

# DEPARTMENT OF NEUROSCIENCE, DEVELOPMENTAL AND REGENERATIVE BIOLOGY

The Department of Neuroscience, Developmental and Regenerative Biology offers the Doctor of Philosophy degree in Cell and Molecular Biology and the Doctor of Philosophy degree in Neuroscience.

- Ph.D. in Cell and Molecular Biology (p. 1)
- Ph.D. in Neuroscience (p. 2)

## Doctor of Philosophy Degree in Cell and Molecular Biology

The Department of Neuroscience, Developmental and Regenerative Biology offers opportunities for advanced study and research leading to the Doctor of Philosophy degree in Cell and Molecular Biology. In addition, the Cell and Molecular Biology degree offers specialized tracks in Molecular Microbiology and Immunology and Stem Cell Biology. The Ph.D. in Cell and Molecular Biology is awarded to candidates who have displayed an in-depth understanding of the subject matter and demonstrated the ability to make an original contribution to knowledge in their specialized area of study.

The regulations for this degree comply with the general University regulations (refer to Student Policies, General Academic Regulations, and the Graduate Catalog, Doctoral Degree Regulations).

### Admission Requirements

Applicants must have a Bachelor of Arts or a Bachelor of Science degree, preferably in biology, from an accredited university and a minimum grade point average of 3.0 in upper-division or graduate work. Applicants must submit, along with the application, transcripts describing previous undergraduate and graduate coursework, three letters of recommendation, and a Statement of Future Plans. Applicants whose native language is not English must score at least 60 on the Test of English as a Foreign Language (TOEFL) paper version or 79 on the Internet version. Admission is accompanied by appointment to a teaching assistantship, research assistantship, or research fellowship. The Doctoral Studies Committees is comprised of members selected from the graduate faculty who are responsible for reviewing applications for admission.

### Degree Requirements

The degree requires a minimum of 79 semester credit hours beyond the baccalaureate degree for the Ph.D. in Cell and Molecular Biology. The curriculum consists of core courses, courses in scientific writing and scientific teaching, elective courses, seminars, research, and completion of the dissertation following advancement to candidacy. Any grade lower than "B" in a graduate course or in remedial coursework at the undergraduate level will not count toward the Ph.D. degree. Students matriculating with a Master's degree may transfer up to 30 semester credit hours toward the Ph.D. degree provided the courses are comparable to required core or elective courses and are approved by the appropriate Doctoral Studies Committee.

A. Core curriculum (19 semester credit hours required):	19
BIO 5123	Principles of Molecular Biology
BIO 5133	Principles of Cell Biology
BIO 5213	Principles of Chemical Biology
BIO 7113	Principles of Biological Scientific Teaching
BIO 7143	Principles of Biological Scientific Writing
BIO 7572	Experimental Techniques in Biology
B. Colloquia (1 credit hour each semester for a minimum of 10 semesters):	10
BIO 7041	Biology Colloquium <sup>1</sup>
C. Doctoral research (41 semester credit hours minimum):	41
BIO 7211	Doctoral Research (before admission to candidacy)
BIO 7212	Doctoral Research (before admission to candidacy)
BIO 7213	Doctoral Research (before admission to candidacy)
BIO 7311	Doctoral Dissertation (for Ph.D. candidates)
BIO 7312	Doctoral Dissertation (for Ph.D. candidates)
BIO 7313	Doctoral Dissertation (for Ph.D. candidates)
D. Electives (9 semester credit hours minimum):	9
These can be selected from any 5000–7000 level lecture courses offered in Biology or from any 5000–7000 level lecture courses offered in other departments with the approval of the Cell and Molecular Biology Doctoral Studies Committee.	
<b>Total Credit Hours</b>	<b>79</b>

<sup>1</sup> Enrollment in BIO 7041 Biology ColloquiumBiology Colloquium is required every semester through the fifth year.

The entire program of study must be approved by the student's dissertation advisor and the Cell and Molecular Biology Doctoral Studies Committee, and must be submitted to the Dean of the Graduate School for final approval.

### Molecular Microbiology and Immunology Track

The primary objective of the track in Molecular Microbiology and Immunology is to provide graduates with advanced academic and research training in all aspects of Microbiology and Immunology, especially in those areas that pertain to infectious diseases. This track will provide expertise in bacteriology, virology, parasitology, mycology, immunology, vaccinology, biodefense, and molecular genetics. The information derived from research in this area has an enormous impact on biology and medicine.

Students in this track follow the regular core curriculum for the concentration in Cell and Molecular Biology. However, their Doctoral Dissertation topic, proposal and research need to be in an area related to Microbiology and Immunology. Similarly, students are also encouraged to select the majority of their elective courses and colloquia from those offered that are broadly related to the fields of Microbiology or Immunology. The overall program of study for this track must be approved by the student's Dissertation Advisor and the Cell and Molecular Biology Doctoral Studies Committee.

### Stem Cell Biology Track

Stem Cell Biology is a rapidly emerging field rooted in basic principles of Cell and Molecular Biology that has provided new avenues to investigate normal cellular and developmental processes as well as novel

approaches to learning more about and/or treating complex diseases and other debilitating conditions. The Stem Cell Biology Track will allow students pursuing their doctoral degree in Cell and Molecular Biology the opportunity to focus on Stem Cell Biology, including topics related to the basic biology of stem cells (from any species) as well as those related to translational research involving potential contributions of stem cells to tissue engineering or other therapeutic approaches. This will include, but is not limited to, molecular biology of stem cells, cell biology of stem cells, epigenetic programming in stem cells, maintenance of genetic integrity in stem cells, and the use of stem cells to study disease etiology, and will be based on studies of embryonic stem cells, induced pluripotent stem cells, germline stem cells, neural stem cells, mesenchymal stem cells or other tissue-specific stem cells, as well as stem cells from non-mammalian organisms including lower vertebrates, microorganisms and/or plants.

Students in this track will follow the standard curriculum and program of study for the concentration in Cell and Molecular Biology. However, their Doctoral Dissertation topic, proposal and research must be in an area related to Stem Cell Biology. In addition, students are encouraged to take elective courses closely related to stem cell biology. Finally, students in the Stem Cell Biology track will be required to enroll in colloquia that address topics related to Stem Cell Biology. The overall program of study for this track must be approved by the student's Dissertation Advisor, a subcommittee that will oversee the Stem Cell Biology Track, and the Cell and Molecular Biology Doctoral Studies Committee.

## Advancement to Candidacy

Advancement to candidacy requires a student to complete University and program requirements and to pass written and oral qualifying examinations following completion of course requirements. The written qualifying exam is administered in connection with the Principles of Cell Biology and Principles of Molecular Biology core courses. The oral qualifying exam is based on the dissertation research proposal and is administered by a five-member Oral Qualifying Exam Committee made up of tenured, tenure-track or adjunct faculty. The qualifying exam is conducted as outlined in the Handbook of Academic Policies and Procedures for the Cell and Molecular Biology concentration. No more than two attempts to pass qualifying examinations are allowed. Results of the written and oral examinations must be reported to the Doctoral Studies Committee and the Dean of the Graduate School. Admission into the Doctoral program does not guarantee advancement to candidacy.

## Dissertation

Candidates must demonstrate their ability to conduct independent research by completing and defending an original dissertation. The research topic is determined by the student in consultation with their supervising professor and a Dissertation Committee. The Dissertation Committee is selected by the student and supervising professor and approved by 1) the Doctoral Studies committee; 2) the Department Chair; 3) the Dean of the College; and 4) the Dean of the Graduate School. The Dissertation Committee guides and critiques the candidate's research. The Committee is composed of four program faculty and one outside member. The Dissertation Committee must approve the completed dissertation.

## Final Oral Examination

Following an open presentation of the dissertation findings, the Dissertation Committee conducts a closed oral examination dealing primarily with the relation of the dissertation to the general field of specialty. Results of the oral examination must be reported to the Dean of the Graduate School. Awarding of the degree is based on the approval

of the Dissertation Committee, which is approved by relevant Doctoral Studies Committee, the Department Chair, and the Dean of the Graduate School. The Dean of the Graduate School certifies the completion of all University-wide requirements

## Doctor of Philosophy Degree in Neuroscience

The Department of Neuroscience, Developmental and Regenerative Biology offers opportunities for advanced study and research leading to the Doctor of Philosophy degree in Neuroscience. The Ph.D. in Neuroscience is awarded to candidates who have displayed an in-depth understanding of the subject matter and demonstrated the ability to make an original contribution to knowledge in their specialized area of study.

The regulations for this degree comply with the general University regulations (refer to Student Policies, General Academic Regulations, and the Graduate Catalog, Doctoral Degree Regulations).

## Admission Requirements

Applicants must have a Bachelor of Arts or a Bachelor of Science degree, preferably in biology, from an accredited university, and a minimum grade point average of 3.0 in upper-division and graduate work. Applicants must submit, along with the application, three letters of recommendation, and a Statement of Future Plans. Applicants whose native language is not English must score at least 60 on the Test of English as a Foreign Language (TOEFL) paper version or 79 on the Internet version. The Doctoral Studies Committees is comprised of members selected from the graduate faculty and are responsible for reviewing applications for admission.

## Degree Requirements

The degree requires a minimum of 79 semester credit hours beyond the baccalaureate degree for the Ph.D. in Neuroscience. The curriculum consists of core courses, elective courses, seminars, required teaching, research, and completion of the dissertation following advancement to candidacy. Any grade lower than "B" in a graduate course or in remedial coursework at the undergraduate level will not count toward the minimum number of required hours. Students matriculating with a Master's degree may use up to 30 semester credit hours toward the degree provided the courses are comparable to core and elective courses and are approved by the Doctoral Studies Committee.

A. Core curriculum (17 semester credit hours required):	17
BIO 5433	Systems Neuroscience
BIO 5443	Molecular Neurobiology
BIO 6233	Quantitative Biology
BIO 7113	Principles of Biological Scientific Teaching
BIO 7143	Principles of Biological Scientific Writing
Select 2 semester credit hours of the following:	
BIO 7571	Experimental Techniques in Biology <sup>1</sup>
B. Colloquia (8 semester hours minimum):	8
BIO 7041	Biology Colloquium
C. Doctoral research (45 semester credit hours minimum):	45
BIO 7211	Doctoral Research (before admission to candidacy)
BIO 7212	Doctoral Research (before admission to candidacy)

BIO 7213	Doctoral Research (before admission to candidacy)	
BIO 7311	Doctoral Dissertation (for Ph.D. candidates)	
BIO 7312	Doctoral Dissertation (for Ph.D. candidates)	
BIO 7313	Doctoral Dissertation (for Ph.D. candidates)	
D. Electives (9 semester credit hours minimum):		9
These can be selected from any 5000–7000 level lecture courses offered in Biology or from any 5000–7000 level lecture courses offered in other departments with the approval of the Neuroscience Doctoral Studies Committee.		
<b>Total Credit Hours</b>		<b>79</b>

<sup>1</sup> Enrollment in BIO 7571 Experimental Techniques in Biology. Experimental Techniques in Biology is required in the Fall and Spring semesters of the first year.

The entire program of study must be approved by the student's dissertation advisor, dissertation committee, and the Neurobiology Doctoral Studies Committee, and must be submitted to the Dean of the Graduate School for final approval.

## Advancement to Candidacy

Advancement to candidacy requires a student to complete University and program requirements and to pass written and oral qualifying examinations following completion of course requirements. The examination is administered by the Doctoral Studies Committee of each concentration and is conducted as outlined in the Handbook of Academic Policies and Procedures for each concentration. No more than two attempts to pass qualifying examinations are allowed. Results of the written and oral examinations must be reported to the appropriate Doctoral Studies Committee and the Dean of the Graduate School. Admission into the Doctoral program does not guarantee advancement to candidacy.

## Dissertation

Candidates must demonstrate their ability to conduct independent research by completing and defending an original dissertation. The research topic is determined by the student in consultation with their supervising professor and a Dissertation Committee. The Dissertation Committee is selected by the student and supervising professor and approved by 1) the Doctoral Studies committee; 2) the Department Chair; 3) the Dean of the College; and 4) the Dean of the Graduate School. The Dissertation Committee guides and critiques the candidate's research. The Committee is composed of four program faculty and one outside member. The Dissertation Committee must approve the completed dissertation.

## Final Oral Examination

Following an open presentation of the dissertation findings, the Dissertation Committee conducts a closed oral examination dealing primarily with the relation of the dissertation to the general field of specialty. Results of the oral examination must be reported to the Dean of the Graduate School. Awarding of the degree is based on the approval of the Dissertation Committee, which is approved by relevant Doctoral Studies Committee, the Department Chair, and the Dean of the Graduate School. The Dean of the Graduate School certifies the completion of all University-wide requirements.

## Biology (BIO) Courses

### BIO 5001. Ethical Conduct in Research. (1-0) 1 Credit Hour.

Prerequisite: Graduate standing. This course provides a basic overview of the requirements for ethical conduct within the research laboratory. The grade report for this course is either "CR" (satisfactory completion) or "NC" (unsatisfactory completion). (Credit cannot be earned for both BIO 5001 and BIO 7413.) Differential Tuition: \$50. Course Fees: GS01 \$30.

### BIO 5003. Epigenetics and Metabolism. (3-0) 3 Credit Hours.

Scientific overview and discussion course related topics including stem cells, diseases, and interaction between metabolism and different epigenetic mechanisms. Differential Tuition: \$150. Course Fees: GS01 \$90.

### BIO 5033. Biotechnology Laboratory. (0-6) 3 Credit Hours.

Prerequisite: Graduate standing. Concurrent enrollment in BIO 5323 is strongly recommended for M.S. in Biotechnology students. An organized course offering an introduction to routine procedures employed in the modern research laboratory. Differential Tuition: \$150. Course Fees: GS01 \$90; IUB1 \$10; L001 \$30.

### BIO 5123. Principles of Molecular Biology. (3-0) 3 Credit Hours.

Prerequisite: BIO 3513 or an equivalent. Molecular structure and function of genes and nucleic acids, and the processes of DNA replication, mutation and repair, as well as transcription and translation of genetic material. Genome projects, functional genomics and the genetic control of development will also be covered. Differential Tuition: \$150. Course Fees: GS01 \$90.

### BIO 5133. Principles of Cell Biology. (3-0) 3 Credit Hours.

Prerequisites: BIO 3513 and BIO 3813, or their equivalents. Basic structure, organization and differentiation of cells. Cell cycle, signaling, growth and movement of cells, as well as cellular immunology and cellular aspects of infectious disease will also be covered. Differential Tuition: \$150. Course Fees: GS01 \$90.

### BIO 5143. Advanced Nucleic Acids Laboratory. (0-6) 3 Credit Hours.

Prerequisite: BIO 3913 or an equivalent, BIO 5033 recommended. An introduction to advanced techniques of molecular biology dealing with manipulations and analyses of DNA, including preparation and analysis of genomic DNA, genomic cloning, the polymerase chain reaction (PCR), Southern blotting, DNA sequencing and computational analysis of DNA sequence data. (Formerly titled "Advanced Molecular Biology Laboratory – DNA Techniques.") Differential Tuition: \$150. Course Fees: GS01 \$90; IUB1 \$10; L001 \$30.

### BIO 5163. Recombinant Protein Biotechnology Laboratory. (0-6) 3 Credit Hours.

Prerequisite: Satisfactory completion of BIO 5033. Small- to large-scale growth of microorganisms and eukaryotic cells followed by downstream processing of supernatants and/or cell pellets, protein purification and protein analysis. (Formerly BIO 7542 and BIO 7543. Credit cannot be earned for both BIO 5163 and BIO 7542 or BIO 7543.) Differential Tuition: \$150. Course Fees: GS01 \$90; IUB1 \$10; L001 \$30.

### BIO 5213. Principles of Chemical Biology. (3-0) 3 Credit Hours.

Prerequisites: BIO 3513 and BIO 3813, or equivalents. The role of chemistry in prokaryotic and eukaryotic biological systems. Topics will cover the probing and controlling biological systems using chemical methods and the manipulation of biological systems via novel chemistries to advance fundamental knowledge which serve as a basis for translational approaches. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5233. Medicinal Plants. (3-0) 3 Credit Hours.**

Prerequisite: Graduate standing in Biology or Chemistry. An overview of plant secondary metabolism, and the ethnobotany, biochemistry, and pharmacology of some of our most important plant-derived pharmaceuticals. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5343. Proteins and Nucleic Acids. (3-0) 3 Credit Hours.**

Prerequisite: BIO 3513 or equivalent. Protein sequences, domains, folding, proteomics, glycoproteins, protein-DNA interaction, RNA conformations. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5423. Neuroanatomy. (3-0) 3 Credit Hours.**

Prerequisite: Consent of instructor. The anatomy of the vertebrate nervous system. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5433. Systems Neuroscience. (3-0) 3 Credit Hours.**

Prerequisite: BIO 3422 or an equivalent. The fundamentals of neurophysiology are presented from the cellular to the systems level. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5443. Molecular Neurobiology. (3-0) 3 Credit Hours.**

Prerequisite: BIO 3433 or an equivalent, BIO 3513 or an equivalent recommended. An introduction to the biochemical basis of synaptic transmission, and the pathological changes in synaptic transmission associated with neurobiological diseases and disorders. (Formerly titled "Neurochemistry.") Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5463. Reproductive Biology. (3-0) 3 Credit Hours.**

Prerequisite: Graduate standing in Biology. Mammalian reproduction including mechanisms involved in sexual differentiation, fertilization, and fetal development. Endocrine regulation and environmental influences with a focus on human reproduction. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5483. Computational Neuroscience. (3-0) 3 Credit Hours.**

Prerequisite: BIO 3433 or an equivalent. A non-mathematical approach to the computational functions of the brain, including sensory coding, neural control of movement, and the computational properties of neurons and neuronal networks. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5493. Cognitive Neuroscience. (3-0) 3 Credit Hours.**

Prerequisite: BIO 3433 (or PSY 3103) recommended, or consent of instructor. The biological foundations of mental phenomena, including perception, attention, learning, memory, language, motor control, and executive function, as well as functional specialization, development and plasticity, through various methodologies. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5523. Enzymes. (3-0) 3 Credit Hours.**

Prerequisite: BIO 3513 or an equivalent. A study of enzyme structure and mechanism, inhibitors, cofactor, kinetics, and regulation. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5543. Pharmacology and Toxicology. (3-0) 3 Credit Hours.**

Prerequisite: Graduate standing in Biology. Mechanisms of action of major classes of therapeutic drugs. Clinical uses, drug comparisons, beneficial and adverse effects involved in clinical therapeutics. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5613. Neurodegenerative Disease. (3-0) 3 Credit Hours.**

Prerequisite: BIO 3513, BIO 3813, or consent of instructor; BIO 5433 or BIO 5443 is recommended. The pathogenesis of neurodegenerative diseases will be covered with an emphasis on the molecular mechanisms and experimental approaches. Current research progress will be covered. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5643. Bioinformatics and Computational Biology. (3-0) 3 Credit Hours.**

Prerequisites: BIO 2313 or an equivalent; enrollment in Biology Ph.D. program required, or permission of the Biology Department or instructor. Computational analysis of sequences, protein structures, and gene expression network on a large scale. Comparative genomics, functional genomics, and proteomics will also be covered. (Credit cannot be earned for both BIO 5643 and BIO 5623.) Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5663. Applications of Recombinant DNA Technology. (3-0) 3 Credit Hours.**

A course on recombinant DNA technology, concentrating on major DNA manipulation methods, including their use in vaccine and bioactive protein production, gene therapy, plant genetic engineering along with ethical and safety considerations. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5713. Ornithology. (3-0) 3 Credit Hours.**

A course covering various aspects of the biology of birds, including anatomy, physiology, systematics, evolution, behavior, ecology, and biogeography. Field trips may be included. (Same as ES 5763. Credit cannot be earned for both BIO 5713 and ES 5763.) Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5733. Advanced Medical Mycology. (3-0) 3 Credit Hours.**

Prerequisites: BIO 3522 and BIO 3722. This course is a comprehensive study of the etiological agents and host factors that lead to fungal disease in humans. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5743. Advanced Virology. (3-0) 3 Credit Hours.**

Prerequisite: Graduate standing in Biology. A detailed study of the diversity of viruses and biochemical mechanisms for their replication. (Formerly titled "Biochemical Virology.") Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5753. Conservation Biology. (3-0) 3 Credit Hours.**

The class topics will include the nature of the biosphere, threats to its integrity, and ecologically sound responses to these threats. Also included will be the origin and preservation of biotic diversity, how the rich variety of plant and animal life arose, how it has been maintained by natural processes, and how its destruction can be prevented. (Same as ES 5753. Credit cannot be earned for both BIO 5753 and ES 5753.) Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5762. Fundamentals of Immunology for Biotechnology. (2-0) 2 Credit Hours.**

An integrated examination of the principles of immunology pertaining to the Biotechnology Industry. An emphasis on current immunological techniques, including: recombinant antibody, flow cytometry and elispot technology. Issues related to vaccine production and therapeutics will also be considered. Differential Tuition: \$100. Course Fees: GS01 \$60.

**BIO 5783. Introduction to Good Manufacturing Practices and Good Laboratory Practices. (3-0) 3 Credit Hours.**

Review of FDA and U.S. Pharmacopia regulations. Practical considerations for the implementation of GMP/GLP systems; data management and reporting, as well as problem solving and interpretive skills, will be emphasized. Differential Tuition: \$150. Course Fees: GS01 \$90.



**BIO 5813. Frontiers in Human Pluripotent Stem Cells. (3-0) 3 Credit Hours.**

Integrates the fundamental aspects of developmental biology with emerging concepts in embryonic and adult stem cells and regenerative medicine. A discussion of various stem cell applications in industry, military, medicine, and ethics of regenerative medicine is presented. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5833. Membrane Structure and Function. (3-0) 3 Credit Hours.**

Prerequisite: BIO 3513 or an equivalent. A study of the composition, organization, transport functions, and permeability of natural and model membranes. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5873. Plant Biotechnology. (3-0) 3 Credit Hours.**

Prerequisite: BIO 3513 or equivalent, BIO 5123 is recommended. The principles of plant physiology and genetics, and techniques used in plant modification, and principles of plant breeding and quantitative genetics as applied to plant biotechnology. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 5971. Directed Research. (0-0) 1 Credit Hour.**

Prerequisites: Admission to either the Biology or Biotechnology Master's program or admission as a special graduate or non-degree-seeking student, and permission in writing (form available) from the instructor and the student's Graduate Advisor of Record. The directed research course may involve either a laboratory or a theoretical problem. May be repeated for credit, but not more than 6 hours, regardless of discipline, in combination with BIO 6951-3 (Independent Study), will apply to the Master's degree. Differential Tuition: \$50. Course Fees: GS01 \$30.

**BIO 5972. Directed Research. (0-0) 2 Credit Hours.**

Prerequisites: Admission to either the Biology or Biotechnology Master's program or admission as a special graduate or non-degree-seeking student, and permission in writing (form available) of the instructor and the student's Graduate Advisor of Record. The directed research course may involve either a laboratory or a theoretical problem. May be repeated for credit, but not more than 6 hours, regardless of discipline, in combination with BIO 6951-3 (Independent Study), will apply to the Master's degree. Differential Tuition: \$100. Course Fees: GS01 \$60.

**BIO 5973. Directed Research. (0-0) 3 Credit Hours.**

Prerequisites: Admission to either the Biology or Biotechnology Master's program or admission as a special graduate or non-degree-seeking student, and permission in writing (form available) of the instructor and the student's Graduate Advisor of Record. The directed research course may involve either a laboratory or a theoretical problem. May be repeated for credit, but not more than 6 hours, regardless of discipline, in combination with BIO 6951-3 (Independent Study), will apply to the Master's degree. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 6133. Methods in Field Biology. (3-0) 3 Credit Hours.**

Prerequisite: BIO 3283 or an equivalent. Examination of techniques to collect, identify, and preserve plants and animals. Field methods used in the analysis of populations and communities are considered. (Same as ES 6133. Credit cannot be earned for both BIO 6133 and ES 6133.) Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 6213. Advanced Ecology. (3-0) 3 Credit Hours.**

Prerequisite: BIO 3283 or an equivalent. Interaction of organisms with their environment, allelopathy, competition, distribution, succession, and factors that control growth and dispersal. Special consideration is given to the concepts of climax, succession, and land management. (Same as ES 6213. Credit cannot be earned for both BIO 6213 and ES 6213.) Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 6233. Quantitative Biology. (3-0) 3 Credit Hours.**

Prerequisite: Graduate standing or consent of instructor. An introduction of quantitative analysis of biological data and design of experiments. Topics include probability theory and distributions; descriptive statistics; hypothesis testing and confidence intervals for means, variances, and proportions; chi-square statistic; categorical data analysis; linear correlation and regression model; analysis of variance; and nonparametric methods. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 6313. Molecular Biology and Biophysics of Ion Channels. (3-0) 3 Credit Hours.**

Prerequisites: BIO 5433 and BIO 5443, or permission of instructor. A study of the molecular composition and biophysical properties of ion channels. The course emphasizes three families of ion channels: voltage-gated, ligand-gated and metabotropically-stimulated channels. Their structure and function will be related to how ion channels mediate cellular actions in excitable cells. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 6323. Essentials of Biostatistics for Biotechnology. (3-0) 3 Credit Hours.**

Basic, intermediate, and advanced (but not bioinformatics) statistical vocabulary, concepts, and methods commonly used in the biotechnology industry. A focus on tests for quality control and assurance of equipment and test systems to assess accuracy, precision, and bias related to test validations. Concepts and appropriate selections of test/study design using power analyses and estimations of sample sizes; also for clinical trials. Analytical calibration curves, frequency distributions, descriptive statistics, measures of central tendency and dispersion/error, probability, paired and unpaired, one-tailed and two-tailed t-tests, correlations, regression, one-way and two-way analysis of variance with repeated measures, parametric and nonparametric tests, post hoc tests for significance, reporting and interpretations of statistical results, validations of clinical tests for specificity, sensitivity, predictive values, likelihood ratios, receiver operating characteristic curves. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 6483. Animal Behavior. (3-0) 3 Credit Hours.**

Prerequisite: BIO 3413 or consent of instructor. An examination of neural, endocrine, genetic, and environmental determinants of behavior. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 6513. Drug Development. (3-0) 3 Credit Hours.**

This course will provide students with an overview of the early drug discovery process, including target identification, validation, assay development and high throughput screening up to pre-clinical trials. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 6543. Vaccine Development. (3-0) 3 Credit Hours.**

Prerequisites: BIO 5762 and permission of instructor. This course will provide students with an overview of issues about the roles of vaccines in the control of infectious diseases, vaccine development, clinical trials and implementation of vaccine programs. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 6573. Microbial Pathogenesis. (3-0) 3 Credit Hours.**

The student will gain an understanding of the cellular and molecular mechanisms by which eukaryotic and viral pathogens cause disease and the host immune responses against these pathogens. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 6803. Advanced Immunology and Immunochemistry. (3-0) 3 Credit Hours.**

Prerequisite: BIO 4743 or consent of instructor. The study of current concepts of humoral and cell-mediated immunity, with emphasis on molecular mechanisms. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 6883. Bacterial Pathogenesis. (3-0) 3 Credit Hours.**

Prerequisites: BIO 3713 and BIO 4743, or consent of instructor. This course will present a selection of topics in the field of bacterial pathogenesis. Lectures will cover regulation of virulence; colonization and host tissue damage; vaccines, antibiotics and novel antimicrobials; evasion of the immune system; intracellular pathogens; pathogenic mechanisms of Gram-negative and Gram-positive bacteria; pathogenic mycobacteriology; and experimental tools in bacterial pathogenesis. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 6951. Independent Study. (0-0) 1 Credit Hour.**

Prerequisites: Graduate standing and permission in writing of the instructor and the student's Graduate Advisor of Record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, in combination with BIO 5971-3 Directed Research will apply to the Master's degree. Differential Tuition: \$50. Course Fees: GS01 \$30.

**BIO 6952. Independent Study. (0-0) 2 Credit Hours.**

Prerequisites: Graduate standing and permission in writing of the instructor and the student's Graduate Advisor of Record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, in combination with BIO 5971-3 Directed Research will apply to the Master's degree. Differential Tuition: \$100. Course Fees: GS01 \$60.

**BIO 6953. Independent Study. (0-0) 3 Credit Hours.**

Prerequisites: Graduate standing and permission in writing of the instructor and the student's Graduate Advisor of Record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, in combination with BIO 5971-3 Directed Research will apply to the Master's degree. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 6961. Comprehensive Examination. (0-0) 1 Credit Hour.**

Prerequisite: Approval of the appropriate Graduate Program Committee to take the Comprehensive Examination. Independent study course for the purpose of taking the Comprehensive Examination. May be repeated as many times as approved by the Graduate Program Committee. Enrollment is required each term in which the Comprehensive Examination is taken if no other courses are being taken that term. The grade report for the course is either "CR" (satisfactory performance on the Comprehensive Examination) or "NC" (unsatisfactory performance on the Comprehensive Examination). Differential Tuition: \$50. Course Fees: GS01 \$30.

**BIO 6973. Special Problems. (3-0) 3 Credit Hours.**

Prerequisite: Consent of instructor. An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. Special Problems courses may be repeated for credit when the topics vary, but not more than 6 hours, regardless of discipline, may be applied to the Master's degree. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 6981. Master's Thesis. (0-0) 1 Credit Hour.**

Prerequisites: Permission of the Graduate Advisor of Record and thesis director. Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the Master's degree. Credit will be awarded upon completion of the thesis. Enrollment in BIO 6981, BIO 6982, or BIO 6983 is required each term in which the thesis is in progress. Differential Tuition: \$50. Course Fees: GS01 \$30.

**BIO 6982. Master's Thesis. (0-0) 2 Credit Hours.**

Prerequisites: Permission of the Graduate Advisor of Record and thesis director. Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the Master's degree. Credit will be awarded upon completion of the thesis. Enrollment in BIO 6981, BIO 6982, or BIO 6983 is required each term in which the thesis is in progress. Differential Tuition: \$100. Course Fees: GS01 \$60.

**BIO 6983. Master's Thesis. (0-0) 3 Credit Hours.**

Prerequisites: Permission of the Graduate Advisor of Record and thesis director. Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the Master's degree. Credit will be awarded upon completion of the thesis. Enrollment in BIO 6981, BIO 6982, or BIO 6983 is required each term in which the thesis is in progress. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 7041. Biology Colloquium. (1-0) 1 Credit Hour.**

Prerequisite: Graduate standing. Oral presentations, discussions, critical evaluation of students' research in progress, or discussions of current journal articles or reviews of recent scientific advances. May be repeated for credit. The grade report for this course is either "CR" (satisfactory participation in the colloquium) or "NC" (unsatisfactory participation in the colloquium). (Formerly BIO 5041. Same as ES 6941. Unless topic varies, credit cannot be earned for both BIO 7041 and ES 6941.) Differential Tuition: \$50. Course Fees: GS01 \$30.

**BIO 7051. Seminar in Life Sciences. (1-0) 1 Credit Hour.**

Prerequisite: Graduate standing. Formal presentations of research by outside authorities in the biological sciences. May be repeated for credit. The grade report for this course is either "CR" (satisfactory participation in the seminar) or "NC" (unsatisfactory participation in the seminar). Differential Tuition: \$50. Course Fees: GS01 \$30.

**BIO 7113. Principles of Biological Scientific Teaching. (0-0) 3 Credit Hours.**

Prerequisite: Admission to candidacy for the Doctoral degree. Required course for Biology doctoral students. The student will be responsible for all aspects of leading a discussion section or laboratory course. Approval by the chair of the appropriate Doctoral Studies committee required. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 7143. Principles of Biological Scientific Writing. (3-0) 3 Credit Hours.**

Prerequisite: Graduate standing. This course will provide an overview of scientific grant and manuscript preparation. The class will be directed toward producing a Ph.D. dissertation proposal and a predoctoral fellowship application. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 7211. Doctoral Research. (0-0) 1 Credit Hour.**

Prerequisite: Admission to either the Neurobiology or Cell and Molecular Biology Doctoral program. May be repeated for credit, but no more than 52 hours may be applied to the Doctoral degree. Differential Tuition: \$50. Course Fees: GS01 \$30.

**BIO 7212. Doctoral Research. (0-0) 2 Credit Hours.**

Prerequisite: Admission to either the Neurobiology or Cell and Molecular Biology Doctoral program. May be repeated for credit, but no more than 52 hours may be applied to the Doctoral degree. Differential Tuition: \$100. Course Fees: GS01 \$60.

**BIO 7213. Doctoral Research. (0-0) 3 Credit Hours.**

Prerequisite: Admission to either the Neurobiology or Cell and Molecular Biology Doctoral program. May be repeated for credit, but no more than 52 hours may be applied to the Doctoral degree. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 7311. Doctoral Dissertation. (0-0) 1 Credit Hour.**

Prerequisites: Admission to candidacy for the Doctoral degree and completion of at least 18 semester credit hours of BIO 7211-3. May be repeated for credit. Differential Tuition: \$50. Course Fees: GS01 \$30.

**BIO 7312. Doctoral Dissertation. (0-0) 2 Credit Hours.**

Prerequisites: Admission to candidacy for the Doctoral degree and completion of at least 18 semester credit hours of BIO 7211-3. May be repeated for credit. Differential Tuition: \$100. Course Fees: GS01 \$60.

**BIO 7313. Doctoral Dissertation. (0-0) 3 Credit Hours.**

Prerequisites: Admission to candidacy for the Doctoral degree and completion of at least 18 semester credit hours of BIO 7211-3. May be repeated for credit. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 7563. Practicum in Biotechnology. (0-0) 3 Credit Hours.**

Prerequisites: Enrollment in Master's in Biotechnology program and at least 18 hours credit including satisfactory completion of BIO 5033 and one other organized laboratory course. An internship in a Biotechnology company. Must have approval of Biotechnology Graduate Studies Committee. Differential Tuition: \$150. Course Fees: GS01 \$90.

**BIO 7571. Experimental Techniques in Biology. (0-2) 1 Credit Hour.**

Prerequisite: Consent of instructor. Topics include research methods in cell and molecular biology, molecular neurobiology, and microbiology. May be repeated for credit as topics vary. (Formerly BIO 5571.) Differential Tuition: \$50. Course Fees: GS01 \$30.

**BIO 7572. Experimental Techniques in Biology. (0-4) 2 Credit Hours.**

Prerequisite: Consent of instructor. Topics include research methods in cell and molecular biology, molecular neurobiology, and microbiology. May be repeated for credit as topics vary. (Formerly BIO 5572.) Differential Tuition: \$100. Course Fees: GS01 \$60.