NEUROSCIENCE

Overview & Learning Goals

Learning Goals

Students will:

1. Understand and be able to use the scientific method to arrive at conclusions based upon appropriate evidence:
   a. Hypothesis development
   b. Experimental design
   c. Analytical reasoning and quantitative data analysis
2. Know and understand fundamental concepts (e.g., in biology, psychology, chemistry) that are the underpinnings for the study of the brain and behavior.
3. Become familiar with fields related to neuroscience, in particular those that neuroscience seeks to explain and those that provide tools or principles that help explain neural functioning.
4. Demonstrate a broad intellectual foundation in neuroscience, including molecular, cellular, cognitive, and behavioral perspectives; and understand how these perspectives are interrelated.
5. Become proficient in multiple techniques used in neuroscience research; be able to evaluate the strengths and weaknesses of each.
6. Apply the scientific method to questions relevant to neuroscience; design and conduct experiments to increase understanding of fundamental questions in neuroscience.
7. Learn to critically assess neuroscience literature.
8. Learn to communicate scientific concepts both orally and in writing.
9. Be exposed to the ethical implications of neuroscience research and the use of neuroscience in society.

Options for Majoring in the Program

Students may elect to major in neuroscience or to coordinate a major in neuroscience with digital and computational studies, education, or environmental studies. Students pursuing coordinate majors may not normally elect a second major. Bowdoin does not offer a minor in neuroscience.

Program Website (https://www.bowdoin.edu/neuroscience/)

Faculty

Manuel Diaz-Rios, *Program Director*
Rachel Reuling, *Program Coordinator*

Professors: Manuel Diaz-Rios (Biology), Hadley Wilson Horch‡ (Biology)
Associate Professor: Erika M. Nyhus (Psychology)
Assistant Professors: Jennifer Honeycutt‡ (Psychology), Daniel Powell (Biology)
Visiting faculty: Michael Fine, Thomas W. Small (Psychology)
Lab instructors: Anja Forche, Tina Rioux
Contributing faculty: Amy S. Johnson, Mary Lou Zeeman

Faculty/Staff Website (https://www.bowdoin.edu/neuroscience/faculty-and-staff/)

Requirements

Neuroscience Major

The major consists of thirteen courses, including ten core courses and three electives from the lists to follow.

Note: The information provided below is a listing of required and elective courses for the major in neuroscience. These courses are offered by other departments and programs within the College. Please refer to the Classfinder (https://classfinder.bowdoin.edu/classfinder/) and the course offerings of the departments of biology (https://bowdoin-public.courseleaf.com/departments-programs/biology/), chemistry (https://bowdoin-public.courseleaf.com/departments-programs/chemistry/), computer science (https://bowdoin-public.courseleaf.com/departments-programs/computer-science/), mathematics (https://bowdoin-public.courseleaf.com/departments-programs/mathematics/), physics (https://bowdoin-public.courseleaf.com/departments-programs/physics-astronomy/), and psychology (https://bowdoin-public.courseleaf.com/departments-programs/psychology/) for further information, including course descriptions, instructors, and semesters when these courses are offered.

Core Courses

Code	Title	Credits
Introductory Level and General Courses		
BIOL 1102	Biological Principles II	1
or BIOL 1109	Scientific Reasoning in Biology	
Select one of the following:		1
CHEM 1092	Introductory Chemistry and Quantitative Reasoning II	
CHEM 1102	Introductory Chemistry II	
CHEM 1109	General Chemistry	
CHEM 2250	Organic Chemistry I	1
PSYC 1101	Introduction to Psychology	1
Select one of the following:		1
PSYC 2520	Data Analysis	
MATH 1300	Biostatistics	
MATH 1400	Statistics in the Sciences	
Introductory Neuroscience Course		
BIOL 2135	Neurobiology	1
or PSYC 2050	Biological Psychology	
Mid-level Neuroscience Courses		
Select three of the following:		3
BIOL 2553	Neurophysiology	
BIOL 2566	Molecular Neurobiology	
BIOL 2510	Neuropharmacology	
PSYC 2750	Behavioral Neuroscience Laboratory: Affective Neuroscience	
PSYC 2775	Laboratory in Cognitive Neuroscience	
Advanced Neuroscience Courses		
Select one of the following:		1
BIOL 3311	Motor Systems Neurobiology	
BIOL 3325	Topics in Neuroscience	
BIOL 3329	Neuronal Regeneration	

PSYC 3050	Hormones and Behavior
PSYC 3055	Cognitive Neuroscience of Memory

Electives

Code	Title	Credits
Electives		
Select three electives from the courses listed above (but not already taken), or below:		3
BIOL 1101	Biological Principles I	
BIOL 2112	Genetics and Molecular Biology	
BIOL 2124	Biochemistry and Cell Biology	
BIOL 2175	Developmental Biology	
BIOL 2214	Comparative Animal and Human Physiology	
BIOL 2423	Biochemistry of Cellular Processes	
CHEM 2320	Biochemistry	
CSCI 1101	Introduction to Computer Science	
PHYS 1140	Introductory Physics II	
PSYC 2010	Infant and Child Development	
PSYC 2025	Psychopathology	
PSYC 2030	Social Psychology	
PSYC 2040	Cognition: The Science of How We Learn, Think, and Act	
PSYC 2060	Cognitive Neuroscience	
PSYC 2099	Brain, Behavior, and Evolution	
PSYC 2510	Research Design in Psychology	

Only one semester of independent study (2970–2999 or 4000–4049) or honors projects (4050 or higher) at any level can count toward the major.

Additional Information

Additional Information and Program Policies

- Normally up to two courses transferred from other institutions can be used toward the completion of the major.
- The three mid-level neuroscience courses and the required advanced neuroscience course must be taken at Bowdoin.
- Only one semester of independent study or honors at any level can count toward the major. Independent study in neuroscience may be used to fulfill one of the three elective credits.
- Students planning to graduate with honors in neuroscience must complete two semesters of advanced independent study during their senior year, in addition to other requirements.
- Majors who earn a general credit for their AP Chemistry scores based on the department of chemistry's requirements may use that general credit to fulfill the introductory chemistry requirement of the neuroscience major and do not need to take an additional course to replace it.
- Majors who place out of PSYC 1101 Introduction to Psychology must take a higher level course in psychology to replace the PSYC 1101 Introduction to Psychology requirement of the neuroscience major. In order to receive credit for advanced placement work, students must have their scores officially reported to the Office of the Registrar by the end of their sophomore year at Bowdoin.
- If majors place out of BIOL 1109 Scientific Reasoning in Biology, thirteen courses related to neuroscience must still be completed.
- Courses that count toward the major must be taken for regular letter grades (not Credit/D/Fail).
- Students must earn a C- or better for a course to count toward the major.
- Only courses that are required for the neuroscience major and a second major or minor may double-count.
- Neuroscience majors cannot also major in chemistry with a neurochemical concentration; they can, however, major in chemistry with a different concentration. Biology majors and minors, biochemistry majors, and psychology majors and minors are also prohibited from declaring a major in neuroscience.

Information for Incoming Students (p. 2)

Students interested in majoring in neuroscience should begin by taking PSYC 1101 Introduction to Psychology and/or BIOL 1102 Biological Principles II/BIOL 1109 Scientific Reasoning in Biology, both of which are required for the major. (Please see the student's biology placement to determine which course is most appropriate.) These courses serve as prerequisites for the two introductory-level neuroscience classes, BIOL 2135 Neurobiology (fall semester) and PSYC 2050 Biological Psychology (spring semester), either of which will prepare students for entry into the mid-level lab courses that form the core of the neuroscience major.

We encourage students interested in majoring in neuroscience to speak with faculty in the neuroscience program early in their Bowdoin career, particularly if they are interested in studying abroad. Students interested in beginning to explore neuroscience in their first year should consider NEUR 1099 Brains in Motion: Exploring the Interface between Mind and Body; however, they should be aware that this course will not count towards the neuroscience major.

Students are also encouraged to consult with the chemistry department (https://www.bowdoin.edu/chemistry/) about their placement into chemistry courses, as an introductory chemistry course and CHEM 2250 Organic Chemistry I are also required for the major.

Courses

NEUR 1099 (a, INS) Brains in Motion: Exploring the Interface between Mind and Body
Manuel Diaz-Rios.
Every Fall. Fall 2023. Enrollment limit: 24.

This course is an introductory exploration of the nervous system as it relates to bodily functions. It explores neurons as the basic building blocks of brain and behavior. Through lectures and classroom experiments, students would learn how electrochemical nerve signals control body movement, cardiovascular function, reflexes, and brain activity. Further, students explore how the nervous system can interact with machine interfaces, including prosthetics. (Same as: BIOL 1099)

Previous terms offered: Fall 2022, Fall 2021, Spring 2021, Fall 2020.

NEUR 2050 (a) Biological Psychology
Thomas Small.
Every Other Year. Spring 2024. Enrollment limit: 35.

An introductory survey of biological influences on behavior. The primary emphasis is on the neurobiological regulation of behavior in humans and other vertebrate animals, focusing on genetic, developmental, hormonal, and neuronal mechanisms. Additionally, the evolution of these regulatory systems is considered. This course explores the structural and functional properties of the central nervous system to understand how behavior occurs—and how it is disrupted—at the molecular, cellular, and systems level. Topics discussed may include cellular processes/communication, sensation/perception, cognition, sleep, eating, sex, and aggression. Emphasis will be placed on how biological mechanisms contribute to psychological [dys]function. (Same as: PSYC 2050)

Prerequisites: PSYC 1101 or BIOL 1102 or BIOL 1109 or Placement in above PSYC 1101 or Placement in BIOL 2000 level.

Previous terms offered: Spring 2023, Spring 2022, Spring 2021, Spring 2020.

NEUR 2055 (a) Psychoneuroimmunology
Non-Standard Rotation. Enrollment limit: 35.

This course is the study of the influence of psychological state on the communication and coordinated function among cells of the nervous system, the endocrine system, and the immune system. We will review the current molecular and cellular evidence that these systems interact through sharing the same cells, chemical messengers, and receptors. Other topics include the role of conscious thought, emotional states, meditation, depression, stress, and positivity on immune function. Through exams and written assignments, students will also evaluate the influence of the complex coordinated activity of this psycho-neuro-immuno cell system on psychogenic disease and aging via the impact on cellular detoxification, tumor surveillance, epigenetic mechanisms, and human gut microbiota. (Same as: PSYC 2055)

Prerequisites: PSYC 1101 or Placement in above PSYC 1101.

Previous terms offered: Fall 2021.

NEUR 2060 (a) Cognitive Neuroscience
Erika Nyhus.
Every Other Year. Fall 2023. Enrollment limit: 35.

An introduction to the neuroscientific study of cognition. Topics surveyed in the course include the neural bases of perception, attention, memory, language, executive function, and decision making. In covering these topics, the course will draw on evidence from brain imaging (fMRI, EEG, MEG), transcranial magnetic stimulation, electrophysiology, and neuropsychology. Also considers how knowledge about the brain constrains our understanding of the mind. (Same as: PSYC 2060)

Prerequisites: PSYC 1101 or BIOL 1102 or BIOL 1109 or Placement in above PSYC 1101 or Placement in BIOL 2000 level.

Previous terms offered: Fall 2022, Fall 2020.

NEUR 2099 (a) Brain, Behavior, and Evolution
Non-Standard Rotation. Enrollment limit: 35.

A comparative and evolutionary approach to animal behavioral neuroscience. The primary focus is on the evolution of the brain and behavior in vertebrate systems, including humans, but invertebrates are also discussed. Topics include the evolution and diversity of sensory systems, reproductive behaviors, parental care, learning and memory, social behaviors, intelligence, and cognition. (Same as: PSYC 2099)

Prerequisites: PSYC 1101 or BIOL 1102 or BIOL 1109 or Placement in above PSYC 1101 or Placement in BIOL 2000 level.

Previous terms offered: Fall 2021, Fall 2020.

NEUR 2135 (a, INS, MCSR) Neurobiology
Stephen Hauptman; Michael Fine.
Every Fall. Fall 2023. Enrollment limit: 35.

Examines fundamental concepts in neurobiology from the molecular to the systems level. Topics include neuronal communication, gene regulation, morphology, neuronal development, axon guidance, mechanisms of neuronal plasticity, sensory systems, and the molecular basis of behavior and disease. Weekly lab sessions introduce a wide range of methods used to examine neurons and neuronal systems. (Same as: BIOL 2135)

Prerequisites: BIOL 1102 or BIOL 1109 or Placement in BIOL 2000 level.

Previous terms offered: Fall 2022, Fall 2021, Fall 2020, Fall 2019.

NEUR 2510 (a, INS) Neuropharmacology
Manuel Diaz-Rios; Tina Rioux.
Every Spring. Spring 2024. Enrollment limit: 24.

This course will discuss drug-induced changes in the functioning of the nervous system. The specific focus will be to provide a description of the cellular and molecular actions of drugs (natural or artificial) on the communication between neurons (known as synaptic transmission) and on the production of behaviors such as walking, breathing, heart function, and learning/memory, among others. This course will also refer to specific diseases of the nervous system and their treatment, in addition to giving an overview of the techniques used for the study of neuropharmacology. The lab portion of this course would involve the dissection and handling of mouse tissue. If you are not comfortable with the idea of dissecting mice you should not take this course. (Same as: BIOL 2510)

Prerequisites: Two of: either BIOL 1102 or BIOL 1109 and either BIOL 2135 (same as NEUR 2135) or BIOL 2214 (same as NEUR 2214) or PSYC 2050 (same as NEUR 2050).

Previous terms offered: Spring 2023, Spring 2022, Spring 2021, Spring 2020.

NEUR 2553 (a, INS) Neurophysiology
Tina Rioux; Daniel Powell.
Every Fall. Fall 2023. Enrollment limit: 20.

A comparative study of the function of the nervous system in invertebrate and vertebrate animals. Topics include the mechanism that underlie both action potentials and patterns of spontaneous activity in individual nerve cells, interactions between neurons, and the organization of neurons into larger functional units. Lectures and four hours of laboratory work per week. (Same as: BIOL 2553)

Prerequisites: Two of: either BIOL 1102 or BIOL 1109 and either BIOL 2135 or BIOL 2214 or PSYC 2050.

Previous terms offered: Fall 2022, Fall 2021, Fall 2020, Fall 2019.

NEUR 2566 (a, INS) Molecular Neurobiology
Anja Forche; Michael Fine.
Every Spring. Spring 2024. Enrollment limit: 24.

Examination of the molecular control of neuronal structure and function. After understanding classic cloning techniques and experiments, students will learn more modern variations of techniques related to nucleic acid sequencing, protein visualization, and genetic manipulation. Additional topics such as intracellular signaling, neurotrophins and cell death, growth cone guidance, and the molecular basis of learning and memory are covered. The final portion of the course revolves around pathological disorders, such as Alzheimer's disease and spinal cord injuries, culminating in an independent investigation of the molecular basis of a neurological disorder of each student's choosing. Students will gain experience reading and interpreting primary research articles, working collaboratively in small groups, and communicating scientifically. Weekly laboratory sessions are devoted to exploring the molecular basis of compensatory plasticity in the cricket auditory system. (Same as: BIOL 2566)

Prerequisites: Two of: either BIOL 1102 or BIOL 1109 or Placement in BIOL 2000 level and either BIOL 2112 or BIOL 2124 (same as BIOC 2124) or BIOL 2135 (same as NEUR 2135) or BIOL 2553 (same as NEUR 2553) or PSYC 2050 (same as NEUR 2050).

Previous terms offered: Spring 2023, Spring 2022, Spring 2021, Spring 2020.

NEUR 2750 (a, INS) Behavioral Neuroscience Laboratory: Affective Neuroscience
Thomas Small; Anja Forche.
Every Year. Fall 2023. Enrollment limit: 20.

A laboratory course that exposes students to modern techniques in neuroscience that can be applied to the study of affective behavior, broadly. Underlying concepts associated with various behavioral, molecular, neuroanatomical, pharmacological, and translational methods will be discussed in a lecture format. Students will apply these concepts and techniques in discussions and laboratory preparations demonstrating how affective processes are organized within the central nervous system of vertebrates. This course will explore using experimental examples how the brain influences behavior, thereby illuminating our understanding of human neuropsychological functioning. (Same as: PSYC 2750)

Prerequisites: Three of: either PSYC 2050 (same as NEUR 2050) or BIOL 2135 (same as NEUR 2135) or PSYC 2060 (same as NEUR 2060) and PSYC 2510 or either BIOL 1102 or BIOL 1109 and PSYC 2520 or either MATH 1300 or MATH 1400.

Previous terms offered: Fall 2022, Fall 2021, Fall 2020, Fall 2019.

NEUR 2775 (a, INS, MCSR) Laboratory in Cognitive Neuroscience
Erika Nyhus; Anja Forche.
Every Year. Spring 2024. Enrollment limit: 20.

A laboratory course in cognitive neuroscience that studies the timing and organization of human cognition through electroencephalography (EEG), a direct measure of brain activity from scalp electrodes with millisecond precision. Students will learn the conceptual and practical foundations of experimental design, data analysis and interpretation, and be introduced to applications of EEG in medicine and technology. (Same as: PSYC 2775)

Prerequisites: Three of: PSYC 2040 or either PSYC 2050 (same as NEUR 2050) or PSYC 2055 (same as NEUR 2055) or PSYC 2060 (same as NEUR 2060) or BIOL 2135 (same as NEUR 2135) or PSYC 2055 (same as NEUR 2055) and PSYC 2510 or either BIOL 1102 or BIOL 1109 or Placement in BIOL 2000 level and PSYC 2520 or either MATH 1300 or MATH 1400.

Previous terms offered: Spring 2023, Spring 2022, Spring 2021, Spring 2020.

NEUR 3050 (a) Hormones and Behavior
Thomas Small.
Every Fall. Spring 2024. Enrollment limit: 16.

An advanced discussion of concepts in behavioral neuroendocrinology. Topics include descriptions of the major classes of hormones, their roles in the regulation of development and adult behavioral expression, and the cellular and molecular mechanisms responsible for their behavioral effects. Hormonal influences on reproductive, aggressive, and parental behaviors, as well as on cognitive processes are considered. (Same as: PSYC 3050)

Prerequisites: Three of: either PSYC 2050 (same as NEUR 2050) or BIOL 2135 (same as NEUR 2135) or PSYC 2060 (same as NEUR 2060) and PSYC 2510 or either BIOL 1102 or BIOL 1109 or Placement in BIOL 2000 level and PSYC 2520 or either MATH 1300 or MATH 1400.

Previous terms offered: Spring 2022, Fall 2020, Spring 2020.

NEUR 3055 (a) Cognitive Neuroscience of Memory
Erika Nyhus.
Every Spring. Fall 2023. Enrollment limit: 16.

An advanced discussion of recent empirical and theoretical approaches to understanding the cognitive neuroscience of memory. Readings and discussions address empirical studies using neuroimaging methods. Topics include hippocampal and cortical contributions to memory encoding and retrieval and the effect of genetic variability, drugs, emotions, and sleep on memory. (Same as: PSYC 3055)

Prerequisites: Three of: either PSYC 2040 or PSYC 2050 (same as NEUR 2050) or PSYC 2055 (same as NEUR 2055) or PSYC 2060 (same as NEUR 2060) or BIOL 2135 (same as NEUR 2135) and Placement in BIOL 2000 level or PSYC 2510 or either BIOL 1102 or BIOL 1109 and PSYC 2520 or either MATH 1300 or MATH 1400.

Previous terms offered: Fall 2020.

NEUR 3057 (a) Seminar in Behavioral Neuroscience
Non-Standard Rotation. Enrollment limit: 14.

An advanced seminar covering brain mechanisms that affect behavior in humans and other animals. Topics may include the neural circuits that regulate normal social interactions, learning and memory processes, and/or higher cognitive functions, as well as the relationship between disrupted neural functions and mental disorders. The major emphasis of the course will be on reading and discussing primary research articles in the field of behavioral neuroscience. (Same as: PSYC 3057)

Prerequisites: Three of: either PSYC 2050 (same as NEUR 2050) or PSYC 2060 (same as NEUR 2060) or BIOL 2135 (same as NEUR 2135) and PSYC 2510 or either BIOL 1102 or BIOL 1109 and PSYC 2520 or either MATH 1300 or MATH 1400.

Previous terms offered: Fall 2019.

NEUR 3058 (a) Topics in Cognitive Neuroscience
Non-Standard Rotation. Enrollment limit: 14.

An advanced discussion of recent empirical and theoretical approaches to understanding cognitive neuroscience. Readings and discussions address empirical studies using neuroimaging methods. (Same as: PSYC 3058)

Prerequisites: Three of: either PSYC 2040 or PSYC 2050 (same as NEUR 2050) or PSYC 2060 (same as NEUR 2060) or BIOL 2135 (same as NEUR 2135) and PSYC 2520 or either MATH 1300 or MATH 1400 and PSYC 2510 or either BIOL 1102 or BIOL 1109 or Placement in BIOL 2000 level.

Previous terms offered: Fall 2022.

NEUR 3311 (a) Motor Systems Neurobiology
Manuel Diaz-Rios.
Non-Standard Rotation. Fall 2023. Enrollment limit: 16.

In this course you will learn about the main animal models used in the study of how the nervous system controls motor behavior as animals, including humans, interact with the environment. The course will cover the principal motor systems (including those for walking, flying, swimming, breathing, and others), focusing in particular on bridging the gap between molecular/cellular neuroscience and higher-level perception and behavior. Topics to be covered include neuroanatomy, neurophysiology and functions of the most studied animal behaviors, and the groups of interconnected neurons (termed neural circuits) that control them. Students will read, interpret, analyze, and discuss seminal (classical) and recent scientific papers from influential motor systems neurobiology laboratories. The course will also discuss the relevance of these neuronal motor systems to human diseases. (Same as: BIOL 3311)

Prerequisites: BIOL 2112 or BIOL 2124 (same as BIOC 2124) or BIOL 2135 (same as NEUR 2135) or BIOL 2175 or BIOL 2553 (same as NEUR 2553) or BIOL 2566 (same as NEUR 2566) or PSYC 2750 (same as NEUR 2750) or PSYC 2751.

Previous terms offered: Fall 2022, Fall 2021, Fall 2020, Fall 2019.

NEUR 3325 (a, INS) Topics in Neuroscience
Michael Fine.
Non-Standard Rotation. Fall 2023; Spring 2024. Enrollment limit: 15.

An advanced seminar focusing on one or more aspects of neuroscience, such as neuronal regeneration and development, modulation of neuronal activity, or the neural basis of behavior. Students read and discuss original papers from the literature. (Same as: BIOL 3325)

Prerequisites: BIOL 2135 (same as NEUR 2135) or BIOL 2553 (same as NEUR 2553) or BIOL 2566 (same as NEUR 2566) or BIOL 2588 (same as NEUR 2588) or PSYC 2750 (same as NEUR 2750)- 2751 or PSYC 2775 (same as NEUR 2775).

Previous terms offered: Spring 2023, Spring 2022, Spring 2021, Spring 2020.

NEUR 3329 (a, INS) Neuronal Regeneration
Every Fall. Enrollment limit: 15.

The consequences of neuronal damage in humans, especially in the brain and spinal cord, are frequently devastating and permanent. Invertebrates, on the other hand, are often capable of complete functional regeneration. Examines the varied responses to neuronal injury in a range of species. Topics include neuronal regeneration in planaria, insects, amphibians, and mammals. Students read and discuss original papers from the literature in an attempt to understand the basis of the radically different regenerative responses mounted by a variety of neuronal systems. (Same as: BIOL 3329)

Prerequisites: BIOL 2112 or BIOL 2124 or BIOL 2135 or BIOL 2175 or BIOL 2553 or BIOL 2566 or PSYC 2750 or PSYC 2751.

Previous terms offered: Fall 2021.