

DEPARTMENT OF NEUROSCIENCE, DEVELOPMENTAL AND REGENERATIVE BIOLOGY

Mission Statement

The mission of the Department of Neuroscience, Developmental and Regenerative Biology is to conduct high-impact, internationally recognized research and to educate and train the next generation of leaders in biological sciences. As a department of neuroscientists, and developmental and regenerative biologists, we focus on understanding organismal, tissue, and cellular function from molecules to behavior in health and disease.

General Information

The Department of Neuroscience, Developmental and Regenerative Biology studies key questions relating to how the brain works in normal and disease states (neuroscience) and how cells and tissues are formed, maintained, and repaired (developmental and regenerative). Collectively and collaboratively, we seek to learn, investigate, and communicate knowledge in these fields. Our diverse and recognized faculty and state-of-the-art laboratory facilities provide master's and Ph.D. students with opportunities for personal interaction, mentorship, and undergraduate research projects.

Neuroscience

Neuroscience research at UTSA is interdisciplinary and explores neural function from molecules to cells to neural networks to behavior. Students will find a highly collaborative atmosphere across the department. Our neuroscience laboratories employ behavioral, cellular, computational, developmental, and molecular approaches to answer questions associated with neural function. Many of our faculty are leading investigators attempting to understand debilitating brain diseases, including Alzheimer's disease, Parkinson's disease, epilepsy, and psychopathologies related to anxiety disorders. Students also can participate in various neuroscience-related activities supported by UTSA's Brain Health Consortium, including weekly seminar and special seminar programs. Graduate study in the neurosciences is supported through an M.S. in Biology degree with an emphasis in Neuroscience, and a Ph.D. degree in Neuroscience.

Developmental and Regenerative Biology

Faculty and students in the areas of Developmental and Regenerative Biology study a wide range of questions relating to stem cells, cancer and cell cycle regulation, tissue regeneration, epigenetic regulation of cell fate and function, gene expression, fertility, and organoid models. State-of-the-art technologies include genomics, epigenomics, proteomics, cell sorting, and cell imaging. A wide range of lecture courses are available to graduate students in Developmental and Regenerative Biology, along with opportunities for seminar classes, independent study, and directed research. Many of our faculty and students are associated with UTSA's Institute of Regenerative Medicine, a joint collaborative initiative between UTSA's Klesse College of Engineering and Integrated Design and the College of Sciences, and multiple research institutions in San Antonio. Graduate study in this area is supported through an M.S. in Biology

degree with an emphasis in Developmental and Regenerative Sciences and a Ph.D. degree in Developmental and Regenerative Sciences.

Career Pathways

Graduates of our programs have many opportunities to explore diverse career options. Our faculty are dedicated to helping students find a career path that best suits their passions and skills. Master's thesis and Ph.D. students select innovative research projects aligned with their interests, and our graduate students are optimally prepared for careers that include academic, industry, clinical, or government research settings.

- Ph.D. in Developmental and Regenerative Sciences (p. 1)
- Ph.D. in Neuroscience (p. 2)

Doctor of Philosophy Degree in Developmental and Regenerative Sciences

The Department of Neuroscience, Developmental and Regenerative Biology offers opportunities for advanced study and research leading to the Doctor of Philosophy degree in Developmental and Regenerative Sciences. The degree 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, a current résumé, three letters of recommendation, and a Statement of Future Plans.
- Applicants whose native language is not English must score at least 79 on the Test of English as a Foreign Language (TOEFL) iBT.

Admission is accompanied by appointment to a teaching assistantship, assistantship, or research fellowship. The Doctoral Studies Committee is comprised of members selected from the graduate faculty who are responsible for reviewing applications for admission and overseeing academic progress of students enrolled in the program.

Degree Requirements

The degree requires a minimum of 79 semester credit hours beyond the baccalaureate degree for the Ph.D. in Developmental and Regenerative Sciences. 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 a "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 Doctoral Studies Committee.

Code	Title	Credit Hours
A. Core Curriculum		17
Select courses from the list below to complete a total of 17 credits of core coursework:		
NDRB 5001	Ethical Conduct in Research	
NDRB 5123	Principles of Molecular Biology	
NDRB 5133	Principles of Cell Biology	
NDRB 7113	Principles of Biological Scientific Teaching	
NDRB 7143	Principles of Biological Scientific Writing	
Select 4 semester credit hours of Experimental Techniques in the Fall and Spring of the first year to complete Research Rotation requirement:		
NDRB 7572	Research Rotations ¹	
B. Colloquia		10
Complete 10 credits of colloquia coursework.		
NDRB 7041	Colloquium ²	
C. Doctoral Research		43
Select a minimum of 43 credits from the courses below:		
Doctoral Research courses may only be taken before student's admission to Ph.D. candidacy.		
NDRB 7211	Doctoral Research	
or NDRB 7212	Doctoral Research	
or NDRB 7213	Doctoral Research	
or NDRB 7214	Doctoral Research	
or NDRB 7215	Doctoral Research	
or NDRB 7216	Doctoral Research	
Doctoral Dissertation courses may only be taken by Ph.D. candidates.		
NDRB 7311	Doctoral Dissertation	
or NDRB 7312	Doctoral Dissertation	
or NDRB 7313	Doctoral Dissertation	
or NDRB 7314	Doctoral Dissertation	
or NDRB 7315	Doctoral Dissertation	
or NDRB 7316	Doctoral Dissertation	
D. Electives		9
Select 9 credits from any 5000- to 7000-level lecture NDRB, MMI, or BIO courses with the approval of the Developmental and Regenerative Sciences Doctoral Studies Committee.		
Total Credit Hours		79

¹ Enrollment in NDRB 7572 Research Rotations is required in the Fall and Spring semesters of the first year.

² Enrollment in NDRB 7041 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 Developmental and Regenerative Sciences 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 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 Developmental and Regenerative Sciences program. 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 the 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. This program focuses on training students on topics related to nervous system function. The areas of study aim to understand the brain and neurological disease at many levels, from single cells to circuits and populations, to determine how neural changes affect behavior and cognition. Areas of interest include circuits controlling addiction and motivated behavior, mechanisms of sensation and motor control, learning and memory, spatial navigation, modeling and computational analysis of brain function, and mechanisms of brain abnormalities including neurodegeneration and genetic conditions. 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, a current résumé, three letters of recommendation, and a Statement of Future Plans. Applicants whose native language is not English must score at least 79 on the Test of English as a Foreign Language (TOEFL) iBT. The Doctoral Studies Committees are 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.

Code	Title	Credit Hours
A. Core Curriculum		18
Select courses from the list below to complete a total of 18 credits of core coursework:		
NDRB 5001	Ethical Conduct in Research	
NDRB 5443	Molecular and Cellular Neurobiology	
NDRB 5453	Neurophysiology	
NDRB 6233	Quantitative Biology	
NDRB 7113	Principles of Biological Scientific Teaching	
NDRB 7143	Principles of Biological Scientific Writing	
Select 2 semester credit hours of Research Rotation in the Fall and Spring of the first year:		
NDRB 7571	Research Rotations ¹	
B. Colloquia		8
Complete 8 credits of colloquia coursework.		
NDRB 7041	Colloquium	
C. Doctoral Research		44
Select a minimum of 44 credits from the courses below:		
Doctoral Research courses may only be taken before student's admission to Ph.D. candidacy.		
NDRB 7211	Doctoral Research	
or NDRB 7212	Doctoral Research	
or NDRB 7213	Doctoral Research	
or NDRB 7214	Doctoral Research	
or NDRB 7215	Doctoral Research	
or NDRB 7216	Doctoral Research	
Doctoral Dissertation courses may only be taken by Ph.D. candidates.		
NDRB 7311	Doctoral Dissertation	
or NDRB 7312	Doctoral Dissertation	
or NDRB 7313	Doctoral Dissertation	
or NDRB 7314	Doctoral Dissertation	

or NDRB 7315 Doctoral Dissertation
or NDRB 7316 Doctoral Dissertation

D. Electives 9

Select 9 credits of electives from any 5000- to 7000-level lecture courses with the approval of the Neuroscience Doctoral Studies Committee.

Total Credit Hours 79

¹ Enrollment in NDRB 7571 Research Rotations 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 Neuroscience 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 written qualifying exam is administered in connection with the Neurophysiology and Molecular Neuroscience core courses. The oral qualifying exam is based on the dissertation research proposal and is administered by a four-member Oral Qualifying Exam Committee made up of tenured, tenure-track, or adjunct faculty. The qualifying exams are conducted as outlined in the Handbook of Academic Policies and Procedures for the Neuroscience Ph.D. program. 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.

Neuroscience, Developmental and Regenerative Biology (NDRB) Courses

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

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). (Same as BIO 5001. Formerly BIO 7413. Credit can only be earned for one of the following: NDRB 5001, BIO 5001, or BIO 7413.) This course has Differential Tuition. Course Fee: GS01 \$30; IUB1 \$10.

NDRB 5033. Biotechnology Laboratory. (0-9) 3 Credit Hours.

Prerequisite: Good Standing. An organized course offering an introduction to routine procedures employed in the modern research laboratory. (Same as BIO 5033. Credit cannot be earned for both BIO 5033 and NDRB 5033.) This course has Differential Tuition. Course Fee: GS01 \$90; L001 \$30; IUB1 \$10.

NDRB 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. (Formerly BIO 5123. Credit cannot be earned for both NDRB 5123 and BIO 5123.) This course has Differential Tuition. Course Fee: GS01 \$90.

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

Prerequisite: BIO 3513 and NDRB 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. (Same as BIO 5133. Credit cannot be earned for both NDRB 5133 and BIO 5133.) This course has Differential Tuition. Course Fee: GS01 \$90; IUB1 \$10.

NDRB 5143. Advanced Nucleic Acids Laboratory. (0-9) 3 Credit Hours.

Prerequisite: NDRB 3913 or an equivalent, NDRB 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. Same as BIO 5143. Credit cannot be earned for both BIO 5143 and NDRB 5143. This course has Differential Tuition. Course Fee: GS01 \$90; IUB1 \$10; L001 \$30.

NDRB 5163. Recombinant Protein Biotechnology Laboratory. (0-9) 3 Credit Hours.

Prerequisite: Satisfactory completion of NDRB 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. (Same as BIO 5163. Formerly BIO 7542 and BIO 7543. Credit can only be earned for one of the following: BIO 5163, BIO 7542, BIO 7543, or NDRB 5163.) This course has Differential Tuition. Course Fee: GS01 \$90; IUB1 \$10; L001 \$30.

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

Prerequisite: BIO 3513 and NDRB 3813, or equivalents. Cell- and organism-level functions viewed from a chemical perspective. Studies of molecular interactions of metabolites, pharmaceuticals, proteins, polysaccharides, lipids, and nucleic acids, including protein folding and unfolding, protein modification, ligand binding, proteomics, metabolomics, lipidomics, glycoproteins, and nucleotide modification. (Same as BIO 5213. Credit cannot be earned for both NDRB 5213 and BIO 5213.) This course has Differential Tuition. Course Fee: GS01 \$90.

NDRB 5223. Principles of Developmental Biology. (3-0) 3 Credit Hours.

Prerequisite: NDRB 3813 or NDRB 4143, or equivalent. Experimental models and approaches used to address the fundamental processes of multicellular development. The course will cover foundational concepts, such as cell-type specification, morphogenesis, and growth coordination, as well as the next frontiers in developmental biology, organogenesis and regenerative medicine. This course has Differential Tuition. Course Fee: GS01 \$90.

NDRB 5423. Neuroanatomy. (3-0) 3 Credit Hours.

Prerequisite: Consent of instructor. The anatomy of the vertebrate nervous system. (Formerly BIO 5423. Credit cannot be earned for both NDRB 5423 and BIO 5423.) This course has Differential Tuition. Course Fee: GS01 \$90.

NDRB 5433. Systems Neuroscience. (3-0) 3 Credit Hours.

Prerequisite: NDRB 3433 or an equivalent. The fundamentals of neurophysiology are presented from the cellular to the systems level. (Formerly BIO 5433. Credit cannot be earned for both BIO 5433 and NDRB 5433.) This course has Differential Tuition. Course Fee: GS01 \$90; IUB1 \$10.

NDRB 5443. Molecular and Cellular Neurobiology. (3-0) 3 Credit Hours.

Prerequisite: NDRB 3813 or equivalent. This course is an introduction to the fundamental genetics, cell biology, development, and plasticity of the nervous system. This course uses a combination of lecture and discussion of current and foundational literature, to cover a range of topics and techniques in molecular neurobiology. (Formerly BIO 5443. Credit cannot be earned for both BIO 5443 and NDRB 5443.) This course has Differential Tuition. Course Fee: GS01 \$90.

NDRB 5453. Neurophysiology. (3-0) 3 Credit Hours.

Prerequisite: NDRB 3433 or equivalent. The fundamentals of cellular and synaptic neurophysiology. This course has Differential Tuition. Course Fee: GS01 \$90; IUB1 \$10.

NDRB 5463. Reproductive Biology. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing in Biology. This course covers mammalian reproduction including mechanisms involved in sexual differentiation, fertilization, and fetal development. Endocrine regulation and environmental influences with a focus on human reproduction. (Formerly BIO 5463. Credit cannot be earned for both BIO 5463 and NDRB 5463.) This course has Differential Tuition. Course Fee: GS01 \$90; IUB1 \$10.

NDRB 5473. Neurobiology of Learning and Memory. (3-0) 3 Credit Hours.

Prerequisite: NDRB 3433 or equivalent, or consent of instructor. This course focuses on the fundamental neurobiological mechanisms underlying learning and memory. Neurotransmission, synaptic plasticity, molecular events, neurophysiological correlates, and behavioral readouts are considered to describe how discrete brain regions and neural networks contribute to learning and memory. This course has Differential Tuition. Course Fee: GS01 \$90.

NDRB 5483. Computational Neuroscience. (3-0) 3 Credit Hours.

Prerequisite: NDRB 3433 or equivalent. An introduction to the computational functions of the brain, including sensory coding, neural control of movement, and the computational properties of neurons and neuronal networks. (Formerly BIO 5483. Credit cannot be earned for both BIO 5483 and NDRB 5483.) This course has Differential Tuition. Course Fee: GS01 \$90; IUB1 \$10.

NDRB 5493. Cognitive Neuroscience. (3-0) 3 Credit Hours.

Prerequisite: NDRB 3433 or PSY 3403 recommended, or consent of instructor. This course surveys the field of cognitive neuroscience covering a variety of topic areas and methodologies. Specific topics covered may vary, and may include subjects such as perception, memory, language, motor control, emotion, development, or other related subjects. Students will have the opportunity for (1) an overview of the neural correlates of human cognition, (2) technical and inferential aspects of various human neuroimaging techniques, (3) reading primary research publications, and (4) developing and presenting a research question in the field. (Same as NDRB 4823. Formerly BIO 5493 and BIO 4823. Credit can only be earned for one of the following: BIO 4823, NDRB 4823, BIO 5493, or NDRB 5493.) This course has Differential Tuition. Course Fee: GS01 \$90.

NDRB 5583. Developmental Neuroscience. (3-0) 3 Credit Hours.

Prerequisite: NDRB 3813 and NDRB 3913 or consent of instructor. A comparative approach will be used to understand basic patterning mechanisms that control the formation of the nervous system along the major axes of the body. Emphasis will be placed on the study of the cerebral cortex, hindbrain, spinal cord, and the various origins of the peripheral nervous system. Other topics may include the study of epigenetic mechanisms regulating neuronal plasticity and disease. This course has Differential Tuition. Course Fee: GS01 \$90.

NDRB 5613. Neurodegenerative Disease. (3-0) 3 Credit Hours.

Prerequisite: NDRB 3433 and NDRB 3813, or consent of instructor; NDRB 5433 and NDRB 5443 are 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. (Formerly BIO 5613. Credit cannot be earned for both BIO 5613 and NDRB 5613.) This course has Differential Tuition. Course Fee: GS01 \$90.

NDRB 5643. Integrative Genomics and Bioinformatics. (3-0) 3 Credit Hours.

An exploration of genomics and bioinformatics methods to analyze and interpret biological data. Students will have the opportunity to gain a foundational understanding of different types of genomic data and learn to use various bioinformatics tools. Students will develop computational skills essential for bioinformatics and become acquainted with major genomic databases and resources. A basic understanding of molecular biology and genetics is recommended. Familiarity with programming (Python or R) is beneficial, but not mandatory. Formerly titled Introduction to Bioinformatics. (Same as MMI 6643. Credit cannot be earned for both MMI 6643 and NDRB 5643.) This course has Differential Tuition. Course Fee: GS01 \$90.

NDRB 5663. Human Embryology. (3-0) 3 Credit Hours.

Prerequisite: BIO 2313 or equivalent, or consent of the instructor. This course will provide a basic understanding of the developing human body from fertilization and organ formation to the birth of the fetus. Modern techniques will be introduced to appreciate how conserved patterning mechanisms contribute to normal and disease states. An emphasis will also be placed on the integration of developmental principles with functional anatomy and physiology. This course has Differential Tuition. Course Fee: GS01 \$90.

NDRB 5673. Space and Time in the Brain. (3-0) 3 Credit Hours.

Prerequisite: NDRB 3433 or equivalent. Specific cells in the brain appear to signal position in space as well as the passage of time, suggesting that the brain uses common mechanisms to process space and time while forming memories. In this course, students will be introduced to the concepts of place cells, grid cells, and other spatial cells found within and beyond the hippocampal formation. This course has Differential Tuition. Course Fee: GS01 \$90.

NDRB 5683. Neural Data Science. (3-0) 3 Credit Hours.

Prerequisite: MAT 1193, CS 1063 or DS 4013, STA 1403 or PSY 2073, and NDRB 2113, or equivalents. Analysis and interpretation of neurophysiological data, such as spike trains and EEG traces recorded from behaving animals or human subjects. While gaining hands-on computer-programming experience, this course will examine how neuroscientists use data analysis to investigate open questions. This course has Differential Tuition. Course Fee: GS01 \$90.

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

This course 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. (Formerly BIO 5813. Credit cannot be earned for both BIO 5813 and NDRB 5813.) This course has Differential Tuition. Course Fee: GS01 \$90.

NDRB 5833. Membrane Transport and Ion Channels. (3-0) 3 Credit Hours.

Prerequisite: NDRB 3433, BCH 3303 or equivalent course, or permission of instructor. This course is a study of ion transport across membranes and how it mediates cellular activity in electrically excitable cells. Topics include the molecular structures of ion transporters, voltage-gated, ligand-gated, mechanically-gated, and metabotropically stimulated channels, gap junctions, and channel regulation by membrane remodeling. (Formerly BIO 5833 and NDRB 6313. Credit can only be earned for one of the following: BIO 5833, NDRB 6313, or NDRB 5833.) This course has Differential Tuition. Course Fee: GS01 \$90.

NDRB 5971. Directed Research. (0-0) 1 Credit Hour.

Prerequisite: 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 NDRB 6951, NDRB 6952, and NDRB 6953 (Independent Study), will apply to the Master's degree. This course has Differential Tuition. Course Fee: GS01 \$30.

NDRB 5972. Directed Research. (0-0) 2 Credit Hours.

Prerequisite: 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 NDRB 6951, NDRB 6952, and NDRB 6953 (Independent Study), will apply to the Master's degree. This course has Differential Tuition. Course Fee: GS01 \$60.

NDRB 5973. Directed Research. (0-0) 3 Credit Hours.

Prerequisite: 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 NDRB 6951, NDRB 6952, and NDRB 6953 (Independent Study), will apply to the Master's degree. This course has Differential Tuition. Course Fee: GS01 \$90.

NDRB 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. (Same as BIO 6233. Credit cannot be earned for both NDRB 6233 and BIO 6233.) This course has Differential Tuition. Course Fee: GS01 \$90; IUB1 \$10.

NDRB 6483. Neurobiology of Animal Behavior. (3-0) 3 Credit Hours.

Prerequisite: NDRB 3433 or BIO 3413 or consent of instructor. This course is designed to develop critical thinking skills while examining current neurobiology research on the extrinsic and intrinsic factors influencing animal behavior. The class will focus on behaviors that are relevant models for human disorders. (Formerly BIO 6483. Credit cannot be earned for both BIO 6483 and NDRB 6483.) This course has Differential Tuition. Course Fee: GS01 \$90; IUB1 \$10.

NDRB 6643. Advanced Multicellular Bioinformatics. (3-0) 3 Credit Hours.

The ability to sequence and analyze genomes has transformed biology. The genomic revolution has been made possible by the development of bioinformatics tools that combine computation with principles of molecular biology. In this course students will learn how to use some of the major bioinformatics tools and will examine a few genomes to understand the vast amount of information present in them. This course has Differential Tuition. Course Fee: GS01 \$90.

NDRB 6951. Independent Study. (0-0) 1 Credit Hour.

Prerequisite: Graduate standing and permission in writing of the instructor and the student's Graduate Advisor of Record. This course includes 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 NDRB 5971, NDRB 5972, and NDRB 5973. Directed Research will apply to the Master's degree. This course has Differential Tuition. Course Fee: GS01 \$30.

NDRB 6952. Independent Study. (0-0) 2 Credit Hours.

Prerequisite: Graduate standing and permission in writing of the instructor and the student's Graduate Advisor of Record. This course includes 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 NDRB 5971, NDRB 5972, and NDRB 5973. Directed Research will apply to the Master's degree. This course has Differential Tuition. Course Fee: GS01 \$60.

NDRB 6953. Independent Study. (0-0) 3 Credit Hours.

Prerequisite: Graduate standing and permission in writing of the instructor and the student's Graduate Advisor of Record. This course includes 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 NDRB 5971, NDRB 5972, and NDRB 5973. Directed Research will apply to the Master's degree. This course has Differential Tuition. Course Fee: GS01 \$90.

NDRB 6961. Comprehensive Examination. (0-0) 1 Credit Hour.

Prerequisite: Approval of the appropriate Graduate Program Committee to take the Comprehensive Examination. This is an 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). This course has Differential Tuition. Course Fee: GS01 \$30.

NDRB 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. This course has Differential Tuition. Course Fee: GS01 \$90.

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

Prerequisite: Permission of the Graduate Advisor of Record and thesis director. Corequisites: Enrollment in NDRB 6981, NDRB 6982, or NDRB 6983 is required each term in which the thesis is in progress. 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. This course has Differential Tuition. Course Fee: GS01 \$30.

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

Prerequisite: Permission of the Graduate Advisor of Record and thesis director. Corequisites: Enrollment in NDRB 6981, NDRB 6982, or NDRB 6983 is required each term in which the thesis is in progress. 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. This course has Differential Tuition. Course Fee: GS01 \$60.

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

Prerequisite: Permission of the Graduate Advisor of Record and thesis director. Corequisites: Enrollment in NDRB 6981, NDRB 6982, or NDRB 6983 is required each term in which the thesis is in progress. 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. This course has Differential Tuition. Course Fee: GS01 \$90.

NDRB 7041. Colloquium. (1-0) 1 Credit Hour.

Prerequisite: Graduate standing. This course will include 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). This course has Differential Tuition. Course Fee: GS01 \$30; IUB1 \$10.

NDRB 7051. Seminar. (1-0) 1 Credit Hour.

Prerequisite: Graduate standing. Formal presentations of research by outside authorities in the biological sciences. May be repeated for up to 3 semester credit hours. The grade report for this course is either "CR" (satisfactory participation in the seminar) or "NC" (unsatisfactory participation in the seminar). This course has Differential Tuition. Course Fee: GS01 \$30; IUB1 \$10.

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

Prerequisite: Admission to candidacy for the Doctoral degree. Required course for Neuroscience or Developmental and Regenerative Sciences doctoral students. The student will be trained on strategies to be an effective presenter and/or course instructor. The student may also gain direct experience being responsible for leading a discussion session or a teaching laboratory section. Approval by the chair of the appropriate Doctoral Studies committee is required. This course has Differential Tuition. Course Fee: GS01 \$90.

NDRB 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. This course has Differential Tuition. Course Fee: GS01 \$90.

NDRB 7211. Doctoral Research. (0-0) 1 Credit Hour.

Prerequisite: Admission to either the Neuroscience or Developmental and Regenerative Sciences doctoral program. May be repeated for credit, but no more than 52 hours may be applied to the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 \$30; IUB1 \$10.

NDRB 7212. Doctoral Research. (0-0) 2 Credit Hours.

Prerequisite: Admission to either the Neuroscience or Developmental and Regenerative Sciences doctoral program. May be repeated for credit, but no more than 52 hours may be applied to the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 \$60; IUB1 \$10.

NDRB 7213. Doctoral Research. (0-0) 3 Credit Hours.

Prerequisite: Admission to either the Neuroscience or Developmental and Regenerative Sciences doctoral program. May be repeated for credit, but no more than 52 hours may be applied to the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 \$90; IUB1 \$10.

NDRB 7214. Doctoral Research. (0-0) 4 Credit Hours.

Prerequisite: Admission to either the Neuroscience or Developmental and Regenerative Sciences doctoral program. May be repeated for credit, but no more than 52 hours may be applied to the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 \$120; IUB1 \$10.

NDRB 7215. Doctoral Research. (0-0) 5 Credit Hours.

Prerequisite: Admission to either the Neuroscience or Developmental and Regenerative Sciences doctoral program. May be repeated for credit, but no more than 52 hours may be applied to the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 \$150; IUB1 \$10.

NDRB 7216. Doctoral Research. (0-0) 6 Credit Hours.

Prerequisite: Admission to either the Neuroscience or Developmental and Regenerative Sciences doctoral program. May be repeated for credit, but no more than 52 hours may be applied to the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 \$180; IUB1 \$10.

NDRB 7311. Doctoral Dissertation. (0-0) 1 Credit Hour.

Prerequisite: Admission to candidacy for the Doctoral degree and completion of at least 18 semester credit hours of NDRB 7211, NDRB 7212, or NDRB 7213. May be repeated for credit. This course has Differential Tuition. Course Fee: GS01 \$30; IUB1 \$10.

NDRB 7312. Doctoral Dissertation. (0-0) 2 Credit Hours.

Prerequisite: Admission to candidacy for the Doctoral degree and completion of at least 18 semester credit hours of NDRB 7211, NDRB 7212, or NDRB 7213. May be repeated for credit. This course has Differential Tuition. Course Fee: GS01 \$60; IUB1 \$10.

NDRB 7313. Doctoral Dissertation. (0-0) 3 Credit Hours.

Prerequisite: Admission to candidacy for the Doctoral degree and completion of at least 18 semester credit hours of NDRB 7211, NDRB 7212, or NDRB 7213. May be repeated for credit. This course has Differential Tuition. Course Fee: GS01 \$90; IUB1 \$10.

NDRB 7314. Doctoral Dissertation. (0-0) 4 Credit Hours.

Prerequisite: Admission to candidacy for the Doctoral degree and completion of at least 18 semester credit hours of NDRB 7211, NDRB 7212, or NDRB 7213. May be repeated for credit. This course has Differential Tuition. Course fees: IUB1 \$10; GS01 \$120.

NDRB 7315. Doctoral Dissertation. (0-0) 5 Credit Hours.

Prerequisite: Admission to candidacy for the Doctoral degree and completion of at least 18 semester credit hours of NDRB 7211, NDRB 7212, or NDRB 7213. May be repeated for credit. This course has Differential Tuition. Course Fee: GS01 \$150; IUB1 \$10.

NDRB 7316. Doctoral Dissertation. (0-0) 6 Credit Hours.

Prerequisite: Admission to candidacy for the Doctoral degree and completion of at least 18 semester credit hours of NDRB 7211, NDRB 7212, or NDRB 7213. May be repeated for credit. This course has Differential Tuition. Course Fee: GS01 \$180; IUB1 \$10.

NDRB 7571. Research Rotations. (0-3) 1 Credit Hour.

Prerequisite: Consent of instructor. Topics may include research methods in developmental biology, regenerative biology, cellular neuroscience, and systems neuroscience. May be repeated for credit as topics vary. Formerly titled "Experimental Techniques in Biology." (Same as BIO 7571.) This course has Differential Tuition. Course Fee: GS01 \$30; IUB1 \$10.

NDRB 7572. Research Rotations. (0-6) 2 Credit Hours.

Prerequisite: Consent of Instructor. Topics may include research methods in developmental biology, regenerative biology, cellular neuroscience, and systems neuroscience. May be repeated for credit as topics vary. Formerly "Experimental Techniques in Biology." (Same as BIO 7572. Credit cannot be earned for both BIO 7572 and NDRB 7572.) This course has Differential Tuition. Course Fee: GS01 \$60.