

Biology

Chair: Nathalia Holtzman

Doctoral Studies Advisor: John Dennehy

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The Biology Department offers programs of courses and research leading to the Master of Arts degree at Queens College. It also offers programs of courses and research leading to the PhD at the CUNY Graduate Center in the subprograms of cellular, molecular, and developmental biology; evolution, ecology, and behavior; physiology and neurosciences; and plant sciences. Refer to the *Bulletin* of the Graduate Center for application, financial aid, and course information for the PhD program. Opportunities for specialization in applied and basic research are included below in the listing of the supervising faculty.

The department offers a variety of graduate courses appropriate for master's-level students in education. Students should meet with the department's graduate advisor for guidance in the selection of biology courses. It also offers an accelerated graduate track that allows qualifying students to apply credit for advanced courses taken as undergraduates to both their bachelor's and master's degrees.

In addition to the program of courses described below, students are encouraged to participate in the extensive research programs of the biology faculty. Their research activities have recently been funded by various agencies, including the National Science Foundation, National Institutes of Health, Howard Hughes Medical Institute, and a number of private foundations, including the American Cancer Society and American Heart Association. Participation in research is one of the best

ways for students to learn biology first-hand, and to appreciate how scientific methodology is used to answer important biological questions. A description of current faculty research can be found below.

Opportunities are enhanced by affiliation with other city institutions and cooperative efforts with other divisions of the City University of New York and the American Museum of Natural History.

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Weinstein, Daniel C., Chair, *Professor*, PhD 1995,

Rockefeller University: vertebrate molecular embryology, signal transduction

Dennehy, John, Doctoral Studies Advisor, *Professor*, PhD 2003, Clark University: microbial evolutionary ecology, experimental evolution

Lahti, David, Master's Program Advisor, *Associate Professor*, PhD 1998, Whitefield Institute, Oxford: philosophy; PhD 2003, University of Michigan: evolutionary biology, behavioral ecology, human social evolution

Alvarado, Sebastian, *Assistant Professor*, PhD 2013, McGill University: plasticity, DNA methylation, social behavior, pigmentation

Baker, Mitchell B., *Associate Professor*, PhD 1998, University of California at Davis: behavioral ecology, dispersal, evolution, arthropods, birds

Cheema, Saima, *Lecturer*, PhD 2006, City University of New York: microbiology

Fath, Karl, *Assistant Professor*, PhD 1997, Case Western University: cell biology of intracellular transport, molecular motors, and cytoskeleton

Glickman Holtzman, Nathalia, *Associate Professor*, PhD 2000, University of Oregon: cardiac morphogenesis in zebrafish, regulation of morphogenesis at the cellular and molecular levels

Ma, PoKay M., *Associate Professor*, PhD 1986, Washington University: neuroscience, neural control of behavior, structure, and development of *locus coeruleus* in zebrafish

Meléndez, Alicia, *Professor*, PhD 1995, Columbia University: role of autophagy in *C. elegans* development, genetics of aging

Muehlbauer, Esther, *Lecturer*, PhD 1987, New York University: estuarine ecology, herpetology
Savage-Dunn, Cathy, *Professor*, PhD 1992, Columbia University: development, molecular genetics, signal transduction, *C. elegans*

Short, Timothy W., *Associate Professor*, PhD 1991, Stanford University: plant physiology and molecular biology, light control of plant development

Sperling, Jon A., *Associate Professor*, PhD 1972, University of Wisconsin: algal and bryophyte ecology and physiology, limnology

Tajerian, Maral, *Assistant Professor*, PhD 2012, McGill University: neuroscience, mechanism and treatments of pain

Vesanen, Mika, *Lecturer*, PhD 1995, University of Helsinki: virology and immunology

Waldman, John R., *Professor*, PhD 1986, City University of New York: ecology, evolution, conservation biology of fish

Zakeri, Zahra F., *Professor*, PhD 1984, St. John's University: molecular developmental biology, regulation of gene expansion in aging and cell death

FACULTY EMERITI

Professors Emeriti: Chabora, Greller, Michels, Roze, Szalay

Associate Professors Emeriti: Alsop, Calhoon, Koepfer, Rifkin

MASTER OF ARTS PROGRAM

Requirements for Matriculation

These requirements are in addition to the general requirements for admission.

1. Students are expected to have a minimum of 20 credits in biology beyond the introductory level. Undergraduate courses in physics, chemistry, and

* MAT charges are possible.

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mathematics are required. A course in statistics is highly recommended.

2. The credentials of each applicant will be examined by the departmental admissions committee. This committee may request an interview with a candidate for admission.

Requirements for the Master of Arts Degree

These requirements are in addition to the general requirements for the Master of Arts degree.

1. Each student's program will be approved by a supervising professor chosen by the student with the approval of the graduate advisor.
2. Students who have taken a 300-level Queens College biology course that is also offered at the 600-level may not take that 600-level course for credit. All graduate students must take at least 10 credits of 700-level lecture courses. Only 600- and 700-level courses may be applied toward degree requirements. Furthermore, the combination of BIOL 788 (Cooperative Education Placement), BIOL 799 (Research), BIOL 791 (Colloquium), and BIOL 792 (Tutorial) may not exceed 12 credits.
3. Depending on personal interests and career goals, candidates for the MA degree in Biology may choose one of two tracks to fulfill the degree requirements:
 - A. Research-intensive track (30 credits required). Students in this track are expected to present significant independent research in a written Master's thesis, followed by an oral examination/defense, conducted by an Examination Committee established for each candidate. The chair of this committee shall be a member of the Queens College Biology Department, chosen by the candidate in consultation with the Biology MA advisor. The remaining members of the committee shall be chosen by the committee chair in consultation with the candidate. The content and nature of the oral examination shall

be determined by the chair of the committee in consultation with the student to be examined. Each student will be limited to two attempts to pass this examination.

- B. Course-intensive track (32 credits required). Students in this track are required to write a literature-based review paper, followed by an oral examination/defense conducted by an Examination Committee composed of Queens College Biology Department faculty. Each student will be limited to two attempts to pass this examination, which can be taken only after at least 24 course credits have been completed. Students in this track are eligible to take BIOL 788 (Cooperative Education Placement) and participate in the Graduate Cooperative Education Program.

Accelerated MA Degree in Biology

If you are an undergraduate Biology major, have at least a 3.0 GPA in the major (meaning all science and math courses), and have taken at least 60 credits, you are eligible for our accelerated MA. This will save you both time and money in attaining both a BA and an MA degree in Biology.

As an undergraduate, a student can take up to 12 credits of 600- or 700-level courses (with instructor permission), and these will count toward both the undergraduate (BA) and graduate (MA) degrees. Students who maintain at least a 3.0 GPA average as an undergraduate will automatically be accepted into the Biology master's program upon completion of the BA. Other students may apply to the Accelerated MA track through the regular procedure. No more than 12 graduate credits may count toward both the BA and the MA. Some rules and limitations:

- Students must maintain a 3.0 GPA until receiving their MA.
- Each course that counts toward the MA must be a *B-* (2.7 GPA) or better. This is a general rule that applies

to any Queens College Biology MA students, not just students in the accelerated MA. Grades as low as *C-* still count toward the undergraduate degree.

- Colloquium (BIOL 791) and Research (BIOL 799) are not included in the courses that may be taken as an undergraduate. Undergraduate students should take the 300-level versions of these courses.
- The 600- or 700-level courses taken as undergraduates may count either toward required 300-level undergraduate courses for the Biology major, or as electives. Laboratory field courses may count as undergraduate laboratory requirements.

Students interested in this option should speak to Professor David Lahti, graduate advisor for the Biology Department. An application consists of an application form and a personal statement of your reasons for requesting admission to this track, why you want a master's in biology, and a bit about your broader goals (to whatever extent you have considered them). Please request one letter of reference from a Queens College faculty member, such as your undergraduate advisor.

Other Information

Arrangements may be made for students to take courses for graduate credit in other departments at Queens College or within CUNY in order to fulfill particular career requirements (i.e., resource management, environmental impact essays, etc.).

Faculty in the Biology Department at Queens College participate actively in the CUNY PhD program in biology. Arrangements can be made to transfer graduate credits earned at Queens College to the PhD program at CUNY. Students are encouraged to discuss their long-range goals with the master's program graduate advisor as soon as possible.

The CUNY doctoral program in Biology is described in the *Bulletin* of the Graduate Center.

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COURSES IN BIOLOGY*

500-Level Courses

BIOL 585. Genetics. 3 lec., 1 rec. hr.; 4 cr. Prereq.: BIOL 105 and CHEM 114 or equivalent. Not open to students who have completed BIOL 285 except by permission of the chair. The inheritance, structure, and mode of genetic material. Designed for the Master of Science in Education candidates who are concentrating in science education. Cannot be used to fulfill requirements for the Master of Arts degree in biology.

BIOL 586. Cell Biology. 3 hr.; 3 cr. Prereq.: BIOL 105 and CHEM 114 or equivalent. Not open to students who have completed BIOL 286 except by permission of the chair. Structure, function, and regulation of cells, including cell cycle, subcellular compartmentalization, signal transduction, and cell-cell interactions. Designed for the Master of Science in Education candidates who are concentrating in science education. Cannot be used to fulfill requirements for the Master of Arts degree in biology.

BIOL 587. Evolutionary Biology. 3 lec., 1 rec. hr.; 4 cr. Prereq.: BIOL 105. Not open to students who have completed BIOL 287. The mechanisms and processes of biological evolution. Designed for the Master of Science in Education candidates who are concentrating in science education. Cannot be used to fulfill requirements for the Master of Arts degree in biology.

600-Level Courses

BIOL 610. Lower Plants. 2 lec., 1 rec., 3 lab. hr.; 4 cr. A survey of algae, bryophytes, and fungi of the northeastern United States, with an emphasis on identification, morphology, physiology, and ecology. A library or field research paper is required.

BIOL 611. Mycology. 2 lec., 1 rec., 3 lab. hr.; 4 cr. Prereq.: One semester of genetics and permission of the instructor. A survey of the major taxa of fungi, including slime molds, with emphasis on their

morphology and taxonomy. The importance of fungi as causal agents in diseases of man, other animals, and plants, as experimental tools of genetic, biochemical, and physiological research will be considered. Basic techniques of culturing fungi will be utilized in the execution of individual projects.

BIOL 612. Morphology and Evolution of Plants. 2 lec., 1 rec., 3 lab. hr.; 4 cr. Prereq.: Permission of the instructor. Comparison of plant form and function. Lectures will emphasize the structure and origin of plant organs, and the use of this information in classifying major plant groups. Information from paleobotany will be integrated with comparative morphology of living plants. A library research paper will be required. Laboratory includes several field trips.

BIOL 613. Field Botany. 2 lec., 1 rec., 3 lab. hr.; 4 cr. Prereq.: Permission of the instructor. Introduction to local flora and vegetation. Lectures will emphasize the structure and composition of local vegetation. Laboratories will consist mainly of field trips to parks, preserves, and botanical gardens. Students will submit a field trip report, a plant collection, and a library research paper.

BIOL 614. Plant Systematics. 2 lec., 1 rec., 3 lab. hr.; 4 cr. Prereq.: Permission of the instructor. Survey of the vascular plants with emphasis on flowering plants. Lectures will emphasize taxonomic characters useful in identification of major plant groups. Laboratories will be devoted to techniques of identification. Students will submit a plant collection and a library research paper. Field trips will occupy half days or full days; they will comprise a large part of the lab component.

BIOL 621. Entomology. 2 lec., 1 rec., 3 lab. hr.; 4 cr. Prereq.: Course in invertebrate zoology. Anatomy, physiology, and ecology of insects. Identified insect collection required of each student. Students should expect to reside at a field station for at least one week of the course (dormitory fees will be announced and collected at time of registration). Summer Sessions 1 and 2 only.

BIOL 626. Vertebrate Phylogeny. 2 lec., 1 rec., 3 lab. hr.; 4 cr. Prereq.: A course in comparative anatomy. Phylogeny and interrelationships of the important major groups of the phylum Chordata, emphasizing the origins of higher categories and their adaptive radiation into sub-groups. Laboratory on representatives of fishes, amphibians, reptiles, birds, and mammals, emphasizing differences in locomotion, feeding mechanisms, and sense organs found within the same sub-classes, infra-classes, super-orders, and orders, with practice in the identification of typical specimens likely to be found in the field.

BIOL 630. Biometrics. 2 lec., 1 rec., 3 lab. hr.; 4 cr. Prereq.: Courses in genetics and calculus. Probabilistic models in biology, field, and laboratory sampling, tests of hypotheses; uses of statistics for estimation. Topics selected will include growth processes of organisms and populations, discriminant functions, and genetic descriptions of evolving populations. The laboratory includes computational procedures in evaluating biological data.

BIOL 640. General Ecology. 2 lec., 1 rec., 2 lab. hr.; 4 cr. Prereq.: A course in field biology. Theory and analysis of structure, growth, biological communities in terms of their structure, species abundance and diversity, interspecific interactions, and integration with the physical environment.

BIOL 644. Biology and Society. 3 hr.; 3 cr. Prereq.: Courses in genetics and in cell biology. Critical analysis of selected subjects encompassing current biological research and related technological developments in context of their ethical, scientific, and economic impact on the human social systems.

BIOL 645. Evolution and Cultural Behavior. 3 hr.; 3 cr. Prereq.: BS or BA, a major *or* minor in biology, zoology, or equivalent, or permission of the instructor. A lecture/seminar course that examines several recent evolutionary theories associated with culture, i.e. behavioral ecology, evolutionary psychology, memetics, and biocultural coevolution. These theories are compared

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and assessed in seminars on current research, critiques, and application to human and animal cultures.

BIOL 646. Limnology. 2 lec., 1 rec., 3 lab. hr.; 4 cr. Prereq.: A course in field biology. Survey of the physical, chemical, and biological properties of streams, rivers, and lakes. A comparative analysis of inland waters. Students should expect to reside at a field station and/or the Audubon Center at Greenwich, CT. The site selected depends on scheduling and the availability of space. Three to five other field trips, including two all-day trips are planned. Students should expect to be involved full-time during the duration of this summer course.

BIOL 666. Immunology. 3 lec. hr.; 3 cr. Prereq.: A course in cell biology. The components and mechanisms of action of the immune system. Topics include requirements for antigenicity, types of antibodies, humoral and cell-mediated responses including allergy, graft rejection, and autoimmune diseases.

BIOL 668. The Biology of Cancer. 3 hr.; 3 cr. Prereq.: BIOL 285 and 286, completed with a C+ or better, *or*; BIOL 366, completed with a C+ or better. This course will describe the underlying mechanisms of tumorigenesis. Topics cover the genetic basis of cancer, cancer stem cells, tumor microenvironment, metabolism, angiogenesis, metastasis, and treatments, including cancer immunotherapies. Students are also required to write a comprehensive essay on one topic in cancer. Each student is expected to select a specific topic of their own interest, and validate it with the instructor before performing the assignment.

BIOL 674. Plant Physiology and Development. 4 hr.; 4 cr. Prereq.: Accelerated Master's students taking this course must have a grade of C or better in BIOL 286, CHEM 114, or equivalents, or permission of the instructor. This course integrates major aspects of plant anatomy, physiology, biochemistry, cellular and molecular biology, and influences of the biotic and abiotic environment on growth and development at the

intercellular, intracellular, organismal, and community levels.

BIOL 680. Field Biology Studies. Prereq.: Variable prerequisites and permission of the instructor(s). A variable-content course encompassing field studies in the areas of botany, ecology, entomology, invertebrate and vertebrate zoology, and limnology. Usually offered summers only, with 3–6 credits, depending on the subjects included and the time involved. The focus of the course is the comparative study of habitats and their components. Format and destinations are variable, and costs reflect the mode of travel, destination, and type of accommodations. A term paper is required.

BIOL 680.3. 9 hr.; 3 cr.

BIOL 680.4. 12 hr.; 4 cr.

BIOL 680.5. 15 hr.; 5 cr.

BIOL 680.6. 18 hr.; 6 cr.

BIOL 685. Special Topics. 2–6 hr.; 2–4 cr. Special topics in various areas of cellular, developmental, environmental, or evolutionary biology to be taken by arrangement with the instructor and graduate advisor. May be repeated for credit if the topic is different. May include laboratory or field experience.

700-Level Courses

BIOL 700. Genetics. 4 hr.; 4 cr. Prereq.: Undergraduate degree in biology or biochemistry and an undergraduate course in genetics, or permission of the instructor. Structure and function of genes and genomes. Topics will include genetic model organisms and recombinant DNA technology.

BIOL 700.4. Laboratory Techniques in Molecular Genetics. 4 lab. hr.; 2 cr. Prereq. or coreq.: BIOL 700.

BIOL 705.3. Evolution. 3 hr.; 3 cr. Prereq.: Courses in genetics, vertebrate zoology or invertebrate zoology, botany, historical geology, or permission of the

department. Study of the mechanisms and processes of evolution based on the results and concepts of population genetics, speciation, and mega-evolutionary processes.

BIOL 705.4. Laboratory in Evolution. 4 lab. hr.; 2 cr. Prereq. or coreq.: BIOL 705.3.

BIOL 705.6. Macroevolution: Patterns of Evolution above the Species Level. 3 hr.; 3 cr. Prereq.: A course in graduate evolution and undergraduate genetics. A course in evolution above the species level analyzing the interface between evolution at the species level and higher systematic and ecological hierarchies. The discussion will include origin, diversification, and extinction patterns of lineages; rates of evolution, deterministic versus stochastic patterns; the problem of adaptation and diversification; developmental aspects of phylogeny; taxic distribution in space and time; phylogenetic inference; morphological versus paleontological data; the molecular clock; ecological versus historical biogeography; gradualism versus saltationalism; neodarwinian paradigm versus others at supra-specific levels.

BIOL 706.3. Systematics. 3 hr.; 3 cr. Prereq.: A course in evolution or in some major group of organisms. Principles of classification, phylogenetic inference, methods of systematics.

BIOL 706.7. Topics in Systematics. 3 hr.; 3 cr. Prereq.: A course in evolution or in some major group of organisms. Topics in classification, phylogenetic inferences, and systematics of a group of organisms. Course may be taken more than once if topic changes.

BIOL 707.1, 707.3, 707.5, 707.7. Zoology and Phylogeny of the Chordata. 2 lec. hr.; 2 cr. each semester. Prereq.: For BIOL 707.1, courses in comparative vertebrate anatomy and graduate courses in evolution, advanced genetics, and systematics; for BIOL 707.3, BIOL 707.1 or permission of the instructor; for BIOL 707.5, BIOL 707.3 or permission of the instructor; for BIOL 707.7, BIOL 707.5. The first semester to emphasize

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the fishlike chordates; the second semester to emphasize the amphibia, reptiles; the third semester to emphasize mammals; and the fourth semester to emphasize birds.

BIOL 707.2, 707.4, 707.6, 707.8. Laboratory in Zoology and Phylogeny of the Chordata. 4 lab. hr.; 2 cr. each semester. Prereq. or coreq.: For BIOL 707.2, BIOL 707.1; for BIOL 707.4, BIOL 707.3; for BIOL 707.6, BIOL 707.5; for BIOL 707.8, BIOL 707.7.

Examination of living, fossil, and other museum materials illustrating techniques and problems in research. The first semester to emphasize the fishlike chordates; the second semester to emphasize the amphibia, reptiles; the third semester to emphasize mammals; and the fourth semester to emphasize birds.

BIOL 709.1. Population Genetics. 3 hr.; 3 cr. Prereq.: A course in statistics and a course in general genetics, evolution, or permission of the instructor. Study of single gene systems on the population level with emphasis on the mechanisms of evolution/speciation.

BIOL 709.3. Quantitative Genetics. 3 hr.; 3 cr. Prereq.: A course in statistics and a course in general genetics or permission of the instructor. Study of genetic selection, heritability, inbreeding, genetic drift, and the mathematical models that describe these processes.

BIOL 710. Molecular Biology. 5 hr.; 5 cr. Prereq.: Undergraduate degree in biology or biochemistry to include a one-year course in organic chemistry, or permission of the instructor. Structure, function, and synthesis of DNA, RNA, and proteins.

BIOL 710.3. Cellular Physiology. 3 hr.; 3 cr. Prereq.: Courses in physiology and cytology or permission of the department. The functions of acellular organisms and the cells of metazoa and metaphyta, including the normal internal-external environment of the cell; permeability and cell membranes; contractility; action potentials; specialized cells and their functions.

BIOL 710.4. Laboratory in Cellular Physiology. 4 lab. hr.; 2 cr. Prereq. or coreq.: BIOL 710.3.

BIOL 711.3. Experimental Microbiology. 3 lec. hr.; 3 cr. Prereq.: One year of organic chemistry, one year of physics, one-half year of microbiology. The processes whereby microorganisms (1) obtain energy and cellular materials, (2) synthesize cell constituents, and (3) interact with their environment.

BIOL 711.4. Experimental Microbiology Laboratory. 4 lab. hr.; 2 cr. Prereq. or coreq.: BIOL 711.3. The study of the metabolism of selected microorganisms by chemical and physical methods.

BIOL 712.3. Comparative Biochemistry. 3 hr.; 3 cr. Prereq.: Courses in general biochemistry and evolution or permission of the department. Comparison of the chemical constitution and metabolism of major groups of organisms.

BIOL 712.4. Laboratory in Comparative Biochemistry. 4 lab. hr.; 2 cr. Prereq. or coreq.: BIOL 712.3.

BIOL 714. Cell Biology. 4 lec. hr.; 4 cr. Prereq.: Either BIOL 700, or 710, or permission of the instructor. Characteristics and properties of cells and cellular components. Mechanisms underlying cell function and interactions of cells with their environment.

BIOL 717.1. Virology. 3 hr.; 3 cr. Prereq.: One course in genetics, biochemistry, or equivalent. The structure and diversity of viruses will be discussed. The mechanisms of viral infection and multiplication, as well as host cell responses, will be studied. Several types of viruses will be analyzed in detail (e.g., human immunodeficiency virus, herpes viruses, hepatitis viruses, influenza virus).

BIOL 718. Immunology. 3 hr.; 3 cr. Principles of immunology including discussions of relevant experimental techniques and contemporary topics.

BIOL 719. Molecular Communication in Microorganisms. 3 hr.; 3 cr. Prereq.: A course in organic chemistry or biochemistry, or permission of the instructor. A study of the surface of microbial cells and how microbial cells interact by means of molecules between cells of the same or different species. The role of these molecules in the regulation of morphogenesis, sexual and asexual reproduction, life cycles, metabolic regulation, genetic recombination, and bioengineering will be examined. Comparison of these communicating molecules will be made with hormones of higher plants and animals.

BIOL 722.1. Endocrinology. 3 hr.; 3 cr. Prereq.: Courses in physiology (preferably vertebrate) or biochemistry, or permission of the instructor. Study of the mechanisms of hormone action and survey of the major mammalian endocrine systems.

BIOL 723. Ornithology. 3 lec., 3 lab. hr.; 3 cr. Prereq.: A course in evolution or in some major group of organisms is expected. Permission of the instructor required. The evolution, classification, origin of flight, anatomy, physiology, migration, ecology, and reproductive behavior, and conservation of birds. Laboratory includes techniques used in ornithological research and field trips to focus on bird identification and behavior. Students will be expected to attend at least one overnight field trip (e.g., to Cape May, NJ). A library research paper will be submitted and presented in class.

BIOL 724.6. Behavior and Evolution. 3 hr.; 3 cr. A reading, discussion, and seminar course focusing on two basic questions asked by ethnologists: (1) What is the ecological (adaptive) significance of behavior? and (2) What is the evolutionary history of behavior? Gene (biological) evolution is the prime focus; cultural evolution is also examined.

BIOL 726.3. Comparative Animal Physiology. 3 hr.; 3 cr. Prereq.: Courses in invertebrate zoology, vertebrate zoology, physiology, and organic chemistry,

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or permission of the department. Physiological processes in invertebrates and vertebrates are compared. Osmoregulation, respiration, circulation of body fluids, receptors, and effector and integrating mechanisms are explored. Emphasis is placed on an examination of functional homology and analogy as evidence for phylogeny.

BIOL 726.4. Laboratory in Comparative Animal Physiology. 4 lab. hr.; 2 cr. Prereq. or coreq.: BIOL 726.3. Laboratory work will involve qualitative as well as quantitative techniques for measuring environment-organism interaction. Marine, freshwater, and terrestrial invertebrates and vertebrates will be utilized for investigations into the effects on the organism of pressure, temperature, radiant energy, etc.

BIOL 731.3. Microbial Ecology. 3 hr.; 3 cr. Prereq.: General microbiology or protozoology or phycology or mycology or lower plants, or permission of the instructor. Study of the relationships of microorganisms to their natural environments (air, water, soil, higher animals, or plants) and each other.

BIOL 741.3. Radiation Biology. 3 hr.; 3 cr. Prereq.: Courses in organic chemistry, general physics, two advanced courses in biology, or permission of the department. Interaction of radiation with living matter, the effect of such interactions on a variety of plants and animals, and methods for detecting and measuring radiation.

BIOL 741.4. Laboratory in Radiation Biology. 4 lab. hr.; 2 cr. Prereq. or coreq.: BIOL 741.3.

BIOL 750. Developmental Biology. 4 hr.; 4 cr. Prereq.: Either BIOL 700, or 710, or permission of instructor. Cellular and molecular mechanisms underlying axis specification, organogenesis, and cell differentiation.

BIOL 750.4. Laboratory in Developmental Biology. 4 lab. hr.; 2 cr. Prereq. or coreq.: BIOL 750.

BIOL 753.3. Molecular Basis of Development. 2 hr.; 2 cr. Prereq.: A course in developmental biology or biochemistry, or permission of the instructor. Analysis of selected topics in developmental biology at the molecular level, e.g., biochemical basis of induction, hormonal regulation of gene expression in development.

BIOL 760.1. Ecology. 3 hr.; 3 cr. Prereq.: Courses in vertebrate zoology. A general course in ecology covering theoretical and experimental aspects at the population, community, and ecosystem levels of organization. Emphasis is placed on the studies of populations—their organization, growth, and regulation—and interactions within and between species. Basic concepts concerning community organization and dynamics are considered.

BIOL 760.2. Laboratory in Ecology. 4 lab. hr.; 2 cr. Coreq.: BIOL 760.1.

BIOL 760.3. Community Ecology. 3 hr.; 3 cr. Prereq.: A course in botany (higher plants). Analysis of selected topics in synecology. Emphasis will be on structural and temporal relationships of plants, animals, and climate–plant community relationships.

BIOL 760.5. Population Ecology. 3 hr.; 3 cr. Prereq.: Courses in botany, zoology, or permission of the instructor. Study of the composition and dynamics of populations, including age structure, sex ratio, mating systems, growth patterns, life table analysis, regulation, and intraspecific interactions.

BIOL 760.7. Limnology. 3 hr.; 3 cr. The study of the physical, chemical, and biological features of freshwater systems.

BIOL 760.8. Laboratory in Limnology. 4 hr.; 2 cr. Coreq.: BIOL 760.7. This laboratory course must be taken simultaneously with the lecture. Laboratory testing and analysis along with considerable field exercises are designed to provide a survey of physical, chemical, and biological sampling techniques involved in limnological

studies. A portion of the course period will be held at a field station, where intensive day and night sampling and measurements will be conducted. Along with written reports, an identified collection of aquatic specimens is required. Several additional all-day field trips are planned.

BIOL 764.3. Plant Ecology: Vegetation of the World. 3 hr.; 3 cr. Prereq.: A course in botany. A survey of world vegetation, with emphasis on North and Central America. Structural and floristic composition of major vegetation types will be emphasized. Schemes of vegetation classification will be compared and contrasted. Latitudinal and altitudinal zones will be discussed in the context of bioclimatic parameters.

BIOL 768.3. World Vegetation. 3 hr.; 3 cr. A survey of vegetation of the earth touching on paleogeofloristics, from the Paleophytic to Cenophytic Eras. Changes in the Earth's vegetation and present distributions of zonal plant communities are discussed in the light of plate tectonics and bioclimatology. Contemporary world vegetation types are analyzed structurally, physiognomically, and floristically. Systems of vegetation classification are compared and contrasted. Emphasis is placed on New World vegetation. A library research paper is required.

BIOL 772. Theory and Biological Applications of Electron Microscopy. 2 lec., 1 rec., 3 lab. hr.; 4 cr. Prereq.: A course in histological techniques or permission of the instructor. Study of the theory of electron microscopy plus practice of electron microscope operation and preparation of tissues for fine structure studies.

BIOL 780.1. Biostatistics. 2–4 lec. hr.; 2–4 cr. Prereq.: Mathematics through calculus and permission of the instructor. Descriptive and inferential biostatistics, including analysis of variance, regression, and other selected methods.

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BIOL 780.2. Laboratory in Biostatistics. 1 rec., 3–6 lab. hr.; 2–3 cr. Prereq. or coreq.: BIOL 780.1 or equivalent. The laboratory work consists of individual student projects and introduction to computer programming.

BIOL 781.1. Applied Multivariate Statistics. 2 hr.; 2 cr. Prereq.: BIOL 780.1, 780.2, or equivalent; coreq.: BIOL 781.2. This course will involve principal components, factor analysis, discriminant analysis, multivariate analysis of variance, distance statistics, and multiple regression. Material will be covered in the context of biological problems in the laboratory and field.

BIOL 781.2. Applied Multivariate Statistics Laboratory. 3 lab., 1 conf. hr.; 2 cr. Prereq.: BIOL 780.1, 780.2, or equivalent; coreq.: BIOL 781.1. Data analysis and problem-solving using multivariate data from experiments and the field. Use of SAS statistical package, including some programming in matrix algebra.

BIOL 788. Cooperative Education Placement. Hr. to be arranged; 1 to 4 cr. Prereq.: Permission of the department. Opportunities to apply academic learning in biology in a work environment. The student will develop a learning contract with an on-site supervisor and a departmental advisor. A written report and an oral or written examination are required. Open only to students who pursue the 32-credit-coursework track; a maximum of 4 credits may be applied toward the MA in biology.

BIOL 790.1. Seminar in Evolution. 2 hr. plus conf.; 3 cr. Topics relating to the general subject of evolution. Course may be taken more than once if topic changes.

BIOL 790.2. Seminar in Genetics. 2 hr. plus conf.; 3 cr. Heredity and genetics of plants and animals, and applications to other areas.

BIOL 790.4. Seminar in Molecular Genetics. 3 hr.; 3 cr. Prereq.: BIOL 710 or equivalent or permission of the instructor. Seminar course on a specified topic in the

field of molecular genetics. Course may be taken more than once if topic changes.

BIOL 790.5. Seminar in Developmental Biology. 3 hr.; 3 cr. Prereq.: BIOL 750 or equivalent and/or permission of the instructor. Special topics in developmental biology, emphasizing recent work relating to problems of chemical embryology, induction and tissue interaction, genes in development, hormones in development, differentiation and growth, teratology, and regeneration. Course may be taken more than once if topic changes.

BIOL 790.6. Seminar in Ecology. 2 hr. plus conf.; 3 cr. Prereq.: BIOL 760.1 or equivalent and/or permission of the instructor. Seminar in topics of the interrelationships of plants and animals with their biotic and abiotic environments. Course may be taken more than once if topic changes.

BIOL 790.7. Seminar in Cytology. 3 hr.; 3 cr. Special topics in cytology.

BIOL 790.8. Seminar in Biomathematics. 3 hr.; 3 cr. Prereq.: BIOL 780.1 and 780.2 or equivalent or permission of the instructor. Seminar-format course on a specified topic in the field of biomathematics and its applications. Course may be taken more than once if topic changes.

BIOL 791. Colloquium. 1 hr.; 1 cr. Graded on pass/fail basis only. Biology department seminar series. Course may be taken more than once if topic changes.

BIOL 792. Tutorial. 1–4 hr.; 1–4 cr. Prereq.: A minimum of two 600- or 700-level courses in biology. Repeatable for credit.

BIOL 793.1. Seminar in Systematics. 3 hr.; 3 cr. Problems in modern classification and phylogeny, with emphasis on areas such as vertical vs. horizontal classification, convergent and parallel evolution,

adaptive radiation, behavioral aspects, biochemical systematics, computer methods, etc.

BIOL 793.2. Seminar in Zoogeography. 3 hr.; 3 cr. Prereq.: A course in evolution or permission of the instructor. Seminar-format course on a specified topic in the field of zoogeography. Course may be taken more than once if topic changes.

BIOL 793.3. Seminar in Physiology. 3 hr.; 3 cr. Special problems in physiology.

BIOL 793.4. Seminar in Animal Behavior. 3 hr.; 3 cr. Prereq.: A course in animal behavior or permission of the instructor. Seminar-format course on a specified topic in the field of animal behavior. Course may be taken more than once if topic changes.

BIOL 793.5. Seminar in Cell Biology. 3 hr.; 3 cr. Prereq.: BIOL 714 or equivalent or permission of the instructor. Seminar course on a specified topic in the field of cell biology. Course may be taken more than once if topic changes.

BIOL 793.9. Seminar in Special Topics. 2 hr.; 2 cr. Course may be taken more than once if topic changes.

BIOL 794.1. Ecology and Evolutionary Biology Data/Journal Club. 1 hr.; 1 cr. Prereq.: At least one graduate-level course in ecology, evolution, or systematics. Seminar-format course consisting of student and faculty oral presentations. Topics of the presentations will be taken from the student's or faculty member's own research or from journal articles in the scientific literature. Course may be taken more than once if topic changes.

BIOL 795, 796. Basic Laboratory Techniques for Research. 2 lec., 3 lab. hr.; 3 cr. per course. Lecture and laboratory work on modern instrumentation and experimental design used to solve biological problems. The theory underlying the experimental design and equipment will be discussed.

BIOLOGY

BIOL 797.I. Molecular, Cellular, and Developmental Biology Journal Club.

1 hr.; 1 cr.
Prereq.: At least one graduate-level course in molecular genetics, cell biology, developmental biology, or biochemistry. Seminar-format course consisting of student and faculty oral presentations. Topics of the presentations will be taken from journal articles in the scientific literature. Course may be taken more than once if topic changes.

BIOL 798.I. Molecular, Cellular, and Developmental Biology Data Club.

1 hr.; 1 cr.
Prereq.: At least one graduate-level course in molecular genetics, cell biology, developmental biology, or biochemistry. Seminar-format course consisting of student and faculty oral presentations. Topics of the presentations will be taken from the student's or faculty member's own research. Course may be taken more than once if topic changes.

BIOL 799.1, 799.2, 799.3, 799.4, 799.5, 799.6. Research. Prereq.: A minimum of two 600- or 700-level courses in biology. Research under the guidance of a faculty advisor.

