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.

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

Faculty

Patsy S. Dickinson, Program Director
Mary Keenan, Program Coordinator

Professor: Manuel Diaz-Rios (Biology), Patsy S. Dickinson (Biology)
Associate Professor: Hadley Wilson Horch (Biology)
Assistant Professor: Erika M. Nyhus (Psychology)
Visiting Faculty: Thomas W. Small (Psychology)
Lab Instructor: 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. Normally up to two courses transferred from other institutions can be used toward the completion of the major. Please refer to bowdoin.edu/classfinder and the Departments of Biology, Chemistry, Computer Science, Mathematics, Physics, and Psychology for further information, including course descriptions, instructors, and semesters when these courses are offered.

Core Courses

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<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
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<tr>
<td><strong>Introductory Level and General Courses</strong></td>
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</tr>
<tr>
<td>B I O L 1 1 0 2</td>
<td>Biological Principles II</td>
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<tr>
<td>or B I O L 1 1 0 9</td>
<td>Scientific Reasoning in Biology</td>
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<tr>
<td>C H E M 1 0 9 2</td>
<td>Introductory Chemistry and Quantitative Reasoning II</td>
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<td>C H E M 1 1 0 2</td>
<td>Introductory Chemistry II</td>
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<tr>
<td>C H E M 1 1 0 9</td>
<td>General Chemistry</td>
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<td>C H E M 2 2 5 0</td>
<td>Organic Chemistry I</td>
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<td>P S Y C 1 1 0 1</td>
<td>Introduction to Psychology</td>
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<tr>
<td>P S Y C 2 5 2 0</td>
<td>Data Analysis</td>
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<tr>
<td>M A T H 1 3 0 0</td>
<td>Biostatistics</td>
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<tr>
<td>M A T H 1 4 0 0</td>
<td>Statistics in the Sciences</td>
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<td><strong>Introductory Neuroscience Course</strong></td>
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<tr>
<td>B I O L 2 1 3 5</td>
<td>Neurobiology</td>
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<tr>
<td>or P S Y C 2 0 5 0</td>
<td>Physiological Psychology</td>
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<td><strong>Mid-level Neuroscience Courses</strong></td>
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<td>Select three of the following:</td>
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<tr>
<td>B I O L 2 5 5 3</td>
<td>Neurophysiology</td>
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<td>B I O L 2 5 6 6</td>
<td>Molecular Neurobiology</td>
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<td>P S Y C 2 7 5 0</td>
<td>Laboratory in Behavioral Neuroscience: Social Behavior</td>
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<tr>
<td>P S Y C 2 7 7 5</td>
<td>Laboratory in Cognitive Neuroscience</td>
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<td><strong>Advanced Neuroscience Courses</strong></td>
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<td>B I O L 3 3 1 1</td>
<td>Motor Systems Neurobiology</td>
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<td>B I O L 3 3 2 5</td>
<td>Topics in Neuroscience</td>
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<td>B I O L 3 3 2 9</td>
<td>Neuronal Regeneration</td>
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<td>B I O L 3 3 8 8</td>
<td>Neurobiology of the Synapse</td>
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<td>P S Y C 3 0 5 0</td>
<td>Hormones and Behavior</td>
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<td>P S Y C 3 0 5 5</td>
<td>Cognitive Neuroscience of Memory</td>
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Electives

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<td>Genetics and Molecular Biology</td>
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<td>B I O L 2 1 2 4</td>
<td>Biochemistry and Cell Biology</td>
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<tr>
<td>B I O L 2 1 7 5</td>
<td>Developmental Biology</td>
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<tr>
<td>B I O L 2 2 1 4</td>
<td>Comparative Animal and Human Physiology</td>
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<tr>
<td>B I O L 2 4 2 3</td>
<td>Biochemistry of Cellular Processes</td>
<td></td>
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<tr>
<td>C H E M 2 3 2 0</td>
<td>Biochemistry</td>
<td></td>
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<tr>
<td>C S C I 1 1 0 1</td>
<td>Introduction to Computer Science</td>
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<tr>
<td>P H Y S 1 1 4 0</td>
<td>Introductory Physics II</td>
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<tr>
<td>P S Y C 2 0 1 0</td>
<td>Infant and Child Development</td>
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### Additional Information

**Additional Information and Program Policies**

- Only one semester of independent study or honors at any level can count toward the major.
- Advanced placement credits may not be used to fulfill any of the course requirements for the major except Introductory Chemistry.
- Independent study in neuroscience may be used to fulfill one of the three elective credits.
- If students place out of PSYC 1101 Introduction to Psychology or 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.
- Neuroscience majors cannot also major in chemistry with a neurochemical concentration; they can, however, major in chemistry with a different concentration.

### Courses

**NEUR 2050 (a) Physiological Psychology**

Thomas Small.
Every Other Year. Spring 2020. Enrollment limit: 35.

An introductory survey of biological influences on behavior. The primary emphasis is on the physiological 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. Topics discussed include perception, cognition, sleep, eating, sexual and aggressive behaviors, and mental disorders.

(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.


**NEUR 2060 (a) Cognitive Neuroscience**

Every Other Year. 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 Placement in above PSYC 1101.

Previous terms offered: Fall 2018, Fall 2016, Fall 2015.

**NEUR 2135 (a, INS, MCSR) Neurobiology**

Hadley Horch.
Every Fall. Fall 2019. 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 2018, Fall 2017, Fall 2016, Fall 2015.

**NEUR 2553 (a, INS) Neurophysiology**

Patsy Dickinson.

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 or either BIOL 2135 or BIOL 2214 or PSYC 2050.

Previous terms offered: Fall 2018, Fall 2017, Fall 2016, Fall 2015.

**NEUR 2566 (a, INS) Molecular Neurobiology**

Hadley Horch.

Examination of the molecular control of neuronal structure and function. Topics include the molecular 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. 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).

NEUR 2750 (a, INS)  Laboratory in Behavioral Neuroscience: Social Behavior  
Thomas Small.  
A laboratory course that exposes students to modern techniques in neuroscience that can be applied to the study of social behavior. Underlying concepts associated with various molecular, neuroanatomical, pharmacological, and electrophysiological methods are discussed in a lecture format. Students then use these techniques in laboratory preparations that demonstrate how social behavior is organized within the central nervous system of vertebrate animals, including humans. (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 2018, Fall 2017, Fall 2016.  
NEUR 2775 (a, INS, MCSR)  Laboratory in Cognitive Neuroscience  
Erika Nyhus.  
A laboratory course that exposes students to multiple techniques in cognitive neuroscience that can be applied to the study of human cognition. Introduces human neuroimaging methods including electroencephalography (EEG) and functional magnetic resonance imaging (fMRI). Students will then use these methods to study aspects of human cognition including perception, attention, memory, language, problem solving, reasoning, and decision making. (Same as: PSYC 2775)  
Prerequisites: Three of: PSYC 2040 or either PSYC 2050 (same as NEUR 2050) or BIOL 2135 (same as NEUR 2135) 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.  
NEUR 3050 (a)  Hormones and Behavior  
Thomas Small.  
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 MATH 1300.  
Previous terms offered: Spring 2019, Fall 2017, Fall 2016.  
NEUR 3052 (b)  Psychopharmacology, Neuroscience, and Addiction  
Introduction to psychopharmacology of recreationally abused drugs and their effects on the brain and behavior in human and non-human species. Discusses natural and man-made substances, including alcohol, nicotine, caffeine, opioids, stimulants, cannabinoids, hallucinogens, steroids, sedatives, and inhalants. Covers basic structure and function of the nervous system, drug classification, basic principles of neuroscience, neuropsychological assessment, pharmacogenomics, as well as the history and epidemiology of specific drugs of abuse and pharmacological and non-pharmacological interventions to limit use. (Same as: PSYC 3052)  
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 MATH 1300.  
Previous terms offered: Spring 2016.  
NEUR 3055 (a)  Cognitive Neuroscience of Memory  
Every Spring. 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 2060 (same as NEUR 2060) or BIOL 2135 (same as NEUR 2135) and PSYC 2520 or either MATH 1300 or MATH 1400 and Placement in BIOL 2000 level or PSYC 2510 or either BIOL 1102 or BIOL 1109.  
Previous terms offered: Fall 2018, Fall 2015.  
NEUR 3056 (a)  Computational Modelling in Cognitive Neuroscience  
A survey of cognitive neuroscience literature in which researchers have used computational models to formalize their theories. Topics include executive function, learning, attention, and decisionmaking. (Same as: PSYC 3056)  
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 MATH 1300.  
Previous terms offered: Spring 2017.
NEUR 3057 (a)  Seminar in Behavioral Neuroscience
Thomas Small.

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.

NEUR 3311 (a)  Motor Systems Neurobiology
Manuel Diaz-Rios.

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 or BIOL 2135 (same as NEUR 2135) or BIOL 2175 or BIOL 2553 or BIOL 2566 or PSYC 2750 or PSYC 2751.

NEUR 3325 (a, INS)  Topics in Neuroscience
Patsy Dickinson.

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).


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 2017.

NEUR 3388 (a, INS)  Neurobiology of the Synapse

A seminar-style class exploring primary scientific literature focused on the synapse as the fundamental signaling unit of the brain. Focuses on the cell biology, physiology, plasticity, and signal integration of inter-neuronal communication. Topics will also include recent methodological advances in the study of synaptic function. Following short introductory lectures, students will present selected papers and lead discussions. (Same as: BIOL 3388)

Prerequisites: BIOL 2124 (same as BIOC 2124) or BIOL 2135 (same as NEUR 2135) or BIOL 2175 or BIOL 2214 (same as NEUR 2214) or BIOL 2553 (same as NEUR 2553) or PSYC 2750 (same as NEUR 2750).

Previous terms offered: Spring 2018.