Neuroscience

Department Website: http://neuroscience.uchicago.edu/undergraduate

Program of Study

Neuroscience is concerned with the function of nervous systems. The sheer scope of neuroscience necessitates numerous scientific approaches to achieve understanding of sensation, perception, cognition, and behavior. Consequently, students in the major are provided with access to a wealth of scientific variety, including biology, psychology, physics, chemistry, computer science, engineering, mathematics, statistics, and medicine. Neuroscience faculty at the University of Chicago have expertise in all of these areas and are distributed across the Biological Sciences, Social Sciences, and Physical Sciences Divisions.

The bachelor of arts (BA), bachelor of science (BS), and bachelor of science with honors degrees in neuroscience provide a broad foundation in understanding neural function from the perspective of molecules, cells, circuits, systems, organisms, and species. The BA degree provides thorough study in the field of neuroscience while allowing flexibility in elective choice. The BS and BS honors degrees offer a more intensive program of study that includes individual research. Students who wish to incorporate neuroscientific literacy into their degree but have primary interest in other fields can choose to obtain a minor in neuroscience.

Summary of Requirements for the Major in Neuroscience

The major curriculum includes nine required neuroscience courses, which provide a comprehensive overview of the field. Students must also take neuroscience electives, which may include up to two neuroscience-related electives. Neuroscience electives increase a student's knowledge of neural systems, while neuroscience-related electives are included to provide students with tools or context to enhance understanding of neural systems. Elective courses can be selected either to achieve breadth, i.e., broad exposure to many topics, or for depth in a particular area of neuroscience. Students who wish to major in neuroscience are strongly encouraged to declare the major in their second year.

Program Requirements: BA - Nine required neuroscience courses beyond the general education requirement (which should begin in the first year), plus a minimum of seven electives are required for a BA.

Program Requirements: BS - Nine required neuroscience courses beyond the general education requirement (which should begin in the first year), plus a minimum of 10 electives. Enrollment in faculty-supervised research for elective credit culminating in a poster presentation and thesis submission are also required for a BS.

Program Requirements for BS with Honors - The honors program expands on the program requirements for the BS by requiring a minimum GPA plus a summer of full-time research and three quarters of faculty-supervised research for elective credit culminating in a public talk and thesis submission. Interested majors must apply for admittance into the honors program in their third year.

Grading

All courses used to satisfy prerequisites and requirements must be taken for quality grades. Students must pass each course in the Fundamental Neuroscience Sequence (NSCI 20100-20140) with a C or higher. Students are also required to pass general education courses with an average GPA of 2.0 or higher to continue in the program.

General Education Requirements for the Major

To satisfy the general education requirements students must take 200 units of Biology, 200 units of Math and 200 units of Chemistry from the selected list of General Education courses for the Neuroscience major (see General Education Table).

Bachelor of Arts Degree in Neuroscience

The basic degree in neuroscience is the BA. To qualify for a BA, students must minimally satisfy the general education requirements and complete the neuroscience required courses (900 units), 500 units of neuroscience elective courses, and 200 units of neuroscience or neuroscience-related elective courses as listed in the table below.

Major: Bachelor of Arts Required Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>NSCI 20101</td>
<td>Foundations of Neuroscience</td>
<td>100</td>
</tr>
<tr>
<td>NSCI 20111</td>
<td>Cellular Neurophysiology</td>
<td>100</td>
</tr>
<tr>
<td>NSCI 20130</td>
<td>Systems Neuroscience</td>
<td>100</td>
</tr>
<tr>
<td>NSCI 20140</td>
<td>Sensation and Perception</td>
<td>100</td>
</tr>
<tr>
<td>PHYS 12100-12200</td>
<td>General Physics I-II (or higher)</td>
<td>200</td>
</tr>
<tr>
<td>NSCI 20100</td>
<td>Neuroscience Laboratory</td>
<td>100</td>
</tr>
<tr>
<td>STAT 22000</td>
<td>Statistical Methods and Applications</td>
<td>100</td>
</tr>
<tr>
<td>CHEM 11300</td>
<td>Comprehensive General Chemistry III</td>
<td>100</td>
</tr>
</tbody>
</table>
Neuroscience

or CHEM 12300  Honors General Chemistry III
At least five Neuroscience electives **  500
No more than two Neuroscience-related electives ^  200
Total Units  1600

* Credit may be granted by examination.
^ May also include additional neuroscience electives
** While students may register for multiple quarters of NSCI 29700 Reading and Research in Neuroscience, only one may be counted toward major requirements.

INDEPENDENT RESEARCH

By their third year, students majoring in neuroscience are strongly encouraged to participate in research with a faculty member. This can take many forms, including internships, fellowships, and research for elective credit. See also BS and Honors in Neuroscience. For more information on research opportunities, visit (https://neuroscience.uchicago.edu/research-opportunities/) the undergraduate major website. (https://neuroscience.uchicago.edu/research-opportunities/)

BACHELOR OF SCIENCE DEGREE IN NEUROSCIENCE

Students can earn a bachelor of science in neuroscience (https://neuroscience.uchicago.edu/bachelor-science/) by completing the neuroscience required courses (900 units), 200 units of neuroscience-related elective courses, and 800 units of neuroscience elective courses, which must include one to three quarters of faculty-supervised NSCI 29100 Neuroscience Thesis Research. At the completion of their thesis research, students will present a poster and write a thesis. BS Students will be required to attend a minimum of two informational meetings during their fourth year before the submission of the thesis and poster. Note that Neuroscience Thesis Research (NSCI 29100) must be completed before the final quarter of the student's graduating year to allow sufficient time to prepare the written document and presentation. The additional neuroscience electives and thesis work require approval by the office of the director of undergraduate studies and the thesis adviser.

MAJOR: BACHELOR OF SCIENCE REQUIRED COURSES

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>NSCI 20101</td>
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<td>NSCI 20111</td>
<td>Cellular Neurophysiology</td>
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<td>NSCI 20130</td>
<td>Systems Neuroscience</td>
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<td>NSCI 20140</td>
<td>Sensation and Perception</td>
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<td>PHYS 12100-12200</td>
<td>General Physics I-II (or higher)</td>
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<tr>
<td>NSCI 20100</td>
<td>Neuroscience Laboratory</td>
<td>100</td>
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<tr>
<td>STAT 22000</td>
<td>Statistical Methods and Applications</td>
<td>100</td>
</tr>
<tr>
<td>CHEM 11300</td>
<td>Comprehensive General Chemistry III</td>
<td>100</td>
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<tr>
<td>or CHEM 12300</td>
<td>Honors General Chemistry III</td>
<td>100</td>
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</tbody>
</table>

At least eight Neuroscience electives **  800
No more than two Neuroscience-related electives ^  200
Total Units  1900

* Credit may be granted by examination.
** Must include one to three courses of NSCI 29100, NSCI 29101, NSCI 29102 Neuroscience Thesis Research or NSCI 29200, NSCI 29201, NSCI 29202 Neuroscience Honors Thesis Research
^ May also include additional neuroscience electives

HONORS IN NEUROSCIENCE

The BS with honors is an extension of the BS and is targeted toward students with a particularly strong interest in research. To obtain honors in neuroscience, students must have a minimum GPA of 3.5 in the major and a cumulative GPA of 3.25 to apply for the honors program. This level of achievement must be maintained throughout the academic year corresponding to the thesis submission. Applications for the honors program will be reviewed by a faculty examining committee. A faculty sponsor (https://neuroscience.uchicago.edu/faculty/) and approved topic must be identified before applying.

The honors program begins with 10 weeks of full-time research during the Summer Quarter between the student's third and fourth years. This continues with research as a graded elective research course (NSCI 29200, NSCI 29201, and NSCI 29202 Neuroscience Honors Thesis Research) during Autumn, Winter, and Spring Quarters of the fourth year, which culminates in a public talk and a written thesis. A stipend is provided during the summer research component of the honors program. As part of the research course work, honors students participate in regular group meetings in which they share their research with each other and supervising faculty, and receive guidance on formulating testable hypotheses, experimental design, report writing, and oral
presentations. They also receive training in the responsible conduct of research. Experimental research may not be credited toward honors in more than one major.

MINOR IN NEUROSCIENCE
The minor in neuroscience is intended to provide neuroscientific literacy for students whose primary interest lies in other fields. The minor requires that students meet the general education requirements in the biological and physical sciences plus MATH 13100-13200 Elementary Functions and Calculus I-II. Students are strongly encouraged to take STAT 22000 Statistical Methods and Applications (or higher) and NSCI 20140 Sensation and Perception for two of the four electives, if these courses have not already been taken to fulfill major requirements. No course in the minor can count toward the student’s major(s) or other minors, nor can it count toward general education requirements.

REQUIRED COURSES FOR THE MINOR IN NEUROSCIENCE
NSCI 20101 Foundations of Neuroscience 100
NSCI 20111 Cellular Neurophysiology 100
NSCI 20130 Systems Neuroscience 100
Four Neuroscience electives* 400
Total Units 700
* Neuroscience-related electives do not count.

MINOR IN COMPUTATIONAL NEUROSCIENCE
This minor is intended to provide literacy in computational neuroscience and is for students who are majoring in biological sciences and are interested in mathematical approaches, or for students who are majoring in the physical sciences and are interested in neuroscience. Students electing this minor must have completed, or placed out of, the equivalent of a year of collegiate-level calculus and must have completed the general education requirement for the neuroscience major. No course in the minor can count toward the student’s major(s) or other minors, nor can it count toward general education requirements.

Summary of Requirements for the Minor in Computational Neuroscience
BIOS 26210-26211 Mathematical Methods for Biological Sciences I-II 200
NSCI 20101 Foundations of Neuroscience 100
NSCI 23700 Methods in Computational Neuroscience 100
NSCI 24000 Modeling and Signal Analysis for Neuroscientists 100
Total Units 500

DOUBLE MAJORS
Students interested in double majoring in neuroscience and (1) biological sciences or (2) psychology must meet with the NSCI advisors to discuss restrictions on double counting courses. Please email neuromajor@uchicago.edu to receive information on restrictions for double counting courses.

SAMPLE PROGRAM
Neuroscience is a unique and broad field that allows students to plan their undergraduate career in a variety of ways. Below is a sample plan for when to take NSCI required courses:

Year 1: Biological Sciences, Chemistry and Mathematics General Education Courses
Year 2: NSCI 20101, NSCI 20111, NSCI 20130, PHYS 12100-12200 General Physics I-II
Year 3: NSCI 20100 and/or NSCI 20140, Electives, Research Opportunities, STAT 22000
Year 4: NSCI 20100 and/or NSCI 20140, Electives, Research Opportunities, STAT 22000

ELECTIVES
NEUROSCIENCE ELECTIVES (no fewer than five)
NSCI 20500 Neuroanatomy 100
NSCI 20510 Evolution and the Nervous System 100
NSCI 21000 Social Neuroscience 100
NSCI 21015 Biological Psychology 100
NSCI 21100 Photons to Consciousness: Cellular and Integrative Brain Functions 100
NSCI 21300 Animal Models in the Study of Cognition 100
NSCI 21400 Biological Clocks and Behavior 100
NSCI 21600 Attention and Working Memory in the Mind and Brain 100
NSCI 21800 Perspectives in Drug Abuse 100
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>NSCI 21900</td>
<td>Neuropharmacology</td>
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<tr>
<td>NSCI 22010</td>
<td>Neuroscience of Consciousness</td>
<td>100</td>
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<tr>
<td>NSCI 22015</td>
<td>Cognitive Psychology</td>
<td>100</td>
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<tr>
<td>NSCI 22110</td>
<td>Molecular and Translational Neuroscience</td>
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<tr>
<td>NSCI 22300</td>
<td>Molecular Principles of Nervous System Development</td>
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<tr>
<td>NSCI 22355</td>
<td>Observing Proteins in Action: How to Design and Build Your Own Instruments</td>
<td>100</td>
</tr>
<tr>
<td>NSCI 22400</td>
<td>Neuroscience of Seeing</td>
<td>100</td>
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<tr>
<td>NSCI 22450</td>
<td>Conquest of Pain</td>
<td>100</td>
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<tr>
<td>NSCI 22500</td>
<td>Neuroscience of Communication</td>
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</tr>
<tr>
<td>NSCI 22535</td>
<td>The Psychology and Neurobiology of Stress</td>
<td>100</td>
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<tr>
<td>NSCI 23400</td>
<td>Synaptic Physiology</td>
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<tr>
<td>NSCI 23500</td>
<td>Survey of Systems Neuroscience</td>
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<tr>
<td>NSCI 23600</td>
<td>Computational Approaches to Cognitive Neuroscience</td>
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<tr>
<td>NSCI 23700</td>
<td>Methods in Computational Neuroscience</td>
<td>100</td>
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<tr>
<td>NSCI 23810</td>
<td>Neurons and Glia: A cellular and molecular perspective</td>
<td>100</td>
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<tr>
<td>NSCI 24000</td>
<td>Modeling and Signal Analysis for Neuroscientists</td>
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<tr>
<td>NSCI 29100</td>
<td>Neuroscience Thesis Research</td>
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<tr>
<td>NSCI 29101</td>
<td>Neuroscience Thesis Research</td>
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<tr>
<td>NSCI 29102</td>
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<td>NSCI 29200</td>
<td>Neuroscience Honors Thesis Research</td>
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<td>NSCI 29201</td>
<td>Neuroscience Honors Thesis Research</td>
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</tr>
<tr>
<td>NSCI 29202</td>
<td>Neuroscience Honors Thesis Research</td>
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<tr>
<td>NSCI 29700</td>
<td>Reading and Research in Neuroscience</td>
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<tr>
<td>CMSC 25025</td>
<td>Machine Learning and Large-Scale Data Analysis</td>
<td>100</td>
</tr>
<tr>
<td>CMSC 25400</td>
<td>Machine Learning</td>
<td>100</td>
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</tbody>
</table>

* Non-NSCI courses listed here require prior approval from the department. Inquiries and petitions may be submitted to neuromajor@uchicago.edu

**RELATED ELECTIVES (no more than two)**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>BIOS 20172</td>
<td>Mathematical Modeling for Pre-Med Students</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20173</td>
<td>Perspectives of Human Physiology</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20175</td>
<td>Biochemistry and Metabolism</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20187</td>
<td>Fundamentals of Genetics</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20188</td>
<td>Fundamentals of Physiology</td>
<td>100</td>
</tr>
<tr>
<td>or BIOS 20191</td>
<td>Integrative Physiology</td>
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<tr>
<td>BIOS 20189</td>
<td>Fundamentals of Developmental Biology</td>
<td>100</td>
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<tr>
<td>or BIOS 20190</td>
<td>Principles of Developmental Biology</td>
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<tr>
<td>BIOS 20200</td>
<td>Introduction to Biochemistry</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20234</td>
<td>Molecular Biology of the Cell</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20235</td>
<td>Biological Systems</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20236</td>
<td>Biological Dynamics</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20242</td>
<td>Principles of Physiology</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 26210</td>
<td>Mathematical Methods for Biological Sciences I</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 26211</td>
<td>Mathematical Methods for Biological Sciences II</td>
<td>100</td>
</tr>
<tr>
<td>CMSC 12100-12200</td>
<td>Computer Science with Applications I-II</td>
<td>200</td>
</tr>
<tr>
<td>CMSC 15100-15200</td>
<td>Introduction to Computer Science I-II</td>
<td>200</td>
</tr>
<tr>
<td>CMSC 15400</td>
<td>Introduction to Computer Systems</td>
<td>100</td>
</tr>
<tr>
<td>CMSC 16100-16200</td>
<td>Honors Introduction to Computer Science I-II</td>
<td>200</td>
</tr>
<tr>
<td>CMSC 25050</td>
<td>Computer Vision</td>
<td>100</td>
</tr>
<tr>
<td>CMSC 25300</td>
<td>Mathematical Foundations of Machine Learning</td>
<td>100</td>
</tr>
<tr>
<td>LING 27010</td>
<td>Psycholinguistics</td>
<td>100</td>
</tr>
<tr>
<td>MATH 23500</td>
<td>Markov Chains, Martingales, and Brownian Motion</td>
<td>100</td>
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<tr>
<td>PHYS 12300</td>
<td>General Physics III</td>
<td>100</td>
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</tbody>
</table>
or PHYS 13300 Waves, Optics, and Heat
STAT 32940 Multivariate Data Analysis via Matrix Decompositions 100

GENERAL EDUCATION TABLE

GENERAL EDUCATION

One of the following BIOS sequences:*

BIOS 20186 Fundamentals of Cell and Molecular Biology †

Plus one of the following:
BIOS 20153 Fundamentals of Ecology and Evolutionary Biology
BIOS 20151 Introduction to Quantitative Modeling in Biology (Basic)
BIOS 20152 Introduction to Quantitative Modeling in Biology (Advanced)
BIOS 20187 Fundamentals of Genetics
BIOS 20188 Fundamentals of Physiology

OR

BIOS 20170 Microbial and Human Cell Biology
& BIOS 20171 and Human Genetics and Developmental Biology *

OR

BIOS 20234-20235-20236 Molecular Biology of the Cell; Biological Systems; Biological Dynamics **

One of the following two-course MATH sequences:

MATH 13100-13200 Elementary Functions and Calculus I-II
MATH 15100-15200 Calculus I-II *
MATH 16100-16200 Honors Calculus I-II

One of the following two-course CHEM sequences:

CHEM 10100 & CHEM 10200 Introductory General Chemistry I
CHEM 11100-11200 Comprehensive General Chemistry I-II
CHEM 12100 & CHEM 12200 Honors General Chemistry I

Total Units 600

† The neuroscience major general education requirement in the biological sciences can be fulfilled by courses in the Biological Sciences Fundamentals Sequences (BIOS 20186 to 20190) without the Biological Sciences prerequisites (BIOS 20153-20151/20152) unless a student pursues a double major in Biological Sciences. However, all students in the sequence will be expected to possess the mathematical modeling competencies and basic coding in R covered in BIOS 20151/BIOS 20152 and BIOS 20153.

* Credit may be granted by examination.

# BIOS 20171 must be taken concurrently with BIOS 20172.

** Students with a score of 4 or 5 on the Advanced Placement Biology exam may use their AP credit to meet the general education requirement in the biological sciences if the first three quarters of the Advanced Biology sequence are completed.

NEUROSCIENCE COURSES

NSCI 20100. Neuroscience Laboratory. 100 Units.
This course has three components in series, representing (1) molecular neuroscience, (2) cellular electrophysiology, and (3) computation and psychophysics. The course meets one afternoon each week for four hours of laboratory time, including a didactic introduction. Students will be graded on their laboratory reports.
Instructor(s): J. Maunsell; E. Heckscher; M. McNulty Terms Offered: Winter
Prerequisite(s): NSCI 20111. Must be a Neuroscience Major

NSCI 20101. Foundations of Neuroscience. 100 Units.
This course is an introduction to the broad field of neuroscience. This is a lecture-based course that aims to introduce undergraduate students to concepts and principles that explain how the nervous system is built and how it functions. Examples of thematic areas covered in lectures include: (a) cellular anatomy of the nervous system, (b) development and evolution of the nervous system, (c) sensory systems, (d) motor systems, (e) cognition and behavior.
Instructor(s): D. Freedman, P. Kratsios Terms Offered: Autumn
Equivalent Course(s): PSYC 24450, BIOS 24101
NSCI 20111. Cellular Neurophysiology. 100 Units.
This course describes the cellular and subcellular properties of neurons, including passive and active electrophysiological properties, and their synaptic interactions. Readings are assigned from a general neuroscience textbook.
Instructor(s): M. Sheffield, W. Wei Terms Offered: Winter
Prerequisite(s): At least one quarter of Biological Sciences instruction, AND MATH 13100, or MATH 15100, or MATH 16100. Or consent of instructor
Equivalent Course(s): BIOS 24111

NSCI 20130. Systems Neuroscience. 100 Units.
This course covers vertebrate and invertebrate systems neuroscience with a focus on the anatomy, physiology, and development of sensory and motor control systems. The neural bases of form and motion perception, locomotion, memory, and other forms of neural plasticity are examined in detail. We also discuss clinical aspects of neurological disorders.
Instructor(s): J. MacLean Terms Offered: Spring
Prerequisite(s): NSCI 20101, NSCI 20111 or consent of instructors
Equivalent Course(s): PSYC 24010, BIOS 24130

NSCI 20140. Sensation and Perception. 100 Units.
What we see and hear depends on energy that enters the eyes and ears, but what we actually experience—perception—follows from human neural responses. This course focuses on visual and auditory phenomena, including basic percepts (for example, acuity, brightness, color, loudness, pitch) and also more complex percepts such as movement and object recognition. Biological underpinnings of perception are an integral part of the course.
Instructor(s): K. Ledoux Terms Offered: Winter
Equivalent Course(s): PSYC 20700

NSCI 20500. Neuroanatomy. 100 Units.
This course is part of the Study Abroad Neuroscience program in Paris, France. In this course, we will use an understanding of development in order to understand the neuroanatomy of the adult vertebrate nervous system. This understanding will be solidified by dissections of mammalian, fish and bird brains as well as a trip to see myriad brains at the Muséum national d’histoire naturelle. In the second half of the course, neuroanatomical adaptations specific to particular animals will be examined in the context of critical environmental and ecological factors. Examples include postural control in sloths, vision in marine animals and raptors, and the control of muscles of facial expression across mammalian species.
Instructor(s): P. Mason Terms Offered: TBD. Paris Study Abroad Neuroscience Program
Prerequisite(s): Enrollment into the Paris Study Abroad Program

NSCI 20510. Evolution and the Nervous System. 100 Units.
Evolutionary neuroscience has traditionally focused on the neural bases of animal behavior (neuroethology) and employed the methods of comparative anatomy, cellular neurophysiology and behavioral neuropsychology. This course will approach neuroethology from a modern evolutionary perspective, one that integrates findings from genomics, molecular developmental biology and paleontology with insights from neuroethology. Our exploration will include the controversies over the evolutionary origin of neurons and centralized brains, the independent solutions across taxa to processing ecologically important sensory information, and recent insights into the evolution of the neocortex.
Instructor(s): C. Ragsdale Terms Offered: Spring

NSCI 21000. Social Neuroscience. 100 Units.
Social species, by definition, create emergent organizations beyond the individual - structures ranging from dyads and families to groups and cultures. Social neuroscience is the interdisciplinary field devoted to the study of neural, hormonal, cellular, and genetic mechanisms, and to the study of the associations and influences between social and biological levels of organization. The course provides a valuable interdisciplinary framework for students in psychology, neuroscience, behavioral economics, and comparative human development. Many aspects of social cognition will be examined, including but not limited to attachment, attraction, altruism, contagion, cooperation, competition, dominance, empathy, isolation, morality, and social decision-making.
Instructor(s): J. Decety Terms Offered: Autumn
Equivalent Course(s): ECON 21830, BIOS 24137, CHDV 22350, HLTH 22350, PSYC 22350

NSCI 21015. Biological Psychology. 100 Units.
What are the relations between mind and brain? How do brains regulate mental, behavioral, and hormonal processes; and how do these influence brain organization and activity? This course introduces the anatomy, physiology, and chemistry of the brain; their changes in response to the experiential and sociocultural environment; and their relation to perception, attention, behavioral action, motivation, and emotion.
Instructor(s): S. London, L. Kay Terms Offered: Winter
Prerequisite(s): Some background in biology and psychology.
Note(s): This course does not meet requirements for the Biological Sciences Major.
Equivalent Course(s): BIOS 29300, PSYC 20300, CHDV 20300
NSCI 21100. Photons to Consciousness: Cellular and Integrative Brain Functions. 100 Units.
This course uses the visual system as a model to explore how the brain works. We begin by considering the physical properties of light. We then proceed to consider the mechanism of sensory transduction, cellular mechanisms of neuron to neuron communication, the operation of small neural networks, strategies of signal detection in neuron networks, and the hierarchical organization of cortical function. We conclude with visually guided behavior and consciousness.
Instructor(s): E. Schwartz Terms Offered: Winter
Prerequisite(s): NSCI 20111
Equivalent Course(s): BIOS 24136

NSCI 21300. Animal Models in the Study of Cognition. 100 Units.
This course will be a combination of lecture and seminar. In the first half of the course we will read and discuss seminal literature in the study of cognitive questions using animal models (primarily rodents). In the second half of the course we will learn about study design and design two different types of studies in smaller groups. Evaluation will be through short weekly papers, class discussion and a final paper.
Instructor(s): L. Kay Terms Offered: Spring
Prerequisite(s): Completion of PSYC 20300 Biological Psychology or equivalent background in neuroscience and/or biological psychology.
Equivalent Course(s): PSYC 28910

NSCI 21400. Biological Clocks and Behavior. 100 Units.
This course will address physiological and molecular biological aspects of circadian and seasonal rhythms in biology and behavior. The course will primarily emphasize biological and molecular mechanisms of CNS function, and will be taught at a molecular level of analysis from the beginning of the quarter. Those students without a strong biology background are unlikely to resonate with the course material.
Instructor(s): B. Prendergast Terms Offered: Spring
Prerequisite(s): A quality grade in PSYC 20300 Introduction to Biological Psychology. Additional biology courses are desirable. Completion of Core biology will not suffice as a prerequisite.
Equivalent Course(s): HLTH 21750, PSYC 21750, BIOS 24248

NSCI 21600. Attention and Working Memory in the Mind and Brain. 100 Units.
This course will provide a broad overview of current work in psychology and neuroscience related to attention and working memory. We will discuss evidence for sharp capacity limits in an individual's ability to actively monitor and maintain information in an "online" mental state. Readings will be primarily based on original source articles from peer-reviewed journals, with a focus on behavioral and neural approaches for measuring and understanding these basic cognitive processes.
Instructor(s): E. Awh, E. Vogel Terms Offered: Winter
Prerequisite(s): PQ: NSCI 20110 (Fundamental Neuroscience) is required for Neuroscience majors only.
Equivalent Course(s): PSYC 23820

NSCI 21800. Perspectives in Drug Abuse. 100 Units.
It is a broad overview course about drug abuse, that is appropriate for graduate students as well as undergraduates. It includes lectures on epidemiology, genetics, neurobiology, experimental methods, policy and treatment, as well as lectures on several specific drug classes. Lectures are by Dr. de Wit and by other invited faculty members, and students are required to present and discuss recent published papers during classes.
Equivalent Course(s): NURB 32900, BIOS 24135

NSCI 21900. Neuropharmacology. 100 Units.
This is a one quarter course that will explore neuronal pharmacology. Both the autonomic and central nervous system will be examined. The course has a clinical orientation. The course starts with an overview of the nervous system. In this section, we will explore the cellular aspects of neurons and their basic membrane and electrophysiological properties as well cellular and molecular aspects of synaptic transmission. The majority of the course will explore different neurotransmitter systems and drugs that interact with these systems.
Instructor(s): A. Fox Terms Offered: Spring
Prerequisite(s): NSCI 20101, NSCI 20111
Equivalent Course(s): BIOS 24140

NSCI 22010. Neuroscience of Consciousness. 100 Units.
Consciousness has been considered one of great mysteries in human existence. In this course, we will begin by trying to define the term and consider the so-called "hard" and "easy" problems of consciousness. A brief history of ancient civilizations' views on mental experience will be discussed. We will then go over basic neuroscientific concepts and methods that are being used to study the neural correlates of consciousness. We will explore different states of consciousness and disruptions of consciousness in human patients. We will touch on the related problems of intentionality and free will. Finally, we will discuss prevailing scientific theories of consciousness.
Instructor(s): Hatsopoulos, Nicholas Terms Offered: Autumn
Prerequisite(s): NSCI 20101
**NSCI 22015. Cognitive Psychology. 100 Units.**
Viewing the brain globally as an information processing or computational system has revolutionized the study and understanding of intelligence. This course introduces the theory, methods, and empirical results that underlie this approach to psychology. Topics include categorization, attention, memory, knowledge, language, and thought.
Instructor(s): M. Rosenberg Terms Offered: Spring
Equivalent Course(s): PSYC 20400, EDSO 20400

**NSCI 22110. Molecular and Translational Neuroscience. 100 Units.**
This lecture/seminar course explores the application of modern cellular and molecular techniques to clarify basic mechanisms that underlie neural development, synaptic transmission, protein trafficking, and circuit function and the dysfunction of these fundamental processes that results in neurodevelopmental disorders and age-associated neurological diseases.
Instructor(s): S. Sisodia Terms Offered: Winter
Prerequisite(s): Neuroscience Fundamental Series (NSCI 20101-20130)
Equivalent Course(s): BIOS 24143

**NSCI 22300. Molecular Principles of Nervous System Development. 100 Units.**
This elective course provides an overview of the fundamental questions in developmental neurobiology. It is based on primary research papers and highlights key discoveries in vertebrate and invertebrate animals that advanced our understanding of nervous system development. Topics covered, among others, will include neural stem cells, neuronal specification and terminal differentiation, and circuit assembly. Dogmas and current debates in developmental neurobiology will be discussed, aiming to promote critical thinking about the field. This advanced-level course is open to upper level undergraduate and graduate students and combines lectures, student presentations, and discussion sections. Neuroscience major undergrads need to have completed the Fundamentals of Neuroscience sequence.
Instructor(s): E. Grove, P. Kratsios Terms Offered: Spring
Prerequisite(s): For undergrads: NSCI 20110, 20120, 20130 and a basic understanding of Genetics, or ‘BIOS 20187’ (Fundamentals of Genetics) is recommended, but not required.
Equivalent Course(s): NURB 32300, DVBI 32300, CPNS 32300

**NSCI 22355. Observing Proteins in Action: How to Design and Build Your Own Instruments. 100 Units.**
New insights into cell function are now possible using technologies that resolve single molecules. However, as devices become more complicated, we are often faced with three questions: What is it that our instruments actually measure; how can we change the instrument to see a new behavior; and, how do we analyze the data to get the greatest insight? We will learn how to answer these questions by designing, building, and using our own electrical and optical instruments, making measurements, and then analyzing the results. Membrane proteins play an essential role in the behavior of all cells. We will study membrane protein channels in synthetic membranes, host cells, and giant axons from squid collected in the waters surrounding the MBL. The movement of electrical charge produced by conformational changes will be correlated with both the current passing thru single channels and structural information obtained from light and electron microscopy. The course will proceed from simple measurements to student-designed projects.
Note(s): This course will be given at Marine Biological Laboratory, Woods Hole, Massachusetts
Equivalent Course(s): BIOS 27721

**NSCI 22400. Neuroscience of Seeing. 100 Units.**
This course focuses on the neural basis of vision, in the context of the following two questions: 1. How does the brain transform visual stimuli into neuronal responses? 2. How does the brain use visual information to guide behavior? The course covers signal transformation throughout the visual pathway, from retina to thalamus to cortex, and includes biophysical, anatomical, and computational studies of the visual system, psychophysics, and quantitative models of visual processing. This course is designed as an advanced neuroscience course for undergraduate and graduate students. The students are expected to have a general background in neurophysiology and neuroanatomy.
Instructor(s): W. Wei, J. Maunsell, M. Sherman, S. Shevell Terms Offered: Autumn
Prerequisite(s): NSCI 20111 or BIOS 24110 or consent of instructor
Equivalent Course(s): PSYC 34133, PSYC 24133, NURB 34133, BIOS 24133, CPNS 34133

**NSCI 22415. Introduction to Learning and Memory. 100 Units.**
This course examines basic questions in learning and memory. We discuss the historical separation and division of these two areas as well as the paradigmatic differences in studying learning and memory. We also discuss basic research methods for investigating learning and memory and survey established and recent research findings, as well as consider several different kinds of models and theories of learning and memory. Topics include skill acquisition, perceptual learning, statistical learning, working memory, implicit memory, semantic vs. episodic memory, and memory disorders.
Instructor(s): A. Bakkour Terms Offered: Winter
Equivalent Course(s): EDSO 23800, PSYC 23800
NSCI 22450. Conquest of Pain. 100 Units.
This course examines the biology of pain and the mechanisms by which anesthetics alter the perception of pain. The approach is to examine the anatomy of pain pathways both centrally and peripherally, and to define electrophysiological, biophysical, and biochemical explanations underlying the action of general and local anesthetics. We discuss the role of opiates and enkephalins. Central theories of anesthesia, including the relevance of sleep proteins, are also examined.
Instructor(s): K. Ruskin Terms Offered: Winter
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence, CHEM 2200-22100-22200 or BIOS 20200 and prior course in neurobiology or physiology is recommended.
Equivalent Course(s): BIOS 24217

NSCI 22535. The Psychology and Neurobiology of Stress. 100 Units.
This course explores the topic of stress and its influence on behavior and neurobiology. Specifically, the course will discuss how factors such as age, gender, and social context interact to influence how we respond to stressors both physiologically and behaviorally. The course will also explore how stress influences mental and physical health.
Instructor(s): G. Norman Terms Offered: Autumn
Note(s): This course does not meet the requirements for the Biological Sciences Major.
Equivalent Course(s): CHDV 25750, PSYC 25750, BIOS 29271

NSCI 23400. Synaptic Physiology. 100 Units.
This course covers the basic principles of synaptic transmission and plasticity using a combination of lecture and discussion of primary literature. Lecture topics cover membrane electrical phenomena that lead to release of neurotransmitter presynaptically, as well as the physiological consequences of postsynaptic receptor activation. Paper discussions, which make up ~ 2/3 of the course, are centered on two major topics: 1) The molecular machinery controlling synaptic vesicle exocytosis and recycling, and 2) Synaptic plasticity covering LTP, LTD, Metaplasticity, Spike-timing dependent plasticity and Homeostatic plasticity. There is significant emphasis on the connections between the various forms of synaptic modification and behavior.
Instructor(s): D. McGehee Terms Offered: Winter
Prerequisite(s): Upper undergrads by consent of instructor
Equivalent Course(s): NURB 32400

NSCI 23500. Survey of Systems Neuroscience. 100 Units.
This lab-centered course teaches students the fundamental principles of vertebrate nervous system organization. Students learn the major structures and the basic circuitry of the brain, spinal cord and peripheral nervous system. Somatic, visual, auditory, vestibular and olfactory sensory systems are presented in particular depth. A highlight of this course is that students become practiced at recognizing the nuclear organization and cellular architecture of many regions of brain in rodents, cats and primates.
Instructor(s): S. Bensmaia Terms Offered: Autumn
Prerequisite(s): NSCI 20130. For Biological Sciences majors: Three quarters of a Biological Sciences fundamentals sequence
Equivalent Course(s): CPNS 30116, NURB 31600, ORGB 32500, BIOS 24208

NSCI 23600. Computational Approaches to Cognitive Neuroscience. 100 Units.
This course is concerned with the relationship of the nervous system to higher order behaviors (e.g., perception, object recognition, action, attention, learning, memory, and decision making). Psychophysical, functional imaging, and electrophysiological methods are introduced. Mathematical and statistical methods (e.g. neural networks and algorithms for studying neural encoding in individual neurons and decoding in populations of neurons) are discussed. Weekly lab sections allow students to program cognitive neuroscientific experiments and simulations.
Instructor(s): N. Hatsopoulos Terms Offered: Winter
Prerequisite(s): For Neuroscience Majors: NSCI 20110, NSCI 20130, BIOS 26210, and knowledge using Matlab, or consent of instructor.
Equivalent Course(s): ORGB 34650, CPNS 33200, BIOS 24232, PSYC 34410

NSCI 23700. Methods in Computational Neuroscience. 100 Units.
Topics include (but are not limited to): relating neural data to behavior, Signal Detection theory, models of vision and artificial neural networks, Information Theory, Generalized Linear Models, dimensionality reduction, classification, and clustering.
Instructor(s): S. Bensmaia, D. Freedman, M. Kaufman Terms Offered: Winter, L.
Prerequisite(s): For Neuroscience Majors: NSCI 20130, BIOS 26210 and BIOS 26211 which must be taken concurrently, or consent of instructor.
Equivalent Course(s): PSYC 24231, CPNS 34231, BIOS 24231

NSCI 23810. Neurons and Glia: A cellular and molecular perspective. 100 Units.
This course will be an interactive, in-depth analysis of the cell biology of neurons and glia. We will learn and discuss the latest techniques used, for example, to study the structure and function of neuronal proteins. In this way we will illuminate the central concepts that define our understanding of the cell and molecular biology of neurons and glia. The course will consist of lectures and critical reading of contemporary literature.
Instructor(s): R. Carrillo; W. Green Terms Offered: Autumn
Prerequisite(s): Neuroscience Majors: NSCI 20101-20130 (Fundamental Neuroscience Sequence)

NSCI 24000. Modeling and Signal Analysis for Neuroscientists. 100 Units.
The course provides an introduction into signal analysis and modeling for neuroscientists. We cover linear and nonlinear techniques and model both single neurons and neuronal networks. The goal is to provide students with the mathematical background to understand the literature in this field, the principles of analysis and simulation software, and allow them to construct their own tools. Several of the 90-minute lectures include demonstrations and/or exercises in Matlab.
Instructor(s): W. van Drongelen Terms Offered: Spring.
Prerequisite(s): Undergraduates: Biology Major - BIOS 26210 and 26211, or consent of instructor. Neuroscience Major - NSCI 20130, BIOS 26210 and 26211, or consent of instructor.
Equivalent Course(s): BIOS 24408, CPNS 32111

NSCI 29100. Neuroscience Thesis Research. 100 Units.
Scholar or Research Thesis.
Instructor(s): Staff Terms Offered: Autumn, Spring, Summer, Winter
Prerequisite(s): By consent of instructor and approval of major director.

NSCI 29101. Neuroscience Thesis Research. 100 Units.
Scholar or Research Thesis.
Instructor(s): Staff Terms Offered: Autumn, Spring, Summer, Winter
Prerequisite(s): NSCI 29100, and consent of instructor, and approval of major director.

NSCI 29102. Neuroscience Thesis Research. 100 Units.
Scholar or Research Thesis.
Instructor(s): Staff Terms Offered: Autumn, Spring, Summer, Winter
Prerequisite(s): NSCI 29101, and consent of instructor, and approval of major director.

NSCI 29200. Neuroscience Honors Thesis Research. 100 Units.
Research Thesis and Seminar.
Instructor(s): Staff Terms Offered: Autumn, Spring, Summer, Winter
Prerequisite(s): NSCI 29201, and consent of instructor, and approval of major director. Open to Neuroscience majors who are candidates for honors in Neuroscience.

NSCI 29201. Neuroscience Honors Thesis Research. 100 Units.
NSCI 29200, and consent of instructor, and approval of major director. Open to Neuroscience majors who are candidates for honors in Neuroscience.
Instructor(s): Staff Terms Offered: Autumn, Spring, Summer, Winter
Prerequisite(s): NSCI 29200, and consent of instructor, and approval of major director. Open to Neuroscience majors who are candidates for honors in Neuroscience.

NSCI 29202. Neuroscience Honors Thesis Research. 100 Units.
Research Thesis and Seminar.
Instructor(s): Staff Terms Offered: Autumn, Spring, Summer, Winter
Prerequisite(s): NSCI 29201, and consent of instructor, and approval of major director. Open to Neuroscience majors who are candidates for honors in Neuroscience.

NSCI 29700. Reading and Research in Neuroscience. 100 Units.
BA Students can do reading and research in an area of neuroscience under the guidance of a faculty member. A written report is required at the end of the quarter.
Instructor(s): Staff Terms Offered: Autumn, Spring, Summer, Winter
Prerequisite(s): By consent of instructor and approval of NSCI Undergraduate Director.
Note(s): Must be a Bachelor of Arts student. Students are required to submit the College Reading & Research form.