NEUROSCIENCE

Bi-College Interdisciplinary Neuroscience Program

The desire to understand human and animal behavior in terms of nervous system structure and function is longstanding. Historically, researchers and scholars have approached this task from a variety of disciplines, including medicine, biology, psychology, philosophy, and physiology. The field of neuroscience emerged as an interdisciplinary approach, combining techniques and perspectives from these disciplines, as well as emerging fields such as computation and cognitive science, to yield new insights into the workings of the nervous system and behavior.

Neuroscience Major

The major in Neuroscience allows students to pursue an in-depth study of the nervous system and behavior across disciplines. Students should consult with the Neuroscience Chair or any member of the faculty advisory committee in order to declare the major.

Learning Goals

The goals of the major include enabling students to gain:

- Training in cognate disciplines that are fundamental to the study of Neuroscience
- An in-depth understanding of the organization of the nervous system and its relation to the categories of behavior such as motor control, sensation and perception, motivational states, and higher cognition
- Fluency with the many levels at which the nervous system can be studied, including molecular, cellular, systems, behavioral and cognitive neuroscience levels
- An ability to closely examine and critically evaluate primary research on specialized, advanced neuroscience topics
- An appreciation of the interdisciplinary nature of neuroscience and the allied disciplies that inform the study of mind, brain, and behavior
- Experience with neuroscience laboratory skills and the design and analysis of neuroscience experiments

Major Requirements

- Introduction to Neuroscience (1 unit)
  - NEUR B100/NEUR H100
- Foundational Science Courses (4 units)
  - 1 semester of General Chemistry (CHEM B103, H111, H113, or H115)
  - 1 semester of Introductory Biology (BIOL B110, BIOL B111, H200A, or H201B with instructor approval,)
  - 1 semester of Introductory Psychology (PSYC B105 or H100)
  - 1 semester of Statistics (PSYC H200, PSYC B205; MATH H103 or H203, MATH B104, or ECON H203)
- Upper-level Neuroscience Courses with Breadth Requirement (4 units)
  - Students must take 4 units of upper-level neuroscience courses
  - Upper-level Neuroscience courses are divided into three categories: Cellular/Molecular, Behavioral/Systems, and Cognitive. Students must take courses from at least two of the three categories to fulfil the breadth requirement.
  - A list of approved courses and their categories is linked here
- Laboratory Coursework in Neuroscience (1 unit)
  - In order to gain hands-on experience with some of the tools, methods, and paradigms of Neuroscience, majors are required to take 1 unit of neuroscience laboratory coursework. This can be accomplished in several ways (e.g., 2 half-unit psych labs, 1 full-unit psych lab, 1 full-unit neuroscience SuperLab).
  - A list of approved laboratory courses is linked here
- Thesis or Capstone in Neuroscience (1 unit)
  - To culminate their experience as a Neuroscience major, students are required to complete one course of thesis or capstone work. This may take the form of a 2-semester laboratory thesis project or a 1-semester capstone course.

Neuroscience Minor

The minor in Neuroscience allows students with any major to pursue interests in behavior and the nervous system across disciplines. Students should consult with the faculty coordinator or any member of the advisory committee in order to declare the minor.

Learning Goals

The goals of the minor include enabling students to gain:

- a basic understanding of the organization of the nervous system and its relation to categories of behavior such as motor control, sensation and perception, motivational states, and higher cognition
- an appreciation of and fluency with the many levels at which the nervous system can be studied, including molecular, cellular, systems, behavioral and cognitive neuroscience levels
- an appreciation of the interdisciplinary nature of neuroscience and the allied disciplines that inform the study of mind, brain, and behavior
- an ability to closely examine and critically evaluate primary research on specialized, advanced neuroscience topics

Minor Requirements

- One “gateway” course from the following list:
  - NEUR H100 (Introduction to Neuroscience), PSYC H217 (Behavioral Neuroscience), PSYC B218 (Behavioral Neuroscience, or BIOL B202 (Neurobiology)
- Five additional credits beyond the gateway course, with these constraints:
  - Three of the five credits must come from the list of approved upper-level neuroscience courses
  - Two of the five credits must come from the list of approved allied courses.
  - At least one of the credits must be at the 300-level or higher.
  - One of the five credits may come from supervised senior research in neuroscience.
  - No more than two of the six minor credits may come from institutions outside of the Bi-Co.
  - No more than two of the six minor credits may be double-counted towards a major.
- A current list of approved courses, divided into List A: Primary Neuroscience and List B: Allied Disciplines, is linked here (https://docs.google.com/document/d/1y4R4KbisfBggnn4_W7llNCptNEBkB3iBvZSnk3New-Q/edit/?tab=t.0#heading=h.c16p6rpj3gm1).

NEUR B100 Introduction to Neuroscience (1 Unit)
Neuroscience is an interdisciplinary field that seeks to understand the structure and functions of the nervous system. This course includes topics on the broad history of behavioral neuroscience, parts of the nervous system, and a cursory overview of imaging/recording/histology. We also cover basic neurophysiology/chemistry of action potentials and neurotransmission (with some neurobiology of drug effects). Lastly, we explore sensorimotor processing (i.e. reflex arcs), basic sensory transduction and neuroanatomy of perception (sensory pathways from periphery to primary sensory cortex). Prerequisite(s): This course is not open to students who have previously taken HC Psych 217, HC Psych 260, or BMC Psych 218

NEUR B398 Senior Thesis in Neuroscience (1 Unit)

NEUR B399 Neuroscience Senior Capstone (1 Unit)
This course will survey empirical studies from several subdisciplines within the field of neuroscience (eg behavioral, cognitive, computational, molecular, etc) that advance our understanding of the brain. Through exposure to a diversity of approaches, it is hoped that students will be reminded that the boundaries that define the disciplines of neuroscience are blurred, and that it is the language of all these subdisciplines, that continue the advance of modern neuroscience. Each section of the course (defined by a given subdiscipline and relevant empirical articles) will culminate with a visit from a current researcher in that subdiscipline whose studies continue to advance our understanding of the brain. The visiting researcher will lead an in-class discussion about their research, as well as the path they took to get to their current position.

NEUR B403 Supervised Research (0.5 Unit)
Laboratory or field research on a wide variety of topics. Students should consult with faculty members to determine their topic and faculty supervisor, early in the semester prior to when they will begin.

BIOL B110 Biological Exploration I (1 Unit)
BIOL B110 is an introductory-level course designed to encourage students to explore the field of biology at multiple levels of organization: molecular, cellular, organismal and population. Lecture three hours, laboratory three hours a week. BIOL B110 explores the ways the central dogma of molecular biology relates to the biochemical basis of human traits through the lens of biochemistry, cell biology, genetics, and molecular biology. The laboratory portion of the course will explore the fundamentals of molecular and cellular biology through scientific research, with an emphasis on scientific process and experimental design. Topics include genetically modified organisms, stem cell biology, and molecular biological techniques.

BIOL B111 Biological Exploration II (1 Unit)
BIOL B111 is an introductory-level course designed to encourage students to explore the field of biology at multiple levels of organization: molecular, cellular, organismal and ecological. Lecture three hours, laboratory three hours a week. Spring 2023: BIOL B111 will explore how organisms interact with and adapt to their environments, both abiotic and biotic. Topics to be investigated include development, physiology, photosynthesis, ecology (population, community and ecosystem), and evolution. The laboratory portion of the course will explore the fundamentals of organismal biology through scientific research, with an emphasis on the scientific process and experimental design.

BIOL B202 Neurobiology (1 Unit)
This course provides a cellular and molecular lens on foundational topics in neuroscience, such as electrophysiology, synaptic transmission, plasticity, and neural circuit development and function. Students will develop skills necessary to read primary literature in neuroscience. Lecture and activities three hours per week. Prerequisite: One semester of BIOL 110-111, Neuroscience 100, or permission of instructor.

BIOL B217 Biomechanics (1 Unit)
This course integrates anatomy, physiology, neuromechanics, and physics to understand the principles that govern animal and human movement. Concepts will highlight the interdisciplinary nature of biomechanics that must be used to study the mechanics of movement, from running, walking, flying, to swimming. Students will develop fundamental quantitative skills for biological problem-solving and be exposed to the field of comparative biomechanics. Prerequisite: One semester of BIOL 110-111, or permission of instructor.

BIOL B228 Drosophila as a model for neurogenetics (1 Unit)
This course will allow students to gain firsthand experience in how to use the Drosophila melanogaster model to perform original research in neurogenetics. Students will be provided with a novel gene to study and assess the role of these genes in a diversity of behavioral assays. The course will be a mixture of lecture, laboratory activity, paper discussion, and student presentation. One semester of BIOL B110-111 or permission of instructor.

BIOL B305 Sleep and Biological Rhythms (1 Unit)
This seminar course will survey our current understanding of chronobiology and sleep at the molecular, cellular, and organismal level. Classes will be a mixture of lecture, discussion, and student presentations based on both historical and current primary literature. Prerequisite: PSYC H217, PSYC B218, or BIOL B202 or permission of instructor.

BIOL B338 Advanced Topics in Neurobiology: Learning and Memory (1 Unit)
This course will focus on the cellular and molecular mechanisms underlying neuronal synaptic plasticity, learning, and memory. Through a combination of lectures, discussions, and presentations, we will build up to reading primary scientific literature covering multiple model organisms, learning paradigms, and experimental techniques. PSYC H217, PSYC B218, or BIOL B202 or permission of instructor.

BIOL B344 Sensory Physiology (1 Unit)
How do animals sense the world around them? How does an animal's physiology shape its experience of the world? In this class, we will cover the processes underlying animal sensing, including the senses familiar to us – vision (seeing), audition (hearing), somatosensation (touch), olfaction (smell), and gustation (taste) – as well as those we lack, such as electroreception and magnetoreception. The course will focus on the structures and transduction mechanisms that convert sensory signals in the outside world to neural signals. We will highlight commonalities across sensory systems in divergent organisms, as well as examine how animals have evolved unique sensory systems suited to their particular environments.

BIOL B347 Neural Coding (1 Unit)
How do patterns of electrical activity in the brain represent information about the outside world, our movements, and our thoughts? In this course, we will discuss scientists' attempts to decipher this "neural code," examining current knowledge and theories of how information is represented and processed in the brain. We will consider the roles of individual neurons, small neural circuits, and larger brain areas. Topics include: tuning curves, rate and temporal codes, noise and variability, population codes, oscillations and synchrony, and neural adaptation. We will also discuss existing and emerging technologies that are enabled by our understanding of the neural code, as well as the ethical questions raised by these technologies. (This course does not involve programming.) Prerequisite: BIOL B202 or permission of instructor

CHEM B103 General Chemistry I (1 Unit)
This is an introductory course in chemistry, open to students with no previous chemistry experience. Topics include aqueous solutions and solubility; the electronic structure of atoms and molecules; chemical reactions and energy; intermolecular forces. Examples discussed in lecture and laboratory include applications of the material to environmental sciences, material science and biological chemistry. Lecture three hours, recitation one hour and laboratory three hours a week. Prerequisite: Quantitative Readiness Required.

MATH B104 Basic Probability and Statistics (1 Unit)
This course introduces key concepts in descriptive and inferential statistics. Topics include summary statistics, graphical displays, correlation, regression, probability, the Law of Large Numbers, expected value, standard error, the Central Limit Theorem, hypothesis testing, sampling procedures, bias, and the use of statistical software.

PSYC B105 Introductory Psychology (1 Unit)
How do biological predispositions, life experiences, culture, and other social forces contribute to individual differences in human and animal behavior? This biopsychosocial theme will be examined in domains such as perception, cognition, learning, motivation, emotion, and social interaction thereby providing an overview of psychology's many areas of inquiry. The laboratory component of the course provides students opportunities to engage in data collection, research design, data analysis, and scientific writing in the psychological sciences. Students sign up for a laboratory component during the first week of class (laboratory times are typically held for 2 hours per week; (four weekday evening times and one weekend time.

PSYC B205 Research Methods and Statistics (1 Unit)
An introduction to research design, general research methodology, and the analysis and interpretation of data. Emphasis will be placed on issues involved with conducting psychological research. Topics include descriptive and inferential statistics, research design and validity, analysis of variance, and correlation and regression. Each statistical method will also be executed using computers. Lecture three hours, laboratory 90 minutes a week.

PSYC B212 Human Cognition (1 Unit)
This course provides an overview of the field of Cognitive Psychology, the branch of psychology that studies how we think. Over the semester we will survey classic and contemporary theory and findings on a wide range of mental processes that we use every day – from attention and memory to language and problem solving – and our goal will be to understand how the human mind works! Prerequisite: PSYC B105 or H100 (Introductory Psychology), or instructor's permission.

PSYC B218 Behavioral Neuroscience (1 Unit)
This course will introduce students to the field of behavioral neuroscience. The first part of the course will familiarize students with the brain and neuronal communication. Then, we will delve into brain-behavior relationships. Topics covered will include: sex behavior, hunger, sleep, emotion, and psychopathology. Classic and state-of-the-art neuroscience research methodologies leading to this knowledge will be highlighted. Students will learn course content through lectures, readings, and digital media. To culminate the course, students will write a literature review on a topic of their choosing within the field of behavioral neuroscience. Lecture three hours a week. Prerequisite: Introductory Psychology (PSYC B101 or PSYC H100) or NEUR H100

PSYC B265 Computational Neuroscience (1 Unit)
This course introduces students to the field of computational neuroscience. Computational neuroscience uses mathematical models to understand the information carried in the brain at many scales: a single neuron, synaptic connections between neurons, and populations of neurons. Mathematical models help us gain a precise understanding of the dynamics of our nervous system and make better predictions by running simulations of the system. In this course, students will learn key concepts and topics in computational neuroscience. Topics include neural encoding and decoding, artificial neural networks, reinforcement learning, and Bayesian probability theories. They will gain hands-on experience formulating the mental processes in the brain in terms of mathematical equations and writing computer codes in programming languages such as Python and MATLAB to simulate these processes. Prerequisites: Introductory Psychology (PSYC B101 or PSYC H100), or Introduction to Neuroscience (NEUR H100).

PSYC B280 Laboratory in Computational Neuroscience (0.5 Unit)
This writing-intensive laboratory course offers students hands-on experience in conducting computational neuroscience research. Through lab projects, students will develop research questions, perform literature reviews, apply computational theories to interpret existing findings, and run model simulations. They will write an APA-style manuscript and give an oral presentation. This course will use the Python programming language. Prior programming experience is helpful, but not required. This is a 0.5-unit writing-intensive class that meets half of the writing requirement for the major. Prerequisites: (PSYC B105, or PSYC H100, or NEUR 100) AND (PSYC B205, or PSYC H200, or MATH H103, or MATH H203, or MATH B104, or ECON H203) AND (PSYC B265, or PSYC B218, or PSYC H217, or PSYC B212, or PSYC H260) or permission of instructor.

PSYC B286 Laboratory in Behavioral Neuroscience (0.5 Unit)
This writing-intensive laboratory course will provide students with experience in the design, implementation, analysis, and presentation of behavioral neuroscience research. Students will partake in experiments that explore the relationship between the brain and behavior, using Sprague Dawley rats as a model organism. Students should expect to write research reports on experiments performed in the lab, as well as give an oral presentation on research conducted. Prerequisites: (PSYCB105, PSYCB100 or NEUR100) AND Either (PSYCB205, PSYCH200, MATHH103, MATHH203, MATHB104, or ECONH203)

PSYC B287 Laboratory in Cognitive Neuroscience (0.5 Unit)
This writing-intensive laboratory course will provide students with hands-on experience in the design, implementation, analysis, and interpretation of the electrophysiological techniques used in cognitive neuroscience research. Students will read research articles, design an event-related potential (ERP) research project, learn to collect ERP data, conduct EEG/ERP data analysis to test original hypotheses using existing data, and write an APA-style paper. This is a .5 unit writing-intensive class that meets half of the writing requirement in the major.

PSYC B315 Stress Neuroscience (1 Unit)
This course will examine the neural mechanisms underlying physiological and emotional responses to stress. We will explore how stress influences susceptibility to substance use and mental health disorders. We will investigate the physiological effects of stress on the immune system, gut microbiome, and feeding behavior, the effects of stress across the lifespan and in offspring, as well as strategies to build resilience. Students will also be exposed to primary literature on these topics and expected to present these articles in a journal club format. This course is designed to provide students with the skills necessary to evaluate recent findings and trends in stress research. Suggested preparation: PSYCB218 (Behavioral Neuroscience) or equivalent.

PSYC B323 Advanced Topics in Cognitive Neuroscience (1 Unit)
This is a topics course. Course content varies.

PSYC B327 Adolescent Development (1 Unit)
Is adolescence a biologically distinct stage of life, or a social "holding ground" invented by modern culture for young people unready or unwilling to assume the responsibilities of adulthood? Are adolescents destined to make risky decisions because of their underdeveloped brains? At what age should they be held accountable as adults in a court of law? This course will explore these and other questions about the biological, social, and legal forces that define the boundaries and shape the experience of adolescents growing up in the modern world. Students will learn about: (1) historical changes in understanding and treatment of adolescents; (2) puberty-related biological changes marking the beginning of adolescence; (3) brain, behavioral, cognitive, and social development during adolescence; and (4) contemporary debates regarding age of adult maturity, and their implications for law and policy. Prerequisite: PSYC B206 (Developmental Psychology) or PSYC B211 (Lifespan Development) or permission or instructor. PSYC B205 is recommended.

PSYC B344 Early Childhood Experiences & Mental Health (1 Unit)
Development represents a unique period during which the brain shows enhanced plasticity, the important ability to adapt and change in response to experiences. During development, the brain may be especially vulnerable to the impacts of harmful experiences (e.g., neglect or exposure to toxins) and also especially responsive to the effects of positive factors (e.g., community resilience or clinical interventions). This seminar will explore how childhood experiences "get under the skin," shaping neurobiological systems and exerting lasting effects on mental health and well-being. We will examine theoretical models of how early experiences shape development, considering the proposed mechanisms by which different features of childhood environments could shape psychological risk and resilience. We will evaluate the scientific evidence for these models and then apply this knowledge to consider what strategies for intervention–– at the level of the child, family, and society–– could help reduce psychopathology and promote well-being. There is no textbook required for this course. We will read, critically evaluate, and discuss empirical journal articles and explore the implications of this scientific literature for public policy. Prerequisites: PSYC B209 or PSYC B206 or PSYC B218 or permission from instructor; PSYC B205 highly recommended

PSYC B358 Neuroscience of Adaptive Decision-Making (1 Unit)
How do humans and animals make adaptive decisions? What cognitive and neural mechanisms help us choose well, and what constraints get in the way? In this course, we will explore models of optimal decision-making and examine when, why, and how real-world choices deviate from them. We will consider how psychological, neuroscientific, and computational approaches each shed light on how decisions unfold in different contexts. Students will read and discuss peer-reviewed articles, connect theory and empirical data, and frame new questions through a theoretical lens. Prerequisite: Research Methods and Statistics (PSYC B205 or PSYC H200) and either PSYC B265 (Computational Neuroscience) or PSYC B212 (Human Cognition) or PSYC B218 (Behavioral Neuroscience) or permission from instructor.

PSYC B395 Psychopharmacology (1 Unit)
A study of the role of drugs in understanding basic brain-behavior relations. Topics include the pharmacological basis of motivation and emotion; pharmacological models of psychopathology; the use of drugs in the treatment of psychiatric disorders such as anxiety, depression, and psychosis; and the psychology and pharmacology of drug addiction. Prerequisite: PSYC B218 or BIOL B202 or PSYC H217 or permission of instructor.