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# Biology

## Faculty and Fields of Interest

The biology major provides opportunities for building the foundation of a career in one of the many specialties in private industry and in federal and state agencies which employ biologists.

Students planning to enter graduate school should, in consultation with their advisor, strongly consider electing a foreign language, analytic geometry, and calculus. For those students interested in pursuing such broad fields of study as ecology, courses which stress computer literacy and database management are good foundation courses. Students looking toward such disciplines as cell and/or molecular biology and developmental biology should take genetics, molecular and cell biology, and biochemistry.

The existing curriculum for biology majors satisfies almost all of the admissions requirements for medical, dental, veterinary, and other graduate health professional programs. Physics laboratories should be added and in many cases calculus is expected. Premedical students should complete their 300-400 level biology electives with courses such as Embryology, General Microbiology, General Genetics, Animal Physiology, Comparative Vertebrate Anatomy, Developmental Biology, Immunology, Molecular Biology, Virology, and Biochemistry. Anatomy and Physiology is very helpful when preparing for the MCAT exam. Ethics for Health Care Professionals serves as an excellent humanities elective. Check with the individual medical school for additional requirements such as psychology and statistics. For more details, seek the advice of the faculty premedical advisory committee members, especially those in the Biology Department.

Modern biology requires a wide range of supporting courses in such other fields of study as statistics, computers, physics, chemistry, electronics, meteorology, and geology. Student biology majors should consult with their advisors early in their program of study as to possible career choices and plan to take appropriate elective supporting courses for their selected field of study.

**Richard C Connor** marine mammal biology

**Robert Griffith** environmental physiology, vertebrate anatomy and physiology

**Peter Hart** genetics, cell biology, developmental biology, biotechnology

**Whitney E Hable** plant and algal biology, developmental and marine biology

**Frederick Y Kazama** microbiology, cell biology, organismal biology

**Palma Longo** science education

**Nancy J O'Connor** invertebrate biology, marine ecology, biology of marine larvae

**Kenneth Oliveira** fish biology, marine biology, life history strategies and age and growth of fishes

**Tara K Rajaniemi** plant community ecology

**Eli Stahl** plant adaptations, ecological and evolutionary genetics

**Jefferson Turner (chairperson)** biological oceanography, marine plankton, biogeography

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The need for K-12 teachers in the areas of science is great in the region. Biology is a strong major for future teachers. The Biology Department participates in UMass Dartmouth's programs to prepare teachers who are highly qualified, helping provide opportunities for students to receive both initial and professional licensure. Specifically, the department supports students who seek initial licensure as a Teacher of Biology (8-12) through the Post-Baccalaureate Education Certificate and professional licensure as a Teacher of Biology (8-12) through the MAT program. Students should indicate their interest both to their Biology major advisor and to an advisor in UMass Dartmouth's Education Department, to plan to take appropriate prerequisite and enrichment courses.

## Biology Major

BS degree

Students may prepare for admission to medical, dental, and veterinary colleges and for admission to graduate work in the life sciences. Increasing numbers of students elect to major in biology as a means of providing themselves with a general framework of ideas concerning the interactions of living things. A substantial number of these students proceed toward vocational objectives that do not require a specialist's knowledge of biology.

## Biology Major

Marine Biology Option

The marine biology option is designed to meet the needs of students who aspire to careers in ecology, marine biology, fisheries biology, and biological oceanography. Students who elect the Marine Biology Option are urged to plan their program in close cooperation with their advisors. Biology majors who choose the marine biology option have an opportunity to elect marine-oriented courses during their junior and senior years and must meet college degree requirements for the BS degree.

## Goals for Student Learning

The department has the following goals for the learning of its undergraduate students:

- To ensure that every Biology student develops a theoretical and conceptual framework in the biological sciences: content knowledge.
- To ensure that students are able to apply the methods of scientific inquiry in a biological context by demonstrating proficiency in analytical and technical skills.
- To ensure that students are able to read the scientific literature in at least one field of biology: fluency in the scientific literature.

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## Requirements

### First Two Years

(common to both options)

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		Semester Credits	
		First	Second
BIO 121, 131	Biology of Organisms I with Lab	4	
BIO 122, 132	Biology of Organisms II with Lab		4
CHM 151, 152	Principles of Modern Chemistry	3	3
CHM 161, 162	Introduction to Applied Chemistry	1	1
ENL 101, 102	Critical Writing and Reading	3	3
MTH 101, 102*	Elements of College Mathematics	3	3
		<b>14</b>	<b>14</b>

\* Math course to be selected in consultation with the advisor. MTH 111, 112 (Calculus) is recommended for students whose math background is good, and required for later entrance to graduate programs with a molecular orientation. It is also a prerequisite for Physical Chemistry. MTH 111, 112 is required for PHY 113, 114 but can be taken concurrently with it.

### Second Year

BIO 210, 211	Biology of Populations with Lab		4
BIO 234, 244	Biology of Cells with Lab	4	
CHM 251, 252	Organic Chemistry	3	3
CHM 263, 264	Bio-organic Chemistry Lab	1	1
PHY 101, 102**	Introduction to Physics	3	3
	Humanities/Social Science Electives	6	6
		<b>17</b>	<b>17</b>

\*\* PHY 113, 114 may be substituted for PHY 101, 102.

### Third and Fourth Years

(common to both options)

Course selection for the third and fourth years of the biology major must be determined in consultation with an advisor. During the third and fourth year all majors are required to elect at least 18 credits in upper-division biology courses (courses numbered 300 or higher). Upper-division courses in physics, chemistry, engineering, marine science, or mathematics and course credit in BIO 440, 441, or 495 may be substituted with the written approval of the advisor and the department chairperson prior to registration in the course. A maximum of 3 credits in biology proseminar may be included in the 18 credits. The requirements of the College of Arts and Sciences must also be met prior to graduation.

Students who have completed the first two years of the biology major may elect to concentrate in courses dealing with the ecology of the coastal zone, its estuaries and inshore waters.

### General Education Departmental Requirements

Students majoring in Biology will meet their departmentally-determined General Education requirements as follows:

Area E: Students may choose a course from the approved list

Area I, Tier 2: Satisfied by BIO 210, 211

Area W, Tier 2: Satisfied by BIO 234

Area O: Students may take any course on the approved list, including BIO 321, 413, 422, 471, or any course from the approved list

### Junior/Senior Electives for Marine Biology Option

Eighteen credits should be elected from upper-division biology courses. At least 12 of these credits must come from the following list of courses.

BIO 316	Descriptive Oceanography
BIO 317	Biology of Invertebrates
BIO 413	Biology of Fishes
BIO 414	Biology of Marine Mammals
BIO 454	Biology of Sharks
BIO 471	Marine Microbiology
BIO 526	Marine Benthic Ecology
BIO 531	Advanced Ichthyology
BIO 536	Estuarine Ecology
BIO 545	Biological Oceanography

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## Biology Courses

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**BIO 101** three credits **S**

**General Biology I**

3 hours lecture

An introductory human biology course emphasizing energy flow and the function of cells and molecules, basic genetics, and selected aspects of human physiology.

**BIO 102** three credits **S**

**General Biology II**

3 hours lecture

Prerequisite: BIO 101 or permission of instructor

Continuation of introductory biology with emphasis on the reproduction and genetics of organisms, their evolution, behavior, and interactions within ecosystems.

**BIO 103** three credits **S**

**Topics in Biology**

3 hours lecture

Study in specific areas of biological science such as human genetics, microbes, and the insect world. Not offered for credit to biology majors.

**BIO 111** four credits **S**

**Introduction to Human Physiology**

4 hours lecture

Introduction to the general physiological principles involved in human body functions with homeostasis as the unifying theme. Not offered for credit to biology majors.

**BIO 112** three credits **S**

**The Ocean Environment**

3 hours lecture

The study of the ocean environment as an integrated ecosystem: The biology of marine organisms and the related physical, chemical, and geological processes of the sea with attention given to the exploitation of marine resources and pollution. Not offered for credit to biology majors.

**BIO 121, 122** three credits each

**Biology of Organisms I, II**

3 hours lecture

First course for biology majors, an introduction to structure, function, and behavioral adaptations in the world of living organisms. The first semester emphasizes cell origin, structure and chemistry, basic cellular physiology, and genetics. The second semester covers the diversity and evolutionary relationships of living organisms, culminating in an in-depth study of a selected ecosystem. Pre-professional aspects are emphasized during both semesters for the biology major student. Field experiences, writing, and problem-solving are integrated into the course work.

**BIO 131, 132** one credit each

**Biology of Organisms Laboratory I, II**

1 hour laboratory lecture, 2 hours laboratory

The biology of organisms laboratory courses cover two semesters and are designed to provide the student with hands-on experience in investigative techniques and problem-solving. Students work closely with faculty and staff in specialized laboratory investigations in various biological disciplines.

**BIO 210** three credits **I**

**Biology of Populations**

3 hours lecture

Prerequisites: BIO 121, 122, 131, 132

An introduction to the biology of groups of individuals of the same specific kind as units of evolutionary and ecological change: the characterization, origin, and maintenance of phenotypic and genetic variety and the selective and chance processes that shape this variation and effect adaptation, speciation, and the observed geographical and temporal distributions of different kinds of organisms.

**BIO 211** one credit **I**

**Biology of Populations Laboratory**

3 hours laboratory

Corequisite: BIO 210

Experimental approaches to selected topics in population biology are investigated by linking observations on laboratory populations with expectations generated by student-designed computer simulations using BASIC programming. Topics include selection, genetic drift, heritability, and spatial and temporal dispersion patterns.

**BIO 221** three credits

**Anatomy and Physiology I**

3 hours lecture

A systematic study of the human body emphasizing structural and functional relationships. Topics include cellular activity and tissue organization. The skeletal, muscular, and cardiovascular morphology and function are presented.

**BIO 222** three credits

**Anatomy and Physiology II**

3 hours lecture

Prerequisite: BIO 221

Continuation of BIO 221. Study of the structure and function of the respiratory, digestive, nervous, urinary, endocrine, and reproductive systems.

**BIO 223** one credit

**Anatomy and Physiology Laboratory I**

1 hour laboratory lecture, 2 hours laboratory

Gen Ed note: Biology courses satisfy the Natural Science and Technology requirement. Those marked S below are appropriate for non-science/engineering majors.

Emphasis is placed on methods of measuring physiological processes. Study of body structure is accomplished by dissection of animal specimens and by use of tissue materials.

**BIO 224** one credit

**Anatomy and Physiology Laboratory II**

1 hour laboratory lecture, 2 hours laboratory

Prerequisite: BIO 223

Continuation of BIO 223.

**BIO 234** three credits **W**

**Biology of Cells**

3 hours lecture, 1 hour recitation

Prerequisites: BIO 121, 122, 131, 132, and

CHM 151, 152 with C- or better; or permission of instructor; concurrent enrollment or credit in Organic Chemistry recommended

A study of energy transformations, gene expression and regulation, and the function of cells and their organelles. The course emphasizes how function follows structure, particularly at the level of macromolecules.

**BIO 244** one credit

**Biology of Cells Laboratory**

1 hour laboratory lecture, 2 hours laboratory

Corequisite: BIO 234

A laboratory course emphasizing the biochemical, spectroscopic, and microscopic procedures necessary to study cell function.

**BIO 251** three credits

**Medical Microbiology**

3 hours lecture

Prerequisites: BIO 154, CHM 101, 102; open only to students enrolled in the College of Nursing, except by special permission of instructor

Fundamentals of microbiology to prepare students interested in the health science field. Topics include basic microbiology, control of microorganisms, host resistance, and pathogenic microorganisms.

**BIO 261** one credit

**Medical Microbiology Laboratory**

Prerequisite: BIO 154, CHM 101, 102

Corequisite: BIO 251

Exercises in microbiological principles and techniques, such as microscopy, staining, growth and quantitation of microbial cultures, and identification of microorganisms by biochemical and other tests. Intended to accompany and illustrate BIO 251 Medical Microbiology.

**BIO 298** one to six credits

**Experiential Learning**

Prerequisites: At least sophomore standing;

permission of the instructor, department chairperson, and college dean  
Work experience at an elective level supervised for academic credit by a faculty member in an appropriate academic field. Terms and hours to be arranged. Graded CR/NC. For specific procedures and regulations, see section of catalogue on Other Learning Experiences.

**BIO 314** four credits

**General Ecology**

3 hours lecture, 3 hours laboratory  
Prerequisites: Biology core; MTH 101, 102; CHM 151, 152, or permission of instructor  
The principles and practices of the scientific discipline of ecology. Interactions among organisms and between organisms and their environment will be emphasized. Interactions will be described and analyzed at the organismal, population, community, and ecosystem levels. In the laboratory, students will use hypothesis-testing and experimentation to examine theoretical and empirical aspects of ecology.

**BIO 316** three credits

**Descriptive Oceanography**

3 hours lecture  
Prerequisites: Biology core, or permission of instructor  
An introduction to the field of oceanography. Physical, chemical, geological, and biological aspects are emphasized to provide a basic foundation for further work in biological oceanography.

**BIO 317** four credits

**Biology of Invertebrates**

3 hours lecture, 1 hour laboratory lecture, 3 hours laboratory  
Prerequisites: BIO 121, 122, 131, 132, 210, 211  
An intensive survey of the taxonomy and functional morphology of the major invertebrate phyla, with special reference to adaptations of the intertidal marine invertebrates of the North Atlantic coast. Field trips to the diverse habitats of the area constitute an integral part of the laboratory.

**BIO 320** four credits

**Embryology**

3 hours lecture, 3 hours laboratory, 1 hour laboratory lecture  
Prerequisite: Biology core  
A description of reproductive and embryological principles, followed by a study of typical vertebrate and invertebrate embryology. The organogenesis of the major vertebrate systems will be described. The laboratory will include the microscopic study

of vertebrate embryos and the observation of the development of selected living vertebrate and invertebrate embryos.

**BIO 321** four credits **O**

**General Microbiology**

3 hours lecture, 3 hours laboratory  
Prerequisite: Biology core  
The nature and diversity of microorganisms. Special emphasis is placed on bacterial cytology, nutrition, physiology, and growth. Topics on the significance of microorganisms in the environment and the evolutionary relationships of microorganisms are included.

**BIO 333** four credits

**General Genetics**

3 hours lecture, 1 hour laboratory lecture, 3 hours laboratory  
Prerequisites: BIO 121, 122, 131, 132, 234, 244; or permission of instructor; BIO 210, 211 recommended  
Introduction to the science of heredity. The lectures present an integrated concept of the gene provided from the study of Mendelian and molecular genetics. Selected topics in quantitative inheritance, and human genetics are included.

**BIO 350** four credits

**Plant Biology**

3 hours lecture, 3 hours laboratory  
Prerequisites: BIO 121, 122, 131, 132 and one year of biology of organisms or equivalent  
The diversity, cellular biology, anatomy and morphology, physiology, and ecology of plants. In the laboratory, the major groups of plants will be studied, and students will use hypothesis-testing and experimentation to examine concepts in plant physiology and ecology.

**BIO 370** four credits

**Animal Physiology**

3 hours lecture, 1 hour laboratory lecture, 2 hours laboratory  
Prerequisites: Biology of Cells (or equivalent); Organic Chemistry  
A study of the general principles of animal physiology integrating molecular, cellular, organ system, and whole organism approaches. The accompanying laboratory will provide skill in the techniques used in animal physiological investigations.

**BIO 411** one to three credits **O**

**Proseminar: Current Topics in Biology**

1 to 3 hours  
Students with senior standing (or others with consent of the instructor) report on

and discuss current biological problems as presented in principle journals, abstracts and reviews. The work of each seminar is usually built upon a single unifying content area.

**BIO 413** four credits **O**

**Biology of Fishes**

3 hours lecture, 3 hours laboratory  
Prerequisites: BIO 121, 122, 131, 132, 210, 211  
Field trips and extensive laboratory work are emphasized in this course. The life histories, ecology and classification of the fishes of the coastal and inland waters of the northeastern states are studied in detail.

**BIO 414** three credits

**Biology of Marine Mammals**

Prerequisite: Biology core  
Biology of marine mammals, including cetaceans (whales and dolphins), pinnipeds (seals, sea lions, and walruses), sirenians (dugongs and manatees), and sea otters. Fossil, anatomical, physiological, life history, behavioral, and ecological evidence is marshalled to explore marine mammal adaptations for reproduction, feeding, locomotion, diving, thermoregulation, communication, and sensing their environment.

**BIO 415** four credits

**Comparative Vertebrate Anatomy**

3 hours lecture, 1 hour laboratory lecture, 3 hours laboratory  
Prerequisite: Biology core  
Structure and phylogeny of vertebrates. Laboratory work illustrates evolutionary trends and specializations.

**BIO 420** three credits

**Animal Behavior**

Prerequisite: Biology core  
The study of comparative and evolutionary aspects of behavior of invertebrate and vertebrate animals. Structure and function of nervous systems, simple behavioral patterns including reflexes and other forms of innate behavior as well as more complex patterns including learning and social behavior are stressed.

**BIO 421** four credits

**Developmental Biology**

3 hours lecture, 1 hour laboratory lecture, 3 hours laboratory  
Prerequisite: Biology core, especially biology of cells  
The molecular, cellular and morphogenetic aspects of embryology, organogenesis and other developmental phenomena of animals are considered in the lecture. Some aspects

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of plant development are discussed. The laboratory includes experiments that demonstrate the morphogenetic activities of the cell. Students are encouraged to design their own experiments.

**BIO 422** three credits **O**  
**Immunology**

3 hours lecture

Prerequisites: BIO 234 or equivalent, CHM 251

Molecular and cellular basis of immune phenomena with emphasis on experimental foundations of current models. Differentiation of T and B lymphocytes, cell-cell interactions, antibody structure and function with underlying genetic rearrangements, mechanisms of resistance to disease and immune dysfunction, including AIDS. Understanding of research techniques and research process is promoted.

**BIO 427** three credits  
**Molecular Biology**

3 hours lecture

Prerequisites: BIO 234, 244

The methods and research that support models of cell function at the molecular level. This three credit lecture course will present current advanced research methods in molecular biology—those used to study the expression and regulation of genes, and the laboratory research on the macromolecules involved. Students will read and paraphrase current literature in the field of molecular biology.

**BIO 428** three credits  
**Evolutionary Ecology**

Prerequisite: BIO 314, 420 or 437

Natural selection theory applied to diverse problems in evolutionary biology including the levels of selection, adaptation and optimality models, kin selection, recognition systems, cooperation and altruism among non-relatives, co-evolution, mutualism and parasitism, specialization, sex ratio evolution, genetic conflicts, the evolution of sex, sexual selection, parental care, life history evolution, game theory and animal contests, group living and social organization in birds and mammals.

**BIO 430** four credits  
**Introduction to Biological Statistics**

3 hours lecture, 1 hour laboratory lecture, 2 hours laboratory

Prerequisite: MTH 101, 102 or equivalent, upper division biology standing  
Statistical concepts for the planning of experiments and the summarization of numerical data. Lectures emphasize

probability, testing of hypothesis and the application of different, statistical concepts and problems.

**BIO 435** three credits  
**Methods and Materials for Secondary School Teachers of Biology**

Free elective credit only

This course is designed for future teachers of biology. The course emphasizes modes of inquiry, methods of research and experimentation, and teaching strategies. MAT graduate students take this course as BIO 635.

**BIO 437** three credits  
**Evolutionary Biology**

3 hours lecture

Prerequisites: Biology Core

An overview of contemporary evolutionary biology with an emphasis on evolutionary processes. A non-introductory study of the interplay in time and space of genetic variety, ecological opportunity, and chance resulting in the evolutionary change in groups of organisms.

**BIO 438** one credit  
**Evolutionary Biology Laboratory**

3 hours laboratory

Prerequisites: Biology Core

Corequisite: BIO 437

Computer models of aspects of evolutionary processes will be designed. The models will selectively address problems in such areas as selection and polygenic inheritance, genetic drift, concerted evolution in multigene families, differentiation of protein-coding nucleotide sequences, molecular clocks, sex, stochastic processes in macroevolution and wild animal conservation genetics. A Biology of Populations-level (BIO 211) knowledge of BASIC programming is expected.

**BIO 440** variable credits (1-3)  
**Research Project**

Hours will be arranged.

An advanced research project in an advanced student's field of general interest conducted under the supervision of an appropriate staff member, in the form of independent research leading to the solution of a problem.

**BIO 441** variable credits (1-3)  
**Research Project**

Continuation of BIO 440.

**BIO 442** three credits  
**Advanced Genetics**

3 hours lecture

Prerequisite: BIO 333 or permission of

instructor

A historical perspective of the concepts leading to the present theory of gene structure and function. The rigorous experimental evidence supporting this synthesis is reviewed by extensive reading and discussion of original publications. Particular emphasis is placed on papers published since 1940 and having direct bearing in elucidating the structure and function of the gene.

**BIO 452** three credits  
**Virology**

Prerequisites: BIO 234, 244 or permission of instructor

Nature of the virus as both an evolutionary entity and an obligatory cellular parasite. The structure and replicative strategies of representative viruses are studied. The approach is molecular and stresses the interaction of the viral genome with cytoplasmic and nuclear elements of the host cell.

**BIO 454** three credits  
**Biology of Sharks**

Prerequisite: Permission of instructor

The morphology, physiology, behavior and evolutionary history of the most ancient group of living jawed fishes. The most unusual aspects of these fish, such as modes of reproduction, osmotic regulation, feeding mechanisms, and sensory physiology, will be stressed throughout.

**BIO 471** four credits **O**  
**Marine Microbiology**

3 hours lecture, 3 hours laboratory

Taxonomy, physiology, and the role of heterotrophic microorganisms in the marine environment. The viruses will also be considered. Emphasis will be placed on the activities of the viruses, bacteria, and the fungi in the marine environment in the laboratory, exercises will be conducted on the methods of enumeration, detection of selected physiological groups, uptake and deputation of microorganisms by shellfish, marine biodeterioration, and the influence of environmental parameters on the growth and activities of marine microorganisms.

**Note:** Some undergraduate senior-level courses are offered to graduate students under a corresponding 5xx number, with concurrent enrollment but additional work expectations.

**BIO 495** three credits  
**Independent Study**

Prerequisites: Upper-division standing; permission of instructor, department chairperson, and college dean  
Study under the supervision of a faculty member in an area not otherwise part of the discipline's course offerings. Terms and hours to be arranged.

**BIO 196, 296, 396, 496** three credits  
**Directed Study**

Prerequisites: Permission of the instructor, department chairperson, and college dean  
Study under the supervision of a faculty member in an area covered in a regular course not currently being offered. Terms and hours to be arranged.

**Graduate Courses in Biology**

**BIO 511** one to four credits  
**Graduate Seminar in Biology**

1 to 4 hours in varied formats  
Selected topics in Biology. In recent years these have included physiology and biochemistry of marine animals, evolutionary ecology, biology of marine mammals, morphometrics and phylogenetic systematics, and extremophiles.

**BIO 513** four credits  
**Biology of Fishes**  
See BIO 413.

**BIO 514** three credits  
**Biology of Marine Mammals**  
See BIO 414.

**BIO 520** three credits  
**Animal Behavior**  
See BIO 420

**BIO 525** one credit  
**Graduate Student Seminar**  
Prerequisite: Graduate status  
Each student will present a seminar related to the current semester's theme and based on several contemporary publications. Students are responsible for preparing a comprehensive bibliography, an abstract, and evaluations of peers' seminars. (One semester required; maximum two credits towards MS degree.)

**BIO 526** four credits  
**Marine Benthic Ecology**  
3 hours lecture, 3 hours laboratory  
Prerequisite: Graduate standing or permission of instructor  
An advanced overview of the structure and function of marine benthic communities from the intertidal zone to the deep sea, focusing on the power of experimental studies in elucidating ecological processes. Students will improve writing skills via preparation of short research proposals, a term paper, and through peer review of other students' work. Students will also lead discussions of journal articles, and plan, undertake, and present the results of a field biofouling study.

**BIO 527** three credits  
**Molecular Biology**  
See BIO 427. In addition, graduate students will present two typical reviews of current problems in molecular biology, both as written expositions and as interactive lecture presentations to other class members. Pre-

and post-presentation interviews with the instructor are also required.

**BIO 528** four credits  
**Evolutionary Ecology**  
See BIO 428

**BIO 530** four credits  
**Introduction to Biological Statistics**  
See Bio 430

**BIO 535** four credits  
**Analysis of Biological Data**  
3 hours lecture, 2 1-1/2 hour laboratory meetings  
Prerequisite: Introduction to biological statistics or equivalent  
The processing and analysis of biological, and especially ecological data. Topics include problems encountered in processing and handling of data, distributions and transformations, associations, computer simulations, parametric and non-parametric methods, and usefulness and limitations of multivariate methods.

**BIO 536** four credits  
**Estuarine Ecology**  
3 hours lecture, 3 hours laboratory  
Prerequisite: Graduate standing or permission of instructor  
An overview of biological, geological, physical, and chemical factors and processes important for organisms in estuarine environments. Emphasis is on contemporary research areas, including human impacts in estuaries. Students will design, perform, analyze and present the results of semester-long field projects characterizing a local salt-marsh ecosystem.

**BIO 537** three credits  
**Evolutionary Biology**  
See BIO 437.

**BIO 538** one credit  
**Evolutionary Biology Laboratory**  
See BIO 438.

**BIO 545** four credits  
**Biological Oceanography**  
3 hours lecture, 3 hours laboratory  
Prerequisite: BIO 316 or permission of the instructor  
The cycle of productivity in the marine environment and the physiological and morphological adaptations of plant, animal and bacterial populations within various oceanic regions. Interrelationships of the plankton, the nekton, and the benthos are stressed.

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**Note:** Some graduate courses may be open to undergraduates. Please consult your department chairperson. See the *Graduate Catalogue* for graduate general and program requirements.

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**BIO 552** three credits

**Virology**

See BIO 452.

**BIO 554** three credits

**Biology of Sharks**

See BIO 454

**BIO 571** four credits

**Marine Microbiology**

See BIO 471.

**BIO 593** one to three credits

**Graduate Research Project**

Prerequisite: Graduate standing and consent of instructor

Directed research for graduate students, hours by arrangement. Graded A-F.

**BIO 595** three credits

**Graduate Independent Study**

Prerequisites: Graduate standing; permission of instructor, graduate director, and college dean

Study under the supervision of a faculty member in an area not otherwise part of the discipline's course offerings. Terms and hours to be arranged.

**BIO 596** three credits

**Graduate Directed Study**

Prerequisites: Graduate standing; permission of the instructor, graduate director, and college dean

Study under the supervision of a faculty member in an area covered in a regular course not currently being offered. Terms and hours to be arranged.

**BIO 599** not to exceed ten credits

**Graduate Thesis**

Prerequisite: Graduate standing and consent of instructor

Terms and hours to be arranged.

Graded A-F.

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**Graduate Courses in Biology Education for Master of Arts in Teaching**

**BIO 600** three credits

**Teaching Science in the Elementary School**

*Not for credit in Biology MS program.*

Life, physical, and earth sciences that are involved in the development of scientific concepts and processes for elementary school science. A variety of natural phenomena, such as the plant, *Brassica rapa*, will be used as models to develop an inquiry and standards approach to the learning and teaching of science.

**BIO 635** three credits

**Methods and Materials for Secondary School Teachers of Biology**

Not for credit in Biology MS program.

Modes of inquiry, methods of research and experimentation, and teaching strategies.

This course is designed for future teachers of biology. Graduate students enroll concurrently with students in BIO 435 but do additional work.