal-sediment relationships, roles of benthic communities in marine ecosystems. Prerequisites: BIOL 515 or equivalent.

BIOL 751. **Advanced Practices in Ethnobotany. 3 Credits.**
The major objective of this course is modern methods used to study plants influencing human culture. Objectives include plant systematics and applications of DNA bar coding and fingerprinting; phytochemical techniques in drug discovery and food supplements; intellectual property rights; ecological methods for sustainable harvesting of natural products; the ethnobotanical interview and questionnaire development; methods for studying crop origins, history, and development; archeobotany; mining historical data; and importance of identification, vouching, efficacy, and conservation. This course provides a survey of interdisciplinary methodologies used in modern ethnobotanical research. A multi-day field trip is a required component.

BIOL 754. **Phylogeny and Molecular Lecture and Laboratory. 5 Credits.**
This course is intended to be an introduction to the processes and procedures used to reconstruct the evolutionary history of living organisms. Topics include project planning, sampling strategies, molecular techniques, and analytical and tree-building programs used to infer phylogeny. Lab provides computer experience in multiple phylogenetic software packages. Prerequisites: Instructor approval required.

BIOL 755. **Molecular Genetics. 3 Credits.**
Current molecular understanding of genetic processes will be reviewed. Applications to areas such as development and evolution will also be covered.

BIOL 756. **Phylogeny and Molecular Systematics. 5 Credits.**
This course is intended to be an introduction to the processes and procedures used to reconstruct the evolutionary history of living organisms. Topics include project planning, sampling strategies, molecular techniques, and analytical and tree-building programs used to infer phylogeny. Lab provides computer experience in multiple phylogenetic software packages.

BIOL 758. **Molecular Ecology. 4 Credits.**
Scientists are increasingly using molecular methods to help them address fundamental questions in the population ecology and evolution of biological species. This class will introduce graduate students to the basic concepts and methods in molecular evolution, phylogenetcs and methods into their research. Theory and concepts from lecture will be illustrated through reading and discussion of current scientific literature. Students will also directly apply the course material to a class project investigating population structure of marine species from the tropical Indo-Pacific, for which they will be trained in methods of DNA extraction, PCR and sequencing. They will present their results orally in a mini-symposium at the end of the course. Prerequisites: BIOL 671.

BIOL 759. **Foundations and Principles in Ecology. 3 Credits.**
A survey of the seminal ideas and perspectives in historical and contemporary ecology. The course is designed to provide a broad overview of the important theoretical and conceptual paradigms in ecology.

BIOL 770. **Advanced Study in Biology. 3 Credits.**
Tutorial; 3 credits. Under the guidance of members of the graduate faculty and with the approval of the program track coordinator, the student will carry out in-depth studies of selected topics relevant to the area of specialization. Extensive surveys and analyses of the literature. Written reviews, comprehensive and synoptic, and oral presentations are required of each student.
BIOL 771. Vector-Borne Diseases. 3 Credits.
Lecture, 3 hours; 3 credits. Study of the role of insects, ticks and other invertebrates in the transmission of disease. Different areas of disease transmission will be examined, including physiological and biochemical aspects of microbial survival in the vector and transmission to vertebrate hosts, as well as ecological aspects.

BIOL 772. Modeling and Simulation in the Life Sciences. 4 Credits.
Course is designed to introduce students to modeling and simulation techniques using examples and applications in the life sciences.

BIOL 775. Grant Writing for the Life Sciences. 3 Credits.
Provides students with the skills to write competitive grant proposals to both private and federal funding sources (emphasis on NIH and NSF). Students will learn how to find the most appropriate funding mechanisms and how to position themselves to be competitive. Different grant writing formats will be illustrated through proposal development projects.

BIOL 789. Gross Anatomy. 6 Credits.
An intense study of all systems from a regional approach. Extensive dissections required in lab. Clinical applications utilized. Prerequisites: An anatomy course recommended.

BIOL 795. Special Topics in Biology. 1-4 Credits.
1-4 credits. Prerequisite: permission of the instructor.

BIOL 800. Cardiovascular Physiology. 4 Credits.
4 credits. This physiology course will focus solely on Cardiovascular Physiology. Lectures will focus on basic and advance cardiovascular principles. The laboratory will focus on the use of current cardiovascular research.

BIOL 801. Practical Computing for Biology. 3 Credits.
This hands-on training course emphasizes the use of general computing tools to work more effectively in the biological sciences. It integrates a broad range of powerful and flexible tools that are applicable to ecologists, molecular biologists, physiologists, and anyone who has struggled analyzing large or complex data sets. Text file manipulation with regular expressions, basic shell scripting, programming in Python and R, interaction with remote devices, and basic graphical concepts will be reviewed.

BIOL 802. Biomedical Sciences Journal Club. 1 Credit.
1 credit. Review and discussion of current papers in the areas of biomedical sciences. Student presentation, discussions and readings in this field required.

BIOL 805. Advanced Microbiology. 4 Credits.
Lecture 2 hours; laboratory 4 hours; 4 credits. Prerequisite: A microbiology course. Investigate microbiology from historical perspectives to modern molecular microbiology; ecological and biomedical components; bacteria and viruses. Laboratory will involve designing experiments conducting and evaluating results.

BIOL 807. Ecosystem Ecology. 5 Credits.
Ecological principles at ecosystem level of biological organization. Discussion of energy flow, nutrient cycling, ecosystem stability and ecosystem modeling. Laboratory involves field trips and methods of measuring ecosystem parameters. Prerequisites: a general ecology course.

BIOL 808. Ecological Sciences Seminar. 1 Credit.
A graduate seminar course in the ecological sciences. The format of the course depends on the faculty running the seminar, but most seminars involve student-led discussions on current research articles.

BIOL 812. Biological Microscopy. 4 Credits.
Prerequisites: permission of the instructor. Lectures will cover theory and concepts of specimen preparation and operation of various microscopes used in the biological sciences. The laboratory experience will include specimen preparation to viewing.

BIOL 814. Biomedical Sciences Laboratory. 2 Credits.
2 credits. Prerequisite: approval of the program director. Three laboratory rotations (6 credits) are required by the curriculum.

BIOL 816. Endocrinology. 5 Credits.
The biochemical integration of hormones and related agents on vertebrate physiology with emphasis on human endocrinology. Recent literature will be stressed.

BIOL 820. Systematic Ichthyology. 3 Credits.
A systematic survey of fishes emphasizing life history, anatomy, identification and classification. Prerequisites: BIOL 520.

BIOL 824. Neuromuscular Physiology. 3 Credits.
This course will provide a comprehensive discussion of the physiological and chemical properties of nerve and muscle cells.

BIOL 830. Emerging Infectious Diseases. 3 Credits.
Lecture 3 hours; 3 credits. Prerequisite: A microbiology course. Discussion on current studies into new and reemerging infectious diseases with an examination of the infectious agent and factors involved in disease emergence, prevention and elimination.

BIOL 831. Systematics and Speciation. 3 Credits.
Principles of systematic biology and discussion of speciation theory, with emphasis on generation, analysis, and interpretation of taxonomic data and application of these data to a better understanding of classification and speciation processes. Modern theories of evolutionary biology and phylogenetics will be stressed. A research paper is required.

BIOL 832. GIS in the Life Sciences. 3 Credits.
This course is designed to introduce students to geographic information systems through examples and applications in the life sciences.

BIOL 845. Advanced Immunology. 3 Credits.
Lecture 3 hours; 3 credits. Current concepts in cellular and molecular immunology and host defense based on critical review of the primary literature.

BIOL 848. Functional genomics and proteomics in animal models. 3 Credits.
The purpose of this course is to show how animal models of human diseases can be created and analyzed using genomic and proteomic technologies. The course will overview high throughput methods of generating disease models in mice and describe ongoing efforts in this field. Attempts to identify molecular mechanisms of the disease will be presented with particular emphasis on drug target discovery. Prerequisite: An immunology course.

BIOL 849. Biogeography. 3 Credits.
Emphasis on historical biogeography, utilizing both dispersal and vicariance models for explanations of the geographic distribution of organisms. Ecological explanations are also considered. Useful techniques for biogeographic analyses, such as comparison of area cladograms are discussed at length.

BIOL 850. Marine Benthic Ecology. 4 Credits.
Application of ecological principles at the community level to marine benthic environments. Discussion of community structure, animal-sediment relationships, roles of benthic communities in marine ecosystems. Prerequisites: BIOL 515 or equivalent.

BIOL 851. Advanced Practices in Ethnobotany. 3 Credits.
The major objective of this course is modern methods used to study plants influencing human culture. Objectives include plant systematics and applications of DNA bar coding and fingerprinting; phytochemical techniques in drug discovery and food supplements; intellectual property rights; ecological methods for sustainable harvesting of natural products; the ethnobotanical interview and questionnaire development; methods for studying crop origins, history, and development; archeobotany; mining historical data; and importance of identification, vouching, efficacy, and conservation. This course provides a survey of interdisciplinary methodologies used in modern ethnobotanical research. A multi-day field trip is a required component.

BIOL 854. Phylogeny and Molecular Lecture and Laboratory. 5 Credits.
This course is intended to be an introduction to the processes and procedures used to reconstruct the evolutionary history of living organisms. Topics include project planning, sampling strategies, molecular techniques, and analytical and tree-building programs used to infer phylogeny. Lab provides computer experience in multiple phylogenetic software packages. Prerequisite: Instructor approval required.
BIOL 855. Molecular Genetics. 3 Credits.
Current molecular understanding of genetic processes will be reviewed. Applications to areas such as development and evolution will also be covered.

BIOL 856. Phenylogy and Molecular Systematic. 5 Credits.
This course is intended to be an introduction to the processes and procedures used to reconstruct the evolutionary history of living organisms. Topics include project planning, sampling strategies, molecular techniques, and analytical and tree-building programs used to infer phylogeny. Lab provides computer experience in multiple phylogenetic software packages.

BIOL 858. Molecular Ecology. 4 Credits.
Scientists are increasingly using molecular methods to help them address fundamental questions in the population ecology and evolution of biological species. This class will introduce graduate students to the basic concepts and methods in molecular evolution, phylogenetics and methods into their research. Theory and concepts from lecture will be illustrated through reading and discussion of current scientific literature. Students will also directly apply the course material to a class project investigating population structure of marine species from the tropical Indo-Pacific, for which they will be trained in methods of DNA extraction, PCR and sequencing. They will present their results orally in a mini-symposium at the end of the course. Prerequisites: BIOL 671.

BIOL 859. Foundations and Principles in Ecology. 3 Credits.
A survey of the seminal ideas and perspectives in historical and contemporary ecology. The course is designed to provide a broad overview of the important theoretical and conceptual paradigms in ecology.

BIOL 861. Ecological Sciences Internship. 3-6 Credits.
Internship experience. Prerequisites: approval of advisory committee.

BIOL 871. Vector-Borne Diseases. 3 Credits.
Lecture, 3 hours; 3 credits. Study of the role of insects, ticks and other invertebrates in the transmission of disease. Different areas of disease transmission will be examined, including physiological and biochemical aspects of microbial survival in the vector and transmission to vertebrate hosts, as well as ecological aspects.

BIOL 872. Modeling and Simulation in Life Sciences. 4 Credits.
Course is designed to introduce students to modeling and simulation techniques using examples and applications in the life sciences.

BIOL 875. Grant Writing for the Life Sciences. 3 Credits.
Provides students with the skills to write competitive grant proposals to both private and federal funding sources (emphasis on NIH and NSF). Students will learn how to find the most appropriate funding mechanisms and how to position themselves to be competitive. Different grant writing formats will be illustrated through proposal development projects.

BIOL 880. Advanced Study in Biology. 3 Credits.
Tutorial; 3 credits. Under the guidance of members of the graduate faculty and with the approval of the program track coordinator, the student will carry out in-depth studies of selected topics relevant to the area of specialization. Extensive surveys and analyses of the literature. Written reviews, comprehensive and synoptic, and oral presentations are required of each student.

BIOL 889. Gross Anatomy. 6 Credits.
An intense study of all systems from a regional approach. Extensive dissections required in lab. Clinical applications utilized. Prerequisites: Anatomy and Physiology course.

BIOL 895. Special Topics in Biology. 1-4 Credits.
1-4 credits. Prerequisite: permission of the instructor.

BIOL 898. Research in Biology. 1-6 Credits.

BIOL 899. Dissertation. 1-6 Credits.

BIOL 999. Doctoral Graduate Credit. 1 Credit.
This course is a pass/fail course doctoral students may take to maintain active status after successfully passing the candidacy examination. All doctoral students are required to be registered for at least one graduate credit hour every semester until their graduation.