

# Neuroscience

Neuroscience seeks to understand the nervous system and its functioning at levels ranging from that of molecules interacting with cell membranes, to that of brain systems subserving cognitive functions such as language. Dramatic recent progress has been made at all levels, and the field is growing explosively. On the Homewood campus, researchers in the departments of Biology, Biomedical Engineering, Biophysics, Cognitive Science, and Psychological and Brain Sciences and in the Krieger Mind/Brain Institute study the nervous system at many levels. Their presence provides the opportunity for innovative, interdepartmental programs which offer a broad overview of the neuroscience field, as well as more advanced training in one of three areas of concentration.

*Cellular and Molecular Neuroscience* focuses on the mechanisms by which information flows within and between cells in the nervous system, and the mechanisms through which the cellular structure of the nervous system develops and is maintained. Topics include the molecular basis of membrane permeability, action potentials, sensory transduction, synaptic transmission, neuronal modulation, mechanisms of drug action, and the molecular basis of genetic disorders of the nervous system.

*Systems Neuroscience* seeks to relate brain structure and functioning to behaviors and related physiological processes. Research in this area explores the description and analysis of neural circuits. This includes identifying the brain nuclei and interconnections making up a circuit, identifying and investigating the implicated neurotransmitters, and characterizing the intrinsic and extrinsic factors that modulate the development and adult functioning of the circuit. Topics as diverse as learning and memory, communication, sensory systems, and motivated behaviors (e.g., reproduction, feeding, aggression) are explored from this perspective.

*Cognitive Neuroscience* focuses on how cognitive functions, such as vision or language, are implemented by the brain. Drawing upon a variety of techniques for probing the working brain at cognitive and neural levels including functional neuroimaging, analysis of cognitive impairments in brain-damaged patients, and electrophysiological techniques research in cognitive neuroscience seeks to relate mental representations and computations to brain mechanisms and processes.

## Neuroscience Program Committee

**Gregory Ball** (Program Chair), Professor  
(Psychological and Brain Sciences).

**Michela Gallagher**, Professor (Psychological and Brain Sciences).

**Linda Gorman**, Senior Lecturer (Neuroscience and Psychological and Brain Sciences).

**Stewart Hendry**, Professor (Neuroscience); Krieger Mind/Brain Institute; Head of Academic Advising (Neuroscience).

**Michael McCloskey**, Professor (Cognitive Science).

**Brenda Rapp**, Professor (Cognitive Science).

**Eric Young**, Professor (Biomedical Engineering).

**Haiqing Zhao**, Assistant Professor (Neuroscience and Biology Department).

The Neuroscience Program Committee coordinates course offerings, oversees the programs interdepartmental courses, makes decisions about admission to the B.A./M.S. program, approves proposed research programs and mentors for students in the B.A./M.S. mentored research program, and evaluates the final reports and presentations from the research year.

## Undergraduate Programs

The neuroscience major consists of two degree programs: a four-year B.A. based primarily on course work, and a five-year B.A./M.S. involving additional course work and a yearlong intensive laboratory experience. (Under special circumstances, a student may be able to complete the B.A./M.S. program in less than five years.) Both programs are designed to provide rigorous preparation for advanced study in either a Ph.D. program or medicine. All of the mathematics and sciences courses required of premedical students are included in the requirements for the neuroscience major.

Additional information regarding the undergraduate degree programs is available through Aaron Williams, Program Coordinator, 204 Ames Hall and on the Web at <http://undergradneurosci.jhu.edu>.

*This curriculum is being reviewed. Please consult our Web site for the most recent updates.*

## Requirements for the B.A. Degree

(See also General Requirements for Departmental Majors, page 46.)

Degree requirements are the same for each concentration, except in the specific advanced courses and the nature of the laboratory research.

- **Optional Introductory Course**

The following two-credit course, recommended but not required for neuroscience majors, is intended for freshmen considering the neuroscience major. This course is offered in both the fall and the spring.  
080.101 Topics in Neuroscience

- **Neuroscience Sequence (12 credits):**

These courses are normally completed during the sophomore and junior years. Students are recommended to take these courses in the following sequence:

080.205 Systems Neuroscience

080.203 Cognitive Neuroscience

080.304 Cellular and Molecular Neuroscience

080.250 Neuroscience Lab: A Practical Approach (Required beginning with the class of 2008)

- **Advanced Courses (12 credits):**

Twelve credits from neuroscience or neuroscience-related courses at the 300-level or above. At least nine of the 12 credits must be from the chosen area of concentration. Credits for research may not be applied toward this requirement.

- **Mathematics and Science Courses (48 credits):**

110.106-107 Calculus I, II (Biological and Social Sciences)

030.101, 105 Introductory Chemistry I and Lab

030.204, 106 Introductory Chemistry II and Lab

030.205, 206, 225 Introductory Organic Chemistry I, II and Lab

171.101-102 or 103-104 and 173.111-112 General Physics I, II and Lab

For the cellular and molecular neuroscience concentration:

020.305, 315 Biochemistry and Lab and

020.306, 316 Cell Biology and Lab

For the cognitive neuroscience and systems neuroscience concentration:

*either* 020.151-152 and 020.153-154 General Biology I, II and Lab or

020.305, 315 Biochemistry and Lab and

020.306, 316 Cell Biology and Lab

- **Research (6 credits):**

Six credits of research, obtained through work in one of the neuroscience laboratories participating in the program. Students are expected to complete a three- to-five-page paper describing the experimental results for each semester of their research.

## Requirements for the B.A./M.S. Degree

- **B.A. Degree Requirements**

Students in the B.A./M.S. program must complete all requirements for the B.A. degree in Neuroscience, except for the 6-credit research requirement. (The B.A./M.S. program has its own research component.) However, in order to identify a research mentor, B.A./M.S. students usually complete some research prior to entering the program.

- **Additional Advanced and Specialized Courses (12 credits):**

Students completing the M.S. need a total of 24 credits of advanced courses (an additional 12 credits to those required for the B.A.). For students concentrating in cellular and molecular neuroscience, all 12 additional credits must be in advanced or specialized courses in neuroscience or neuroscience-relevant areas. At least one course must be at the 400-level or above. For students concentrating in cognitive neuroscience or systems neuroscience, four of the additional credits must be in advanced or specialized courses in neuroscience or neuroscience-relevant areas, with at least one course at the 400-level or above. The remaining eight credits are taken in a year-long statistics course,  
550.111-112 Statistical Analysis I, II

- **Neuroscience Seminar (12 credits):**

080.411-414 Advanced Seminar in Neuroscience

- **Mentored Research Program (24 credits):**

The Mentored Research Program provides intensive research experience for a full calendar year. Working under the direction of a research mentor on an original research project approved by the Neuroscience Program Committee, the student produces a written report in journal-article form and makes a colloquium-style presentation of the work.

080.650-652 Mentored Research in Neuroscience

## Courses

### 080.101 (N) Topics in Neuroscience

A general introduction to the field of neuroscience. Topics range from the cellular level to systems and clinical applications. Suggested but not required for the neuroscience major. Prerequisite: Freshman standing or upper-classmen with permission of instructor.  
Hendry 2 credits

### 080.203 (N,S) Cognitive Neuroscience

This course surveys theory and research concerning how mental processes are carried out by the human brain. Currently a wide range of methods for probing the functioning brain are yielding insights into the nature of the relation between mental and neural events. Emphasis will be placed on developing an understanding of both the physiological bases of the techniques and the issues involved in relating measures of brain activity to cognitive functioning. Methods surveyed include electrophysiological recording techniques such as EEG, VEP, ERP, single/multiple unit recording, and MEG; functional imaging techniques such as PET and fMRI; and methods that involve lesioning or disrupting neural activity such as WADA, cortical stimulation, animal lesion studies, and the study of brain-damaged individuals. No prerequisites. *Co-listed as 050.203 Cognitive Neuroscience: Exploring the Living Brain.*  
McCloskey, Rapp 3 credits

### 080.205 (N) Systems Neuroscience

This course considers defined neural circuits that mediate behavioral responses. This requires both a consideration of sensory inputs to the brain and the outputs to various effector systems. Specific topics considered include learning and memory, eating and drinking, biological timing, aggression, communication, reproductive behavior, and other social behaviors. Most examples are drawn from vertebrate species, but invertebrates are discussed on occasion. Both the development of these neural systems and their possible modulation by endogenous (e.g., hormones) and exogenous factors are also considered as appropriate.  
Fortune, Gallagher 3 credits

### 080.250 (N,S) Neuroscience Lab: A Practical Approach

This course will give students the “hands-on” experience of the interdisciplinary nature of neuroscience. Students will use anatomical, behavioral, and neurophysiological techniques to understand the basic underlying principles of neuroscience. Prerequisites: 080.203. (Required beginning with the class of 2008).  
Gorman 3 credits

### 080.304 (N) Cellular and Molecular Neuroscience

This course is a survey of the mechanisms through which the nervous system receives sensory signals, transmits signals from neuron to neuron, and drives the activity of target tissues such as glands and muscles. Topics include the molecular basis of the action potential, effect of cell shape and myelination on conduction of action potentials, mechanisms regulating neurotransmitter release, structure and function of neurotransmitter receptors, modulation of neuronal functions, sensory transduction, and muscle contraction. The molecular basis of genetic

disorders involving nerve and muscle function will also be studied. Prerequisites: 020.151-152 or 020.305-306.  
Fambrough 3 credits

### 080.310 (N) Developmental Neurobiology

Cross-listed with Biology 020.310.  
Fambrough, Hendry, Kirkwood, Norris 3 credits

### 080.330 (N) Brain Injury and Recovery of Function

This course investigates numerous types of brain injuries and explores the responses of the nervous system to these injuries. The courses primary focus is the cellular and molecular mechanisms of brain injury and the recovery of function. Discussions of traumatic brain injury, stroke, and neurodegenerative diseases, using historical and recent journal articles, will facilitate students understanding of the current state of the brain injury field.  
Gorman 3 credits

### 080.335 (N) Neuroscience of Pain

This course will focus on the neurobiological mechanisms and psychological aspects of pain. Experimental (animal and human) and clinical models and methods will be discussed throughout. Prerequisites: 080.205 or 200.141.  
Haythornthwaite 3 credits

### 080.340 (N) Neuroplasticity

This course will investigate mechanisms associated with changes that occur within the nervous system. Students will use journal articles to discuss current issues related to developmental, adaptive, and restorative neuroplasticity. Prerequisites: 080.205 or 200.141.  
Gorman 3 credits

### 080.411-414 Advanced Seminar in Neuroscience

All B.A./M.S. students participate in this 3-credit weekly seminar during their last two years, including the research year. The seminar involves student presentations of research, presentations by guest speakers, and discussion of readings on topics of current interest in the field. Students register for 080.411-412 during the fourth year and 080.413-414 during the fifth year.  
Staff 3 credits

### 080.450 (E,Q) Computational Neuroscience

This course introduces students to quantitative modeling techniques for the study of nervous systems. Topics include representation and coding of neuronal information, learning and memory, and the development of biological nervous systems. Open to juniors, seniors, and graduate students. Prerequisites: Elementary knowledge of linear algebra and differential equations, at the level of 550.291.  
Niebur 3 credits

### 080.650-652 Mentored Research in Neuroscience

B.A./M.S. students register for mentored research for three terms (typically the spring and summer terms of the fourth year and the fall term of the fifth year). They receive 9 credit hours per semester for research during the fall and spring semesters, and 6 credit hours for the summer. Satisfactory/unsatisfactory.  
Staff