NEUROSCIENCE

http://krieger.jhu.edu/neuroscience

Neuroscience is the study of the nervous system and how it functions. Neuroscientists study the nervous system at all levels, ranging from molecules interacting with cell membranes to brain systems subserving cognitive functions such as language. Dramatic progress has been made at all levels, and the field continues to grow. On the Homewood campus, researchers studying the nervous system are in the departments of Biology, Biomedical Engineering, Biophysics, Cognitive Science, and Psychological and Brain Sciences and in the Krieger Mind/Brain Institute. Their presence provides the opportunity for an innovative, interdepartmental program which offers a broad overview of the neuroscience field, as well as more advanced training in one of four focus areas.

Cellular and Molecular Neuroscience (CM) 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.

Cognitive Neuroscience (CG) 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.

Computational Neuroscience (CP) focuses on applying mathematical tools and theories to investigate brain function. This discipline incorporates a diverse set of approaches from mathematics, physics, engineering, and computer science, to understand how the nervous system processes information. Such principles are used to answer questions across a variety of domains of neuroscience: cellular/molecular, systems and circuits, behavioral and cognitive.

Systems Neuroscience (ST) 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, and aggression) are explored from this perspective.

Neuroscience Program Committee
The Neuroscience Program Committee coordinates course offerings, oversees the program’s interdepartmental courses, reviews and updates the administration of the program, makes decisions about admission to the B.S./M.S. program, approves proposed research programs and mentors for students in the B.S./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.S. based primarily on course work and 6 credits of research; and a five-year concurrent B.S./M.S. involving additional course work and a yearlong intensive laboratory experience. (Under special circumstances, a student may be able to complete the B.S./M.S. program in less than five years.) Both programs are designed to provide rigorous preparation for advanced study in either a Ph.D., M.D. or Ph.D./M.D. programs. The concurrent B.S./M.S. program accepts students every spring semester.

Additional information regarding the undergraduate degree and the B.S./M.S. programs is available through our website at http://krieger.jhu.edu/neuroscience. You may also contact our Academic Program Administrator, Linda White, mailto:linda.m.white@jhu.edu (linda.m.white@jhu.edu) or 410-516-6196.

Requirements for the B.S. Degree
Also see Requirements for a Bachelor’s Degree (http://e-catalog.jhu.edu/undergrad-students/academic-policies/requirements-for-a-bachelors-degree).

General Information
• Students are required to select their advanced neuroscience elective courses from one of four approved focus areas: cellular and molecular neuroscience, cognitive neuroscience, computational neuroscience, or systems neuroscience. Approved courses fulfilling this requirement are found on the neuroscience website (http://krieger.jhu.edu/neuroscience/bs-program/courses) or in the schedule of classes.
• To apply towards the major, all courses must be taken for a letter grade and a grade of C- or better is required.

Neuroscience Sequence

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS.080.203</td>
<td>Neuroscience: Cognitive (spring)</td>
<td>3</td>
</tr>
<tr>
<td>AS.080.250</td>
<td>Neuroscience Laboratory (fall/spring)</td>
<td>3</td>
</tr>
<tr>
<td>AS.080.305</td>
<td>Neuroscience: Cellular and Systems I (fall)</td>
<td>3</td>
</tr>
<tr>
<td>AS.080.306</td>
<td>Neuroscience: Cellular and Systems II (spring)</td>
<td>3</td>
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Mathematics, Statistics, and Science Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
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<tbody>
<tr>
<td>EN.553.211</td>
<td>Probability and Statistics for the Life Sciences</td>
<td>4</td>
</tr>
<tr>
<td>or EN.553.310</td>
<td>Probability &amp; Statistics</td>
<td></td>
</tr>
<tr>
<td>or EN.553.311</td>
<td>Probability and Statistics for the Biological Sciences</td>
<td></td>
</tr>
<tr>
<td>or EN.553.111</td>
<td>Statistical Analysis I</td>
<td></td>
</tr>
<tr>
<td>&amp; EN.553.112</td>
<td>Statistical Analysis II</td>
<td></td>
</tr>
<tr>
<td>AS.110.106</td>
<td>Calculus I (Biology and Social Sciences)</td>
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</tr>
<tr>
<td>or AS.110.108</td>
<td>Calculus I</td>
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<tr>
<td>AS.110.107</td>
<td>Calculus II (For Biological and Social Science)</td>
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<tr>
<td>or AS.110.109</td>
<td>Calculus II (For Physical Sciences and Engineering)</td>
<td></td>
</tr>
<tr>
<td>or AS.110.113</td>
<td>Honors Single Variable Calculus</td>
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</table>
**Research** must be conducted in one of the neuroscience laboratories participating in the program. Students must register for AS.080.500 Scientific Communication: Neuroscience concurrently with neuroscience research each term they register for research until they have completed 6 credits of research.

**Sample Program**
The following course sequence is only a suggestion and is based on the assumption that there are no AP/IB/TR credits applied. Please consult with your faculty advisor when selecting and registering for classes, as there are multiple ways to complete the major.

**Freshman**

<table>
<thead>
<tr>
<th>Course #1</th>
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<th>Spring</th>
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<tbody>
<tr>
<td>AS.030.101</td>
<td>3</td>
<td>Introductory Chemistry I</td>
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<tr>
<td>AS.030.105</td>
<td>1</td>
<td>Introductory Chemistry II</td>
</tr>
<tr>
<td>AS.030.205</td>
<td>4</td>
<td>Introductory Organic Chemistry I</td>
</tr>
<tr>
<td>AS.171.101</td>
<td>4</td>
<td>General Physics: Physical Science Major I</td>
</tr>
<tr>
<td>AS.030.206</td>
<td>4</td>
<td>Introduction to Laboratory I</td>
</tr>
<tr>
<td>AS.030.303</td>
<td>3</td>
<td>Genetics</td>
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<td>AS.030.316</td>
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<td>General Physics Laboratory I</td>
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<td>AS.030.340</td>
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<tr>
<td>AS.030.101</td>
<td>3</td>
<td>Neuroscience: Cellular and Systems I</td>
</tr>
<tr>
<td>AS.030.205</td>
<td>4</td>
<td>Introduction to Organic Chemistry I</td>
</tr>
<tr>
<td>AS.030.303</td>
<td>3</td>
<td>Neuroscience: Cognitive Science</td>
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| Biology Option 1 | 3 |
| Biology Lab Option 1 | 1 |

**Sophomore**

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<tr>
<td>AS.080.305</td>
<td>3</td>
<td>Neuroscience: Cellular and Systems II</td>
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<tr>
<td>AS.080.306</td>
<td>4</td>
<td>EN.553.211 Probability and Statistics for Life Sciences</td>
</tr>
<tr>
<td>AS.030.205</td>
<td>4</td>
<td>Neuroscience: Cognitive Science</td>
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<table>
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<tr>
<td>AS.171.103</td>
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<td>AS.173.111</td>
<td>4</td>
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<td>AS.080.500</td>
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<th>Course #4</th>
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<tr>
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**Junior**

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<th>Spring</th>
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<tbody>
<tr>
<td>AS.171.103</td>
<td>4</td>
<td>General Physics I for Biological Science Majors</td>
</tr>
<tr>
<td>AS.173.111</td>
<td>1</td>
<td>General Physics Laboratory I</td>
</tr>
<tr>
<td>AS.080.500</td>
<td>0.5</td>
<td>Scientific Communication: Neuroscience for Juniors</td>
</tr>
<tr>
<td>AS.080.551</td>
<td>3</td>
<td>Neuroscience for Juniors</td>
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<tr>
<th>Course #2</th>
<th>Credits</th>
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**Senior**

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<th>Course #1</th>
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<tbody>
<tr>
<td>AS.030.110</td>
<td>3</td>
<td>Neuroscience for Juniors</td>
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<thead>
<tr>
<th>Course #2</th>
<th>Credits</th>
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<td>AS.080.554</td>
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<table>
<thead>
<tr>
<th>Course #3</th>
<th>Credits</th>
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<tbody>
<tr>
<td>AS.080.554</td>
<td>3</td>
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</table>

**Advanced Neuroscience Elective Courses and Focus Area**

- Nine credits of 300-level or higher approved courses from one of four focus areas: systems neuroscience, cognitive neuroscience, computational neuroscience, or molecular neuroscience.
- Three credits of 300-level or higher approved course outside of focus area selected above.

If pursuing the Computational Neuroscience focus area, EN.553.291 is required in addition to the other 12 credits required of the focus area (or the combo of AS.110.201/212 and AS.110.302 may be used).

If pursuing the Cellular and Molecular Neuroscience focus area, AS.020.306 and AS.020.316 must be selected as one of the two required biology courses with lab.

- **Research**

  - Six credits of neuroscience research
  - AS.080.500 Scientific Communication: Neuroscience

* For students with AP Biology credit, they may use only one course and its lab from those credits towards this requirement. Therefore, these students must take at least one biology course and its lab at JHU. Students who elect to take General Biology I or II with its lab will lose the corresponding AP credits. Students should also refer to AP credit policies for additional details around the use of AP Biology credits.
### Senior Fall Credits

<table>
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<tr>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>AS.080.250 Neuroscience Laboratory</td>
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</tr>
<tr>
<td>Upper Level Neuroscience Course #4</td>
<td>3</td>
</tr>
<tr>
<td>Total Credits</td>
<td>6</td>
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</tbody>
</table>

**Upper Level Neuroscience Course #3**

**Total Credits: 71-73**

1. Biology Course Options and Biology Lab Options can be taken in any year. For Students who are obtaining a Cellular and Molecular focus area, one of the biology options must be Cell Biology with lab.
2. AS.080.305 Neuroscience: Cellular and Systems I & AS.080.306 Neuroscience: Cellular and Systems II can be taken sophomore or junior year.
3. AS.080.203 Neuroscience: Cognitive can be taken at any time after AS.200.141 or AS.080.305 & AS.080.306
4. Research in Neuroscience can be taken at any time.
5. AS.080.250 Neuroscience Laboratory can be taken any time after completing AS.200.141 or AS.080.305 & AS.080.306.

### Honors in the Major

To receive honors in Neuroscience, students must meet the following criteria:

- Earn a GPA of 3.5 or better in major requirements
- Conduct research and give a research presentation
- Receive a recommendation from research mentor
- Three (3) additional Neuroscience Research credit(s) beyond the required 6 credits for the major (Effective for students entering Fall 2016)

### Graduate Program

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

Current JHU undergraduate Neuroscience majors who wish to apply for the B.S./M.S. Program in their junior or senior year must meet the following minimum requirements (prior to applying):

- A minimum 3.5 GPA in all required courses for the undergraduate major and cumulative GPA of 3.5.
- Completion of all courses required 6 credits of research for the JHU B.S. degree in Neuroscience.

#### Advanced Seminars in Neuroscience (6 credits)

The Advanced Seminar in Neuroscience is offered in the fall and spring terms.

#### Final Spring Courses (12 credits)

Degree requirements include 12 credits of additional advanced course work (300-level or above). At least three credits must be at 400-level or above. Courses must be related to the study of neuroscience and ideally focused on the student's concentration of study and area of research. Students may choose courses from the approved list of undergraduate advanced courses. (In addition, up to six additional credits of the Advanced Seminar in Neuroscience, and/or statistics courses, graduate courses and seminars may be taken with the approval of the program director.)

#### Mentored Research (24 credits)

During the research year, students will complete a total of 24 credits of mentored research. Students must complete nine credits of research in a spring academic term, six in the summer and an additional nine in the fall.

#### B.S./M.S. Commencement Project (1 credit)

After completing the research year, students must register for a one-credit independent study course intended to track the progress and defense of the student's final research project.

**Note:** This masters degree is only open to current Johns Hopkins University undergraduate students pursuing a major in neuroscience.

For current faculty and contact information go to http://neuroscience.jhu.edu/research-faculty/faculty-profiles/primary-faculty/

### Faculty

#### Chair
Hey-Kyoung Lee, Ph.D.
Professor, Mind/Brain Institute

#### Director of Undergraduate Studies
Linda Gorman, Ph.D.
Teaching Professor, Psychological and Brain Sciences

#### Director of BS/MS Program
Jay Baraban, MD., Ph.D.
Psychological and Brain Sciences

#### Professors
- Patricia Janak, Ph.D.
  Psychological and Brain Sciences
- Michael McCloskey, Ph.D.
  Cognitive Science
- Brenda Rapp, Ph.D.
  Cognitive Science
- Haiqing Zhao, Ph.D.
  Biology

#### Assistant Professors
- Robert Johnston, Ph.D.
  Biology
- Shrees Mysore, Ph.D.
  Psychological and Brain Sciences
- Vikram Chib, Ph.D.
  Psychological and Brain Sciences

#### Lecturers
- Hita Adwanikar, Ph.D.
  Psychological and Brain Sciences
- Dani Smith, Ph.D.
  Psychological and Brain Sciences
- Jason Trageser, Ph.D.
  Senior Lecturer, Psychological and Brain Sciences
- Susanne Sterbing-D’Angelo
  Psychological and Brain Sciences
For current course information and registration go to https://sis.jhu.edu/classes/

Courses

AS.080.203. Neuroscience: Cognitive. 3.0 Credits.
This course surveys theory and research concerning how the human brain carries out mental processes. The sections of this course correspond with the sections listed for AS.020.203. All sections will meet together on exams day and guest lecture days. Co-listed as AS.050.203 in Cognitive Science. It’s strongly recommended that students have background in one of the following courses: AS.050.101 OR AS.050.105 OR AS.200.141.
Instructor(s): Staff
Area: Natural Sciences, Social and Behavioral Sciences.

AS.080.250. Neuroscience Laboratory. 3.0 Credits.
This course will give students the "hands-on" experience of the interdisciplinary nature of neuroscience. Students will use anatomical and neuro-physiological techniques to understand the basic underlying principles of neuroscience. There will be a total of 13 class meetings during the summer session. Course open to JHU undergraduates only.
Prerequisites: (AS.080.305 AND AS.080.306) OR AS.200.141
Instructor(s): J. Trageser, L. Gorman
Area: Natural Sciences.

AS.080.260. Bridging the gap between Biology and Statistics. 1.0 Credit.
This course is designed to support the lectures and assignments in Probability and Statistics in Life Sciences, EN.553.211. This one-hour per week course is led by a behavioral biology professor with extensive expertise in statistics and mathematics. The primary goal of this course is to increase success and understanding of EN.553.211 by bridging the gap between theoretical statistics and biological thinking. In addition, when possible, examples and direct applications in neuroscience and behavioral biology will be presented to provide a context for EN.553.211 materials.
Instructor(s): K. Bohn.

AS.080.301. Behavioral Assessment of Animal Models of Cognition and Neuropsychiatric Disorders. 3.0 Credits.
What does a rat exploring it's environment tell us about memory? How can a mouse help us better understand schizophrenia? This course will focus on procedures that are routinely used to study behavior in animal models of cognition and neuropsychiatric disorders. Topics will include motor function, emotional and motivational states, disorders such as dementia and schizophrenia, among others. Throughout the course, we will read and discuss original research articles to illustrate and compare some of the measures and results from the various procedures.
Prerequisites: Students may not have taken AS.200.302, AS.200.141 OR (AS.080.305 and AS.080.306), OR by instructor permission.
Instructor(s): D. Smith
Area: Social and Behavioral Sciences.

AS.080.302. Structure of the Nervous System. 3.0 Credits.
This course takes a structural biological approach to studying the nervous system. In using a systems approach it provides students of cellular-molecular and computational neuroscience with a thorough introduction to functional, microscopic and submicroscopic organization of the brain, spinal cord and peripheral nervous system.
Prerequisites: AS.080.305 AND AS.080.306
Instructor(s): S. Hendry
Area: Natural Sciences.

AS.080.304. Neuroscience Learning and Memory. 3.0 Credits.
This course is an advanced survey of the scientific study of learning and memory. Different perspectives will be used to review the science of learning and memory including the cellular-molecular basis of synaptic plasticity, the functional circuitry involved in learning and memory and memory systems in the brain. The course is designed to provide a deep understanding of the issues and current debates in learning and memory research and focuses specifically on animal models of memory and memory impairment. This is an interactive lecture course with a strong emphasis on student participation.
Prerequisites: AS.200.141[C] OR (AS.080.305[C] AND AS.080.306[C]) OR (AS.020.312[C] AND AS.020.306[C]) OR instructor permission.
Instructor(s): A. Bakker
Area: Natural Sciences.

AS.080.305. Neuroscience: Cellular and Systems I. 3.0 Credits.
(Formerly Nervous Systems I) Neuroscience: Cellular and Systems I is a fully integrated, two-semester course that surveys the cellular and molecular biology of neurons as well as the structure and function of the nervous system. Students must register for Neuroscience: Cellular and Systems II offered in the second term. Course open to JHU undergraduates only.
Prerequisites: AS.080.203 OR AS.050.203 OR AS.200.141 OR 080.105 or Permission
Instructor(s): H. Zhao; S. Hendry
Area: Natural Sciences.

AS.080.306. Neuroscience: Cellular and Systems II. 3.0 Credits.
(Formerly Nervous Systems II) Neuroscience: Cellular and Systems II uses the functional organization of the somatosensory system as a means to examine mechanisms of neutral development. Generation and maturation of neurons, guidance of axons, formation of synapses and the regressive events that shape the adult nervous system will be examined. At the same time we will explore the structure and function of brain regions that allow us to feel pain and temperature, detect vibration, recognize shape and perceive where we are in space. Finally, the single-neuron events that lead to adaptive changes in function will be explored in the context of central nervous system control of movement and of higher order functions of speech and memory. Students who do not register for Neuroscience: Cellular and Systems I offered during the first term should not register for this class.
Prerequisites: AS.080.305
Instructor(s): H. Zhao; S. Hendry
Area: Natural Sciences.
AS.080.308. Neuroeconomics. 3.0 Credits.
Every day decisions often require us to weigh the costs and benefits of engaging in a particular course of action in order to obtain some expected outcome. Unfortunately, we often lack the information necessary to obtain our desired goal with complete certainty. Economists have long been interested in understanding human decision-making under these circumstances. In parallel, neuroscientists have made great strides at describing the underlying neural basis of simple decision-making. However, despite much progress in both fields, our understanding of how the brain makes decisions is incomplete. In order to strengthen and further research in both fields, the interdisciplinary field of Neuroeconomics arose. This course will survey the field of Neuroeconomics focusing on theoretical concepts developed by economists and the role these theories are playing in guiding current experimental neuroscience. Recommended Course Background: AS.080.305 and AS.080.306 or AS.020.312 and AS.020.306 or AS.200.141 and AS.020.306 or permission.
Prerequisites: Pre-reqs: AS.080.306 OR AS.200.141 OR AS.020.312
Instructor(s): J. Trageser
Area: Natural Sciences.

AS.080.309. The Auditory System. 3.0 Credits.
This course will cover the neuroanatomy and neurophysiology of the human auditory system from the ear to the brain. Behavioral, electrophysiological, and neuroimaging methods for assessing peripheral and central auditory function will be discussed. Acquired and developmental disorders of auditory function will be reviewed using clinical case studies.
Prerequisites: AS.080.305 OR AS.080.203 OR AS.050.203 OR AS.200.141 OR AS.020.312 or permission of the instructor.
Instructor(s): D. Boatman
Area: Natural Sciences.

AS.080.310. Communication Between Cells: The Synapse as a Model System. 3.0 Credits.
Biochemistry (020.305) & Cell Biology (020.306) or 080.304 All cells inform neighbors of their own activities. That act of communication frequently requires the formation of cell junctions across which information can pass. One of the best studied of the means of communication between cells is the synapse between neurons. This course examines the synapse in depth; both as a means to look at the nature of neuronal communication and as a model for communication across cells of all types. Lectures on the physiology, structure, biochemistry and cell biology of synapses will be used as an introduction to the function of synapses in learning and memory and the effects on synapses of drugs and disease. (CM)
Prerequisites: Pre-reqs: AS.020.306 OR (AS.080.304 AND AS.080.306)
Instructor(s): A. Kirkwood; H. Lee
Area: Natural Sciences.

AS.080.311. Developmental Neurobiology: Signaling in Development and Disease. 3.0 Credits.
An advanced undergraduate level seminar on current topics on signal transduction mechanisms underlying neural morphology, development and function. The proper functioning of the nervous system relies on the establishment of precise neuronal circuits through a developmental program including proliferation, neuronal migration, axonal growth, and neuronal survival. This course pertains to the extracellular cues and downstream neuronal signaling pathways that coordinate these key events during neuronal development. The course will also cover the role of aberrant signaling mechanisms in neuronal degeneration and disease. Recommended Course Background: AS.020.305 and AS.020.306.
Prerequisites: Pre-req: AS.080.306
Instructor(s): R. Kuruvilla
Area: Natural Sciences.

AS.080.317. Developmental Neurobiology: Signaling in Development and Disease. 3.0 Credits.
This course will cover the neuroanatomy and neurophysiology of the human auditory system from the ear to the brain. Behavioral, electrophysiological, and neuroimaging methods for assessing peripheral and central auditory function will be discussed. Acquired and developmental disorders of auditory function will be reviewed using clinical case studies.
Prerequisites: AS.080.305 OR AS.080.203 OR AS.050.203 OR AS.200.141 OR AS.020.312 or permission of the instructor.
Instructor(s): D. Boatman
Area: Natural Sciences.

AS.080.326. Neurobiology and Diseases of the Peripheral Nervous System. 3.0 Credits.
This course will cover neurobiology and disorders of the peripheral nervous system (PNS). A particular emphasis will be on cellular interactions within the PNS and with target tissues. For example, the two principal components of the peripheral nerves- axons and Schwann cells-have intimate and continuous cellular communications that are critical for physiological function of the PNS. The course will teach how these cellular interactions are developed, maintained throughout life, and are impacted by injury and diseases.
Prerequisites: AS.080.305 AND AS.080.306
Instructor(s): M. Farah
Area: Natural Sciences
Writing Intensive.

AS.080.328. Behavioral Neuroscience Lab. 3.0 Credits.
Class designed to give students first-hand knowledge of the behavioral procedures and techniques used to study behavior in the field of neuroscience. Students will gain hands-on experience by carrying out some of the behavioral tasks used to assess animals under specific behavioral domains, discuss why certain aspects (i.e. genotype, environment conditions, group size, etc.) are important factors to consider when designing, planning, and carrying out such experiments, and learn the relevance of behavioral research in translational medicine.
Prerequisites: AS.200.141 OR AS.200.302 OR AS.080.301 OR (AS.080.305 AND AS.080.306) or permission by instructor.
Instructor(s): D. Smith
Area: Natural Sciences.
AS.080.330. Brain Injury & Recovery. 3.0 Credits.
This course investigates numerous types of brain injuries and explores the responses of the nervous system to these injuries. The course’s primary focus is the cellular and molecular mechanisms of brain injury and the recovery of function. Discussions of traumatic brain injury, stroke, spinal cord, and tumors, using historical and recent journal articles, will facilitate students’ understanding of the current state of the brain injury field. Cross-listed with Psychological and Brain Sciences and Behavioral Biology.
Prerequisites: (AS.080.305 AND AS.080.306) OR (AS.020.312 OR AS.020.306) OR (200.141 and 020.306) OR Permission of Instructor
Instructor(s): L. Gorman
Area: Natural Sciences
Writing Intensive.

AS.080.336. Effects of Other Organs on the Nervous System Function. 3.0 Credits.
Both classical and recent primary research papers that deal with cross signaling of other major organs with the nervous system, particularly the central nervous system, will be discussed. Students will be exposed to emerging literature on how peptides, signaling molecules, and hormones effect the nervous system function both in health and in diseases.
Instructor(s): M. Farah
Area: Natural Sciences
Writing Intensive.

AS.080.345. Great Discoveries in Neuroscience. 3.0 Credits.
This course examines the historical and intellectual context of selected, key advances in neuroscience, how they were made and the impact they had on an understanding of the nervous system. Particular attention will be paid to advances in cellular and molecular neuroscience. Among the topics covered will be the discovery of monoamine neurotransmitters and of endocannabinoids, the role of neurotrophins in neural development, and prion-based diseases of the brain.
Prerequisites: Pre-reqs: AS.080.306
Instructor(s): J. Baraban
Area: Natural Sciences.

AS.080.348. Science of Learning. 3.0 Credits.
Can we know about the brain guide how we learn or teach in our schools? This seminar course is designed to address this question. In this course we will focus on the science of what we know about learning and teaching (and not the politics) to see if we can actually use the research to “optimize learning in society”. As we read the literature, we will look at some of the “neuromyths” that have been propagated thus far and discuss how to avoid creating new neuromyths by effectively communicating the research.
Prerequisites: Pre-reqs: AS.080.306 OR AS.200.141
Instructor(s): L. Gorman
Area: Natural Sciences, Social and Behavioral Sciences
Writing Intensive.

AS.080.357. Developmental Neuroscience. 3.0 Credits.
The developmental neuroscience course will cover principles of neural development. The course will focus on major events in neural development: patterning and growth of the nervous system, neuronal determination, axonal navigation and targeting, neuron survival and death, synapse function, developmental plasticity, and behavioral and cognitive development.
Prerequisites: AS.080.305 AND AS.080.306
Instructor(s): M. Farah.
AS.080.411. Advanced Seminar: Neuroscience I. 3.0 Credits.
For students in the first semester of the BS/MS Program. Instructor permission required.
Instructor(s): J. Baraban
Area: Natural Sciences.

AS.080.412. Advanced Seminar: Neuroscience II. 3.0 Credits.
For students in the 2nd semester of the BS/MS Program.
Instructor(s): J. Baraban
Area: Natural Sciences.

AS.080.413. Advanced Seminar: Neuroscience III. 3.0 Credits.
For students in the 3rd semester of the BA/MS Program.
Instructor(s): J. Baraban
Area: Natural Sciences.

AS.080.500. Scientific Communication: Neuroscience. 0.5 Credit.
Scientific communication is crucial to advancing science. The Scientific Communication section is taken concurrently with Neuroscience Research and consists of a two hour research orientation session held at the beginning of the semester and a two hour exit session held at the end of the semester. The student is also expected to meet with their lab supervisor or attend a lab meeting once a week to understand the research the lab is currently working on and receive feedback on the work they are doing. See special notes section for specific meeting day/time. Students must sign up for Scientific Communication prior to signing up for NS Research until they complete their 6 credits of research. See Neuroscience Research website for more details.
Corequisites: Co-reqs: AS.080.531 OR AS.080.541 OR AS.080.551 OR AS.080.561
Instructor(s): Staff.

AS.080.511. Independent Study. 1.0 - 3.0 Credits.
Instructor(s): L. Gorman.

AS.080.512. Independent Study. 0.0 - 3.0 Credits.
Instructor(s): L. Gorman.

AS.080.531. Research Neuroscience-Freshmen. 1.0 - 3.0 Credits.
Corequisites: AS.080.500 (Scientific Communication)
Instructor(s): Staff.

AS.080.534. Neuroscience Research- Freshmen. 0.0 - 3.0 Credits.
Corequisites: AS.080.500[C]
Instructor(s): Staff.

AS.080.541. Research Neuroscience - Sophomores. 1.0 - 3.0 Credits.
Corequisites: AS.080.500 (Scientific Communication)
Instructor(s): Staff.

AS.080.544. Neuroscience Research-Sophomores. 0.0 - 3.0 Credits.
Corequisites: AS.080.500
Instructor(s): Staff.

AS.080.550. Neuroscience BS/MS Summer Research - Seniors.
This summer research course is only for Neuroscience BS/MS students that are seniors in the program over the summer.
Instructor(s): J. Baraban.

AS.080.551. Research Neuroscience for Juniors. 1.0 - 3.0 Credits.
Corequisites: AS.080.500 (Scientific Communication)
Instructor(s): Staff.

AS.080.554. Neuroscience Research - Juniors. 0.0 - 3.0 Credits.
Corequisites: AS.080.500
Instructor(s): Staff.

AS.080.561. Research Neuroscience for Seniors. 1.0 - 3.0 Credits.
Corequisites: AS.080.500 (Scientific Communication)
Instructor(s): Staff.

AS.080.564. Neuroscience Research - Seniors. 0.0 - 3.0 Credits.
Corequisites: AS.080.500
Instructor(s): Staff.

AS.080.572. Direct Readings/Independent Study. 0.0 - 3.0 Credits.
Instructor(s): J. Baraban; L. Gorman.

AS.080.582. Neuroscience: Internship. 1.0 - 3.0 Credits.
Instructor(s): L. Gorman.

AS.080.590. Independent Study. 1.0 - 3.0 Credits.
Corequisites: AS.080.500
Instructor(s): J. Baraban; L. Gorman.

AS.080.592. Research-Freshmen. 1.0 - 3.0 Credits.
Corequisites: AS.080.500
Instructor(s): Staff.

AS.080.594. Research-Sophomores. 1.0 - 3.0 Credits.
Corequisites: AS.080.500
Instructor(s): Staff.

AS.080.595. Neuroscience: Internship. 1.0 - 3.0 Credits.
Corequisites: AS.080.500
Instructor(s): L. Gorman.

AS.080.596. Research-Juniors-Summer. 1.0 - 3.0 Credits.
Corequisites: AS.080.500
Instructor(s): Staff.

AS.080.597. Internship: Neuroscience. 1.0 - 3.0 Credits.
Instructor(s): L. Gorman.

AS.080.598. Research-Seniors-Summer. 1.0 - 3.0 Credits.
Corequisites: AS.080.500
Instructor(s): Staff.

AS.080.600. Neuroscience Research: BA/MS Undergraduate.
This course is ONLY for Neuroscience BA/MS students that are in the program during their undergraduate senior year. This course is similar to the course that the BA/MS graduate students take but is for BA/MS Seniors in their 7th semester summer period.
Instructor(s): J. Baraban.

AS.080.601. Neuroeconomics -Graduate Level.
Every day decisions often require us to weigh the costs and benefits of engaging in a particular course of action in order to obtain some expected outcome. Unfortunately, we often lack the information necessary to obtain our desired goal with complete certainty. Economists have long been interested in understanding human decision-making under these circumstances. In parallel, neuroscientists have made great strides at describing the underlying neural basis of simple decision-making. However, despite much progress in both fields, our understanding of how the brain makes decisions is incomplete. In order to strengthen and further research in both fields, the interdisciplinary field of Neuroeconomics arose. This course will survey the field of Neuroeconomics focusing on theoretical concepts developed by economists and the role these theories are playing in guiding current experimental neuroscience. Only graduate students can register for this course. Instructor signature is required.
Instructor(s): J. Trageser.
This experiential learning experience provides the opportunity to learn and interact with children recovering from brain, spinal, and musculoskeletal injuries. Students will travel to the Kennedy Krieger Institute to volunteer in the Child Life Department where they will participate in a variety of therapeutic activities including playing with the children and helping them achieve goals on Saturdays (days/times TBA). Students will gain valuable clinical experience while learning patient empathy. Students MUST attend a mandatory orientation and a mandatory exit session held on the Homewood campus (see section web notes for days/times). Students are required to present a written description of their experiences and to discuss their experiences at the exit session. Transportation will be provided by the JHMI shuttle. No credit - S/U Grading Only Instructor(s): L. Gorman.

In this experiential learning experience, students will work with children who have a variety of neurological disabilities, including autism, cerebral palsy and Down syndrome through exercise and recreational activities. We partner with the KEEN (Kids Enjoy Exercise Now), a nonprofit organization. Student “coaches” will receive a profile for the KEEN athlete that they will pair up with during a session. Students will receive initial training and then select 4 sessions to attend. Sessions are held on the first and third Sunday of each month during the semester at KEEN centers in Maryland. Students MUST attend a mandatory orientation and a mandatory exit session held on the Homewood campus (see section web notes for days/times). Students are required to present a written description of their experiences and to discuss their experiences at the exit session. Transportation will be via student carpools using Zipcars, personal vehicles or Hop Vans. No credit - S/U Grading Only Instructor(s): L. Gorman.

AS.080.614. Experiential Learning: STEM in the Classroom.
STEM subjects are particularly important in today’s society and getting students interested in these areas early is crucial. Working with Making Neuroscience Fun (MNF), a community outreach program, which brings age-appropriate interactive presentations about the brain and nervous system to Baltimore city and county elementary school students, our students share their love of the sciences with young children. The elementary school students learn about the nervous system and our students learn valuable communication skills. Hopkins students will receive initial training prior to participating and will select and present 6, 45-minute presentations. In order to participate, students must be available either 7am-11am or 11am-3pm at least one day per week, Monday-Friday. Students MUST attend a mandatory orientation, a mandatory training and a mandatory exit session held on the Homewood campus (see section web notes for days/times). Students are required to present a written description of their experiences and to discuss their experiences at the exit session. Students will also be given the opportunity to work with the faculty to develop new materials for the program. Presentations will take place at Baltimore city and county elementary schools. Transportation to the schools will be via student carpools using Zipcars or personal vehicles. No credit - S/U Grading Only Instructor(s): L. Gorman.

AS.080.616. Experiential Learning: Working with Children in the Clinic.
This experiential learning experience provides students the opportunity to learn, play and interact with children receiving treatment in over 20 different specialties including dermatology, endocrine, GI, immunology, urology, plastics and hematology. Students will volunteer in outpatient clinics at the Johns Hopkins Children’s Center where they will encourage, play and participate in a variety of activities including art projects, coloring, board games, and reading. Students will gain valuable clinical experience and be exposed to a wide range of children with a variety of diseases/illnesses. Students MUST attend a mandatory orientation and a mandatory exit session held on the Homewood campus (see section web notes for days/times). Students will sign up for 5 shifts on a first-come, first-serve basis after the mandatory orientation. Shifts are Mondays 1pm-3pm, Tuesdays 10am-12pm, Wednesdays 1pm-3pm, Thursdays 10am-12pm and Fridays 10am-12pm throughout the semester. There is a limit of 4 students per session. Students are required to present a written description of their experiences and to discuss their experiences at the exit session. Volunteer shifts will take place at outpatient clinics in the Rubenstein Child Health Building. Transportation will be provided by the JHMI shuttle. No credit - S/U Grading Only Instructor(s): L. Gorman.

AS.080.620. Theoretical Neuroscience.
Topics of theoretical neuroscience and computational neuroscience will be discussed based on the original literature. Students are expected to actively participate in the discussion and also to present selected material to the class.
Instructor(s): E. Niebur.

AS.080.630. Bodian Seminar Series.
The Bodian Seminar is an interdisciplinary colloquium for discussion of current research into the neural basis of mental processes. Leading researchers, generally from outside the University, are invited to give lectures, which will be announced per e-mail. Undergraduate students who register for this course are asked to study a publication by the speaker, as provided with the announcement, and to prepare a question for each speaker together with a brief discussion of the possible answers. Permission required for undergraduate students.
Instructor(s): V. Stuphorn.

Graduate students and Seniors with instructor permission. The Bodian Seminar is an interdisciplinary colloquium for discussion of current research into the neural basis of mental processes. Leading researchers, generally from outside the University, are invited to give lectures. About 12 lectures are scheduled per semester (see http://www.mb.jhu.edu/seminars.asp). Speakers, titles of lectures, and dates are announced to participants per e-mail (contact Debby Kelly, 410 516-8640). The announcements also include links to one or two recent publications of the speaker. Undergraduate students who register for this course are asked to study these papers and to prepare a question for each speaker together with a brief discussion of the possible answers. Question and discussion have to be in writing and turned in the day before the lecture. Undergraduates must e-mail the instructor for permission (von.der.heyd@jhu.edu) prior to registering for the course.
Instructor(s): V. Stuphorn.
**AS.080.660. Commencement Project.**
This course is for BA/MS students that have completed their year of research and are now working on their final thesis. In this course, students devote their semester to preparing their final thesis documentation and move forward with their Master’s Thesis Defense which is the last piece to the program. This course is for BA/MS student only and students should only register for this course in their last semester in the program.
Instructor(s): J. Baraban.

**AS.080.850. Mentored Research: Neuroscience I.**
For students in the BA/MS Program first semester. Permission required.
Instructor(s): J. Baraban.

**AS.080.851. Mentored Research: Neuroscience.**
Instructor(s): L. Gorman
Writing Intensive.

**AS.080.852. Mentored Research: Neuroscience II.**
Permission Required. For students in the BA/MS Program.
Instructor(s): J. Baraban.

**AS.080.854. Mentored Research: Neuroscience III.**
For students in the BA/MS Program Permission required.
Instructor(s): J. Baraban.

**Cross Listed Courses**

**Biology**

**AS.020.317. Signaling in Development and Disease. 3.0 Credits.**
An advanced undergraduate level seminar on current topics on signal transduction mechanisms underlying neuronal morphology, development and function. The proper functioning of the nervous system relies on the establishment of precise neuronal circuits through a developmental program including proliferation, neuronal migration, axonal growth, and neuronal survival. This course pertains to the extracellular cues and downstream neuronal signaling pathways that coordinate these key events during neuronal development. The course will also cover the role of aberrant signaling mechanisms in neuronal degeneration and disease. Recommended Course Background: AS.020.305, AS.020.306, and AS.080.306
Instructor(s): R. Kuruvilla
Area: Natural Sciences.

**Cognitive Science**

**AS.050.102. Language and Mind. 3.0 Credits.**
Introductory course dealing with theory, methods, and current research topics in the study of language as a component of the mind. What it is to “know” a language: components of linguistic knowledge (phonetics, phonology, morphology, syntax, semantics) and the course of language acquisition. How linguistic knowledge is put to use: language and the brain and linguistic processing in various domains. Cross-listed with Neuroscience and Psychology.
Instructor(s): C. Wilson
Area: Natural Sciences, Social and Behavioral Sciences.

**AS.050.105. Introduction to Cognitive Neuropsychology. 3.0 Credits.**
When the brain is damaged or fails to develop normally, even the most basic cognitive abilities (such as the ability to understand words, or perceive objects) may be disrupted, often in remarkable ways. This course explores a wide range of cognitive deficits, focusing on what these deficits can tell us about how the normal brain works. Topics include brain anatomy and causes of brain damage, reading and spelling deficits, unilateral spatial neglect, hemispheric disconnection, cortical plasticity, and visual perception of location and orientation. Students read primary sources: journal articles that report deficits and discuss their implications.
Instructor(s): M. McCloskey
Area: Natural Sciences, Social and Behavioral Sciences.

**AS.050.315. Cognitive Neuropsychology of Visual Perception: The Malfunctioning Visual Brain. 3.0 Credits.**
When we think about our ability to see, we tend to think about our eyes, but in fact vision happens mostly in the brain. This course explores the remarkable perceptual deficits that occur when the visual regions of the brain are damaged or fail to develop normally, focusing on what these perceptual malfunctions tell us about normal visual perception. Topics include visual system anatomy and physiology; functional specialization in the lower visual system as revealed by cerebral achromatopsia (color blindness resulting from brain damage) and akinetopsia (impaired motion perception); cortical plasticity in the visual system; spatial deficits in perception and action; and the implications of high-level visual deficits, including prosopagnosia (impaired face recognition), Charles Bonnet syndrome (complex visual hallucinations in blind areas of the visual field), blindsight (accurate responding to visual stimuli despite apparent inability to see them), and Anton’s syndrome (denial of blindness).
**Prerequisites:** AS.050.105 OR AS.050.203 OR AS.080.203 OR AS.050.101 OR AS.200.110 OR AS.200.211 or instructor's permission.
Instructor(s): M. McCloskey
Area: Natural Sciences, Social and Behavioral Sciences.

**AS.050.326. Foundations of Cognitive Science. 3.0 Credits.**
This course explores general issues and methodologies in cognitive science through the reading of classic works (from Plato and Kant through Skinner and Turing) and recent research articles to begin construction of a coherent picture of many seemingly divergent perspectives on the mind/brain. Recent brain-based computational models serve to focus discussion. Also offered as AS.050.626.
Instructor(s): P. Smolensky
Area: Natural Sciences, Social and Behavioral Sciences
Writing Intensive.

**AS.050.332. Developmental Cognitive Neuroscience. 3.0 Credits.**
In-depth examination of the current literature on cognitive development in the context of developmental cognitive neuroscience. Please see course prerequisites. Meets with AS.050.632.
**Prerequisites:** AS.050.101 OR AS.050.339 OR AS.200.132 OR AS.050.105 OR Instructor's permission.
Instructor(s): B. Landau
Area: Natural Sciences, Social and Behavioral Sciences.
AS.050.339. Cognitive Development. 3.0 Credits.
This is a survey course in developmental psychology designed for individuals with some basic background in psychology or cognitive science, but little or none in development. The course is strongly theoretically oriented, with emphasis on issues of nature, and development psychology as well as relevant empirical evidence. The principle focus will be early development, i.e., from conception through middle childhood. The course is organized topically, covering biological and prenatal development, perceptual and cognitive development, the nature and development of intelligence, and language learning.
Instructor(s): J. Yarmolinskaya
Area: Natural Sciences, Social and Behavioral Sciences.

Also offered as AS.050.326. This course explores general issues and methodologies in cognitive science through the reading of classic works (from Plato and Kant through Skinner and Turing) and recent research articles to begin construction of a coherent picture of many seemingly divergent perspectives on the mind/brain. Recent brain-based computational models serve to focus discussion.
Instructor(s): P. Smolensky
Area: Natural Sciences, Social and Behavioral Sciences
Writing Intensive.

Also offered as AS.050.339. This is a survey course in developmental psychology designed for individuals with some basic background in psychology or cognitive science, but little or none in development. The course is strongly theoretically oriented, with emphasis on issues of nature, and development psychology as well as relevant empirical evidence. The principle focus will be early development, i.e., from conception through middle childhood. The course is organized topically, covering biological and prenatal development, perceptual and cognitive development, the nature and development of intelligence, and language learning.
Instructor(s): J. Yarmolinskaya.

Psychological Brain Sciences
AS.200.141. Foundations of Brain, Behavior and Cognition. 3.0 Credits.
A survey of neuropsychology relating the organization of behavior to the integrative action of the nervous system. Cross-listed with Behavioral Biology and Neuroscience.
Instructor(s): L. Gorman
Area: Natural Sciences, Social and Behavioral Sciences.

AS.200.302. Behavioral Assessment of Animal Models of Cognition and Neuropsychiatric Disorders. 3.0 Credits.
What does a rat exploring its environment tell us about memory? How can a mouse help us better understand schizophrenia? This course will focus on procedures that are routinely used to study behavior in animal models of cognition and neuropsychiatric disorders. The procedures discussed will include assessments that fall into 3 broad functional domains: motor function, affective or emotional states, and cognition. Throughout the course, we will read and discuss original research articles to illustrate and compare some of the measures and results from the various procedures. Postdoc Teaching Fellowship. This is designed to be an upper level course.
Prerequisites: Pre-reqs: AS.200.141 OR (AS.080.305 AND AS.080.306) or permission of the instructor.
Instructor(s): D. Smith
Area: Social and Behavioral Sciences.

AS.200.304. Neuroscience of Decision Making. 3.0 Credits.
This course will survey the neural mechanisms of decision-making. Current experimental research and theory concerning selection, control, and evaluation of actions are examined in humans and animals. Topics will range from simple perceptual judgements to complex social behavior. The course involves a weekly lecture about a specific topic followed by a student presentation of a current research paper. Cross-listed with Neuroscience.
Prerequisites: AS.080.305 OR AS.200.141
Instructor(s): V. Stuphorn
Area: Natural Sciences.

AS.200.344. Behavioral Endocrinology. 3.0 Credits.
An examination of the effects of hormones on behavior in non-human and human animals. Topics will include the effects of hormones on sexual differentiation, reproductive behavior, parental behavior, homeostasis and biological rhythms, regulation of body weight, learning and memory. Cross-listed with Behavioral Biology and Neuroscience.
Prerequisites: Prereqs: (AS.200.141 OR AS.080.306) OR (AS.020.151 AND AS.020.152) OR (AS.020.305 AND AS.020.306) or instructor's permission
Instructor(s): K. Bohn
Area: Natural Sciences, Social and Behavioral Sciences.

AS.200.368. Sleep, Dreams, and Altered States of Consciousness. 3.0 Credits.
Sleep, dreaming, resting and arousal to waking represent very different states of consciousness which differ dramatically both psychologically and physiologically. This course focuses on cognitive, psychological, physiological, biological and genetic aspects characterizing each of these states with some reference to other altered states. The course includes a focus on the major pathologies affecting sleep-wake states. Clinical cases will be considered. These inform about both psychological and biological aspects of these states. The relative biological functions of each state will be evaluated with particular attention to the mystery of why we have and apparently need REM and NREM sleep. Actual physiological recordings of sleep states will be reviewed and the student will learn how these are obtained and how to evaluate these. The circadian rhythms, ontogeny and evolution of these sleep-wake states will also be covered. This will include a review of information learned from non-human animal sleep. The change from sleep to full awakening reflects change toward increasing brain organization supporting consciousness. Understanding of the neurobiology of these states will be used to explore some of the more modern and scientific concepts of human self-awareness or consciousness. Recommended Course Background: AS.200.101 OR AS.080.203 OR AS.050.203
Instructor(s): R. Allen
Area: Natural Sciences, Social and Behavioral Sciences.

AS.200.376. Psychopharmacology. 3.0 Credits.
Designed to provide information about how drugs affect the brain and behavior. The course focuses on biological concepts underlying structures and functions of the brain that relate to mental disorders. An introduction to neurobiology and brain function is presented as it applies to the interaction of various classes of drugs with the individual neurotransmitter systems in the brain. A brief historic review is followed by a discussion of clinical relevance. Cross-listed with Behavioral Biology and Neuroscience. Enrollment limited to juniors and seniors.
Prerequisites: AS.200.141 OR AS.020.306 OR AS.080.305 or Instructor Permission
Instructor(s): H. Adwanikar; S. Sterbing-d'angelo
Area: Natural Sciences, Social and Behavioral Sciences.
Biomedical Engineering
EN.580.694. Statistical Connectomics. 3.0 Credits.
This course will cover the basics of an exciting emerging field of statistical connectomics (aka, brain-graphs). It is so new, that we are going to make some of it up in this class! The first week will be introductory lectures that I give. The rest of the semester will be run like a seminar; each week will focus on a different topic. On Tuesdays we will hear about a statistical method that operates on graphs, and on Thursdays we will read about some neuroscience data upon which one could apply these techniques. The final project will consist of implementing a statistical method devised for graphs on a brain-graph problem. Recommended background: coursework in probability, linear algebra, and numerical programming (eg, R, Python, Matlab).
Instructor(s): J. Vogelstein
Area: Engineering.