

# Neuroscience

Neuroscience is the scientific study of the nervous system, including its development, functions, and pathologies. It is an interdisciplinary field that encompasses neurobiology (anatomy, physiology, biochemistry, molecular biology, genetics), elements of psychology and cognitive science, and mathematical and physical principles involved in modeling neural systems.

The Department of Neuroscience offers an undergraduate concentration leading to the Sc.B. degree and a graduate program leading to the Ph.D. degree. These programs include courses offered by the department and by several allied departments. The Department of Neuroscience has modern facilities for conducting research in a broad range of areas from molecular mechanisms to behavior and undergraduate students are encouraged to pursue research projects.

For additional information, please visit: <http://neuroscience.brown.edu/>

## Neuroscience Concentration Requirements

Neuroscience is an interdisciplinary field that seeks to understand the functions and diseases of the nervous system. It draws on knowledge from neurobiology as well as elements of psychology and cognitive science, and mathematical and physical principles involved in modeling neural systems. Through the Neuroscience concentration, students develop foundational knowledge through courses in biology, chemistry, and mathematics as well as three core courses in neuroscience. They are also required to develop facility with research methodologies (through courses in statistics and laboratory methods) before moving into specific topics in the field (e.g., visual physiology, neurochemistry and behavior, and synaptic transmission and plasticity). Members of the Neuroscience faculty are affiliated with the Carney Institute for Brain Science, a multidisciplinary program that promotes collaborative research about the brain. Prospective concentrators should contact [neurowundergrad@brown.edu](mailto:neurowundergrad@brown.edu) in order to have a faculty advisor assigned to them.

### Standard program for the Sc.B. degree

The concentration combines a general science background with a number of specific courses devoted to the cellular, molecular, and integrative functions of the nervous system. The concentration allows considerable flexibility for students to tailor a program to their individual interests. Elective courses focus on a variety of areas including molecular mechanisms, cellular function, sensory and motor systems, neuropharmacology, learning and memory, animal behavior, cognitive function, bioengineering, theoretical neuroscience and computer modeling.

You may find this following form useful for mapping out your courses, be sure to use it before meeting with your concentration advisor for the first time: [link to course plan worksheet PDF ([http://bulletin.brown.edu/biologyandmedicine/neuroscience/NeuroCoursePlanWorksheet\\_Fillable.pdf](http://bulletin.brown.edu/biologyandmedicine/neuroscience/NeuroCoursePlanWorksheet_Fillable.pdf))]

The concentration in neuroscience leads to an Sc.B. degree. The following courses, or their equivalent, are required for the degree. Keep in mind that there are multiple ways to fulfil the various requirements and your concentration advisor can help you go through your options and optimize your course of study:

#### Background Courses:

MATH 0090	Single Variable Calculus, Part I ((only needed as a prerequisite for MATH 10))	1
MATH 0100	Single Variable Calculus, Part II ((or equivalent))	1
PHYS 0030	Basic Physics A (Mechanics *see NOTE)	1
PHYS 0040	Basic Physics B ( Electromagnetism)	1
BIOL 0200	The Foundation of Living Systems ((or placement test))	1
CHEM 0330	Equilibrium, Rate, and Structure	1

CHEM 0350	Organic Chemistry I	1
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Note: ENGN 0030 may be used instead of PHYS 0030, but ENGN 0040 is NOT equivalent to PHYS 0040.

#### Core Concentration Courses:

NEUR 0010	The Brain: An Introduction to Neuroscience	1
NEUR 1020	Principles of Neurobiology	1
NEUR 1030	Neural Systems	1

#### One critical reading course

NEUR 1440	Mechanisms and Meaning of Neural Dynamics	1
NEUR 1510	Neurotechnology: Molecular Tools and Methods for Neurobiology	
NEUR 1530	Communication In the Brain: What We Know and How We Know It	
NEUR 1560	Developmental Neurobiology	
NEUR 1660	Neural Computation in Learning and Decision-Making	
NEUR 1970	Independent Study (*Two Semesters)	
BIOL 1100	Cell Physiology and Biophysics	
BIOL 1180	Comparative Animal Physiology	
BIOL 1190	Synaptic Transmission and Plasticity	
CLPS 1400	The Neural Bases of Cognition	
CLPS 1760	The Moral Brain	
PHP 1890	The Craving Mind	

1930/40 Topics in Neuroscience

NOTE: Critical reading courses are small discussion based courses, with around 20 students, with a focus on primary literature around a neuroscience related topic. Other courses not listed here could also fulfil this requirement, please check with your concentration advisor.

#### One statistics course

PHP 1501	Essentials of Data Analysis	1
PHP 1510	Principles of Biostatistics and Data Analysis	
PHP 2510	Principles of Biostatistics and Data Analysis	
APMA 0650	Essential Statistics	
APMA 1650	Statistical Inference I	
CLPS 0900	Statistical Methods	
SOC 1100	Introductory Statistics for Social Research	
BIOL 0495	Statistical Analysis of Biological Data	
EDUC 1230	Applied Statistics for Ed Research and Policy Analysis	

#### One lab methods course

NEUR 0680	Introduction to Computational Neuroscience	1
NEUR 1440	Mechanisms and Meaning of Neural Dynamics	
NEUR 1600	Experimental Neurobiology	
NEUR 1630	Big Data Neuroscience Ideas Lab	
NEUR 1640	Behavioral Neurogenetics Laboratory	
NEUR 1650	Structure of the Nervous System	
NEUR 1660	Neural Computation in Learning and Decision-Making	
NEUR 1670	Neuropharmacology and Synaptic Transmission	
NEUR 1680	Computational Neuroscience	
NEUR 1970	Independent Study	

\*Two Semesters of NEUR1970 can be used to fulfill one critical reading, lab, or elective requirement

CLPS 1190	Techniques in Physiological Psychology	
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CLPS 1194	Sleep and Chronobiology Research
CLPS 1490	Functional Magnetic Resonance Imaging: Theory and Practice
CLPS 1491	Neural Modeling Laboratory
CLPS 1492	Computational Cognitive Neuroscience
BIOL 0800	Principles of Physiology
BIOL 1880	Comparative Biology of the Vertebrates

#### Four electives related to neuroscience <sup>1</sup> 4

Four courses that will enhance your understanding of the field of neuroscience. While electives need not be from the neuroscience department, the following list are common courses taught by Neuroscience and other departments that are often used as electives. We encourage students to explore the broader course catalog and consult with their concentration advisor to explore the full range of electives, rather than limiting themselves to this list:

NEUR 0680	Introduction to Computational Neuroscience
NEUR 1040	Introduction to Neurogenetics
NEUR 1065	Biology of Hearing
NEUR 1440	Mechanisms and Meaning of Neural Dynamics
NEUR 1510	Neurotechnology: Molecular Tools and Methods for Neurobiology
NEUR 1530	Communication In the Brain: What We Know and How We Know It
NEUR 1540	Neurobiology of Learning and Memory
NEUR 1560	Developmental Neurobiology
NEUR 1600	Experimental Neurobiology
NEUR 1630	Big Data Neuroscience Ideas Lab
NEUR 1650	Structure of the Nervous System
NEUR 1660	Neural Computation in Learning and Decision-Making
NEUR 1670	Neuropharmacology and Synaptic Transmission
NEUR 1740	The Diseased Brain: Mechanisms of Neurological and Psychiatric Disorders
NEUR 1970	Independent Study

\*Two Semesters of NEUR1970 can be used to fulfill one critical reading, lab, or elective requirement

NEUR 2110	Statistical Neuroscience
All NEUR 1930/1940 Seminar Course	
CLPS 0120	Introduction to Sleep
CLPS 0400	Cognitive Neuroscience
CLPS 1150	Memory and the Brain
CLPS 1180B	Animal Languages
CLPS 1193	Laboratory in Genes and Behavior
CLPS 1291	Computational Methods for Mind, Brain and Behavior
CLPS 1400	The Neural Bases of Cognition
CLPS 1420	Cognitive Neuropsychology
CLPS 1478	Translational Models of Neuropsychiatric Disorder
CLPS 1480C	Cognitive Control Functions of the Prefrontal Cortex
CLPS 1480H	Disorders of Memory
CLPS 1490	Functional Magnetic Resonance Imaging: Theory and Practice
CLPS 1492	Computational Cognitive Neuroscience
CLPS 1495	Affective Neuroscience
CLPS 1560	Visually-Guided Action and Cognitive Processes

CLPS 1561	The Nature of Attention
CLPS 1570	Perceptual Learning
CLPS 1580E	Perception, Attention, and Consciousness
CLPS 1620	Developmental Cognitive Neuroscience
CLPS 1760	The Moral Brain
CLPS 1820	Language and the Brain
CLPS 1950	Deep Learning in Brains, Minds and Machines
BIOL 1100	Cell Physiology and Biophysics
BIOL 1110	Topics in Signal Transduction
BIOL 1155	Hormones and Behavior
BIOL 1260	Physiological Pharmacology
BIOL 1545	Human Genetics and Genomics
ENGN 1220	Neuroengineering
PHP 1890	The Craving Mind
COST 1020	Cognitive Neuroscience of Meditation

List 2: Selected common non-neuro courses (no more than 2) - student must be able to justify why it enhances their understanding of Neuro

BIOL 0470	Genetics
BIOL 0800	Principles of Physiology
BIOL 1050	Biology of the Eukaryotic Cell
BIOL 1540	Molecular Genetics
BIOL 1810	21st Century Applications in Cell and Molecular Biology
CLPS 0950	Introduction to programming
CLPS 1195	Life Under Water in the Anthropocene
CLPS 1500	Perception and Action
CSCI 0111	Computing Foundations: Data
ENGL 1900Z	Neuroaesthetics and Reading
PHIL 1770	Philosophy of Mind
PHP 1540	Alcohol Use and Misuse
STS 1700P	Neuroethics
TAPS 1281Z	Arts and Health: Practice

Completing the Concentration Research Requirement As with other ScB concentrations, neuroscience concentrators are required (beginning with the class of 2023) to do the equivalent of one semester of independent study, research or design. This is a chance for the student to explore and apply the concepts that they have learned in their concentration courses. The following are ways in which this research requirement can be met. After consulting with your concentration advisor, be sure to include how you will fulfill your research requirement in the appropriate box within ASK: 1. Enrolling in independent study courses (NEUR 1970, CLPS 1970/80 or BIO 1950/60) for work in a lab. Keep in mind to count this towards your concentration two semesters or one semester and a summer are required. 2. Enrolling in independent study (NEUR 1970) to work with a faculty member to explore an integrative topic related to neuroscience. See our section on independent study for more information. 3. Enrolling in a course-based research experience, also known as a CURE course. Current related CURE courses are NEUR 1630, CLPS 1195, CLPS 1591, but there might be new ones coming down the pipeline. 4. Participating in a structured summer research program (eg. an UTRA or an REU) that is equivalent in scope and scale as would be pursued during a semester of independent research. 5. Participating in a research-focused Fall or Spring UTRA. 6. Pursue a design or independent research project related to neuroscience that could be associated with a different course. 7. Anyone writing an honors thesis automatically fulfills the research requirement, in order to document your research requirement, please describe your plan in your Course Plan Worksheet and in ASK, be sure to discuss it with your concentration advisor to make sure it is appropriate. Honors: Honors in Neuroscience requires a thesis and presentation based on a research project, and quality grades in the concentration. Guidelines and information on faculty research as well as details about declaring Honors are available in the Undergraduate Neuroscience Page [<https://www.brown.edu/academics/neuroscience/undergraduate-concentration>].

**Total Credits** 17

<sup>1</sup> Independent study and honors research projects are encouraged.

## Neuroscience Graduate Program

The program in Neuroscience offers graduate study leading to the Doctor of Philosophy (Ph.D) degree. The program is designed to educate and train scientists who will become leaders in the field and contribute to society through research, teaching and professional service. The core of the training involves close interaction with faculty to develop expertise in biological, behavioral, and theoretical aspects of neuroscience. Graduate research and training are carried out in the laboratories of the program's faculty. These faculty trainers lead outstanding well-funded research programs that use cutting edge technology to explore the nervous system.

For more information on admission and program requirements, please visit: <http://www.brown.edu/academics/gradschool/programs/biomed-neuroscience> (<http://www.brown.edu/academics/gradschool/programs/biomed-neuroscience/>)

## Courses

### NEUR 0010. The Brain: An Introduction to Neuroscience.

Introduction to the mammalian nervous system with emphasis on the structure and function of the human brain. Topics include the function of nerve cells, sensory systems, control of movement and speech, learning and memory, emotion, and diseases of the brain. No prerequisites, but knowledge of biology and chemistry at the high school level is assumed. Please register for any one of the evening recitation sections irrespective of the meeting time listed. Time conflicts will be resolved after classes start.

Fall NEUR0010 S01 10066 TTh 1:00-2:20(06) (M. Paradiso)

### NEUR 0680. Introduction to Computational Neuroscience.

An introductory class to computational neuroscience. Students will learn the main tools of the trade, namely differential equations, probability theory and computer programming, as well as some of the main modern neural-modeling techniques. Assignments will include the writing of simple Matlab code.

### NEUR 0700. Psychoactive Drugs and Society.

Will examine psychoactive drugs from two perspectives: (1) biological mechanisms of drug action and (2) the impact of psychoactive drug use on society and society attitudes towards psychoactive drug usage. Drugs to be discussed will include alcohol, opiates, cocaine, marijuana, LSD, nicotine and caffeine, as well as drugs used therapeutically to treat psychiatric disorders. This course will benefit students who are interested in exploring both the biological and social aspects of psychoactive drug use. Prerequisite: NEUR 0010 or equivalent.

### NEUR 1020. Principles of Neurobiology.

A lecture course covering fundamental concepts of cellular and molecular neurobiology. Topics include structure of ion channels, synaptic transmission, synaptic development, molecular mechanisms of synaptic plasticity, learning and memory and neurological diseases. Prerequisite: NEUR 0010. Strongly recommended: BIOL 0200 or equivalent.

Spr NEUR1020 S01 20080 TTh 9:00-10:20(05) (C. Aizenman)

### NEUR 1030. Neural Systems.

This lecture course examines key principles that underlie the function of neural systems ranging in complexity from peripheral receptors to central mechanisms of behavioral control. Prerequisite: NEUR 0010 or the equivalent. First year and Graduate students require instructor approval.

Fall NEUR1030 S01 10109 MWF 10:00-10:50(14) (M. Linden)

Fall NEUR1030 S02 17314 MWF 11:00-11:50(16) (M. Linden)

### NEUR 1040. Introduction to Neurogenetics.

Recent advances in molecular biology and molecular genetics have allowed researchers to test specific hypotheses concerning the genetic control of behavior and neurological disease. This course will familiarize you with the relatively new and exciting field of neurogenetics. We will cover basic topics, new ideas, and unsolved problems in neurogenetics primarily through the two assigned texts. However, neurogenetics is essentially a "frontier" area in neuroscience, and the best way to approach this topic is by scientific literature, which will be covered in some lectures.

Spr NEUR1040 S01 20081 TTh 10:30-11:50(09) (K. Kaun)

### NEUR 1065. Biology of Hearing.

Examines the sensory and perceptual system for hearing: the external, middle, and inner ears; the active processes of the cochlea; sound transduction and neural coding; neural information processing by the auditory system; and the nature of auditory perception and its biological substrate. Prerequisite: an introductory course in Neuroscience, Cognitive Science, Physics, Engineering or Psychology.

### NEUR 1440. Mechanisms and Meaning of Neural Dynamics.

We humans can shift our attention, perceive new objects, make complex motions, and adjust each of these behaviors within fractions of a second. Neurons and systems of neurons vary in their activity patterns on millisecond to second time scales, commonly referred to as "neural dynamics." This course addresses mechanisms underlying this flexibility and its potential meaning for information processing in the brain. The course integrates biophysical, computational, single neuron and human studies. In addition to lectures and readings, students will learn how to build computational models to simulate neural dynamics at various scales from single neurons to networks, using Matlab and the Human Neocortical Neurosolver. Computational modeling will be taught hands-on in an interactive lab session each week. Please request override through [Courses@Brown](mailto:Courses@Brown).

Fall NEUR1440 S01 10110 TTh 2:30-3:50(12) (S. Jones)

**NEUR 1500. From Neurons to Consciousness.**

NEUR 1500 is an introductory neuroscience course designed for students in the joint Brown-Pfizer Master of Arts Program. It begins with the study of nerve cells: their structure, the propagation of nerve impulses, and synapses. This is followed by lectures on brain anatomy to show how the brain is functionally organized. We then move to the sensory systems such as hearing, vision and touch and discuss how physical energy is converted by each system into neural signals, where these signals travel in the brain, and how they are processed. Next we study the control of voluntary movement. In the last portion of the course we discuss brain mechanisms involved in coordinated brain functions and behavior, including functions of the autonomic functions, motivated behaviors (e.g. eating, drinking), learning and memory, attention and consciousness, and mental illness.

**NEUR 1510. Neurotechnology: Molecular Tools and Methods for Neurobiology.**

New tools are transforming Neurobiology, both in the way experiments are being done and the questions they are addressing. New methods of observation and analysis are enhancing our understanding of the complex workings of the brain. This course is unique in helping students become critical thinkers about choosing the right toolset for different neuroscience questions at both the systems and molecular levels. We will also examine how new molecular tools are developed and evolve to address fundamental questions about how our brain. In many ways, neurotechnology, new methods, and molecular tools open the way for new discoveries in neuroscience. Course is geared towards neuroscience, biomedical engineering, biology and others.

Spr NEUR1510 S01 20082 MW 10:30-11:50 (A. Abdelfattah)

**NEUR 1520. Exploring Neural Data.**

While a large part of being a neuroscientist involves performing experiments to collect data, the reality of studying the brain is that you can often collect way more data than you know what to do with! In this course, we will discuss data analytic challenges in neuroscience. We will provide real data sets for hands-on student activities. By the end of the course, students will have the basic tools and techniques to begin to work with neuroscience data themselves. Topics will include spike train, EEG and behavioral analyses. The course will emphasize basic computer programming skills in Python.

**NEUR 1530. Communication In the Brain: What We Know and How We Know It.**

Neurons communicate through the thousands of synapses they form. In this seminar-style course, we will explore the cellular and molecular underpinnings of synaptic transmission. We will then examine how synapse number and function can be modulated to shape circuit function during development, learning & memory formation, and in response to perturbations. We will develop scientific thinking skills and an understanding of experimental approaches in modern neuroscience by focusing on how the field investigates synaptic transmission and plasticity. All readings are from primary literature. Please request override through C@B.

Fall NEUR1530 S01 10111 TTh 10:30-11:50(13) (K. O'Connor-Giles)

**NEUR 1540. Neurobiology of Learning and Memory.**

Exploration of learning and memory from the molecular to the behavioral level. Topics will include declarative and procedural memory formation and storage, associative and non-associative learning, cellular and molecular mechanisms for learning, and disorders affecting learning and memory. Examples will be drawn from numerous brain areas and a variety of model systems, including humans. Students will gain experience interpreting experiments from primary literature. Prerequisite: NEUR 1020.

**NEUR 1560. Developmental Neurobiology.**

The course will explore core concepts of developmental biology in the context of the developing nervous system. Topics will include: neuronal specification, cell migration, axon guidance, synapse formation, and neural plasticity. Students will gain experience with the primary literature and learn about cellular and molecular mechanisms of brain development and the tools and model organisms used to study them. Request override through C@B. The decision will be made based on a variety of factors including: seniority, concentration requirement, etc.

Spr NEUR1560 S01 20083 W 3:00-5:30(10) (A. Jaworski)

**NEUR 1600. Experimental Neurobiology.**

Please request an override in C@B to get on the waitlist. I will be in touch via email with students on this waitlist as the first class approaches. Intensive laboratory experience in neuroscience appropriate for students with basic background in Neurobiology. Learn and employ the classical neurophysiological techniques of extracellular recording, intracellular recording and receptive field mapping using a variety of animal species. Experiments will include recording of sensory signals in the cockroach leg; frog sciatic nerve and sciatic nerve/muscle preparation and intracellular recording of neurons in Aplysia. Instruction on and practice of effective science writing is another component to this course. Labs are supplemented by informal lectures. DO NOT REQUEST AN OVERRIDE FOR THIS COURSE. Please see the Class Notes section for information about how to gain enrollment into this course.

Spr NEUR1600 S01 20084 W 1:00-6:00 (J. Stein)

**NEUR 1630. Big Data Neuroscience Ideas Lab.**

Recent technological developments have transformed neuroscience research, enabling us to generate comprehensive 'big data' sets that are often shared freely amongst the neuroscience community. This lab course will explore strategies to effectively use such open-sourced neuroscience data sets. Students will identify fundamental open questions in brain science and develop strategies to mine open-source sequencing, imaging and connectivity data to address their research questions.

Fall NEUR1630 S01 10112 MW 2:00-3:20 (A. Fleischmann)

**NEUR 1640. Behavioral Neurogenetics Laboratory.**

Recent advances in molecular biology and molecular genetics have allowed researchers to test specific hypotheses concerning the genetic control of behavior and neurological disease. This course will familiarize you with the relatively new and exciting field of neurogenetics, and provide hands-on experience in developing and conducting behavioral neurogenetic experiments using the fruit fly, *Drosophila melanogaster*. This course will be a laboratory course focused on reading and understanding the primary literature, gaining expertise in the design and implementation of basic fly genetics, behavioral testing and analysis of tracking data, and the preparation of research reports associated with laboratory work. Throughout the course we will discuss the appropriateness, use, and limitations of animal models and human models for studying pathology, run real experiments with live animals, and collect, analyze, interpret, and write up results associated with those experiments.

**NEUR 1650. Structure of the Nervous System.**

Combined lecture and laboratory course on the anatomy of the central nervous system. Lectures survey the circuitry of the major neural systems for sensation, movement, cognition, and emotion. Laboratory exercises (Mon. 10:30-12:30) include brain dissections, microscopy of neural tissue, and discussion of clinical cases. Prerequisites: NEUR 0010, NEUR 1020, and NEUR 1030. Please request an override through C@B. Please keep in mind that decisions on overrides may not be made until the first meeting of the course.

Fall NEUR1650 S01 10113 TTh 2:30-3:50(12) (D. Berson)

**NEUR 1660. Neural Computation in Learning and Decision-Making.**

Your brain is constantly making decisions, receiving feedback about those decisions, and learning from that feedback. In this course we will examine the neuroscience underlying these processes from a computational perspective. The course will involve reading scientific papers from cognitive neuroscience, building and testing the computational models that have been developed to synthesize this literature, and, as a final project, extending an existing model of learning or decision making and characterizing its behavior. A primary goal for the course is to develop the tools and motivation to translate verbal theories of behavior into formal and testable computational models.

Spr NEUR1660 S01 20085 TTh 2:30-3:50(11) (M. Nassar)

**NEUR 1670. Neuropharmacology and Synaptic Transmission.**

Synaptic transmission will be studied from a biochemical and pharmacological point of view. We will explore the factors regulating neurotransmitter synthesis, storage, release, receptor interaction, and termination of action. Proposed mechanisms of psychoactive drugs and biochemical theories of psychiatric disorders will be examined. Prerequisites: NEUR 0010 and BIOL 0200 or the equivalent.

**NEUR 1680. Computational Neuroscience.**

A lecture and computing lab course focused on computational models of neurons and neural systems, and emphasizing Matlab-based computer simulation. The course is open to all undergraduate and graduate students in any of the Brain-Sciences-related departments. It includes two parallel tracks: an intro track for students with little background in math and computation, and an advanced track for students with substantial background in probability, differential equations, and computing. The intro track is the equivalent of NEUR 0680, last taught in 2018. Prerequisites: NEUR 0010, or NEUR 1020, or NEUR 1030. MA 0100 or equivalent. Maximum enrollment: 16.

**NEUR 1740. The Diseased Brain: Mechanisms of Neurological and Psychiatric Disorders.**

The goals of this course are to illustrate what basic science can teach us about neurological disorders and how these pathologies illuminate the functioning of the normal nervous system. Consideration will be given to monoallelic diseases (e.g. Fragile X Syndrome, Duchenne Muscular Dystrophy and Tuberous Sclerosis) as well as genetically complex disorders, such as Autism, Schizophrenia and Alzheimer's Disease. Emphasis will be on the cellular and molecular basis of these disorders and how insights at these levels might lead to the development of therapies. Prerequisites: NEUR 1020. BIOL 0470 suggested.

**NEUR 1750. Brain Rhythms in Cognition, Mental Health and Epilepsy.** "Everything in the universe has a rhythm, everything dances." – Maya Angelou.

The brain, too, dances. Its rhythms are the result of millions of neurons coordinating each other's activity. This course will explore how these rhythms are generated, how they relate to our perception and cognition, and how they can be used to better understand and diagnose psychiatric and neurological disorders. Our readings in this seminar will range from historical reviews of brain rhythms to modern primary literature employing cutting-edge experimental neuroscience techniques. Prerequisite: NEUR 0010 or the equivalent.

**NEUR 1930A. Cognitive Neuroscience: Motor Learning.**

This critical reading course will investigate the behavioral and neural mechanisms of motor learning. Readings will focus on work done with neuroimaging, neural recording and neuropsychological approaches that have addressed how the brain organizes and controls different forms of motor learning including simple conditional, practice-related changes and sensory-motor associations. Prerequisites: NEUR 0010, NEUR 1020, and NEUR 1030, or equivalent.

**NEUR 1930B. From Neurophysiology to Perception.**

This seminar will use readings from the research literature to explore the neural basis of perception. There will be an emphasis on vision, though other sensory modalities may be discussed. Prerequisites: NEUR 0010, NEUR 1020, and NEUR 1030, or equivalent.

**NEUR 1930C. Development of the Nervous System.**

The course will explore core concepts of developmental biology in the context of the developing nervous system. Topics will include: neuronal specification, cell migration, axon guidance, synapse formation, and neural plasticity. Students will gain experience with the primary literature and learn about cellular and molecular mechanisms of brain development and the tools and model organisms used to study them. Sign-up sheet in Sidney Frank Hall, Room 315 beginning on the first day of registration.

**NEUR 1930D. Cells and Circuits of the Nervous System.**

Selected topics on the biology of neurons and neuronal networks emphasizing original research literature about the membrane physiology, transmitter function, synaptic plasticity, and neural interactions of different vertebrate central nervous systems. Appropriate for graduates and undergraduates with strong neuroscience background. Offered alternate years. Previously offered as NEUR 2150.

**NEUR 1930E. Great Controversies in Neurobiology.**

This upper-level course examines some of the great controversies in the history of neurobiology. Reading material is drawn primarily from the primary scientific literature, so students are expected to already be familiar with reading scientific papers. Each theme will focus on a particular controversy, examining experimental evidence supporting both sides of the issue. Prerequisites: NEUR 0010 and NEUR 1020. Sign-up sheet in Sidney Frank Hall, Room 315 beginning on the first day of registration. Instructor permission required.

**NEUR 1930F. Brain Interfaces for Humans.**

Seminar course will cover developing and existing neurotechnology to restore lost human neurological functions. It will cover stimulation technologies to restore hearing, vision and touch, recording technologies to return function for persons with paralysis. The course will also cover devices to modulate brain function (e.g. deep brain stimulators). We will discuss early brain technologies, the present state neural sensors and decoders and future technology developments (e.g. brain-machine hybrids, human augmentation), as well as ethical implications. A final paper will be required. Instructor permission required. Prerequisites: NEUR 0010, NEUR 1020, and NEUR 1030; 1 year of physics, calculus. Enrollment restricted to 20 Neuroscience Concentrators and Graduate Students. Sign-up sheet in Sidney Frank Hall, Room 315 beginning on the first day of registration.

**NEUR 1930G. Disease, Mechanism, Therapy: Harnessing Basic Biology for Therapeutic Development.**

The recent surge in understanding the cellular and molecular basis of neurological disease has opened the way for highly targeted drug discovery and development. In this course we will use several case studies to illuminate how mechanistic insights are being translated into novel therapeutic approaches. Please request an override through C@B. Please keep in mind that decisions on overrides may not be made until the first meeting of the course.

**NEUR 1930H. Neurological Disorders: Neural Dynamics + Neurotechnology.**

A seminar course on neural dynamics and therapeutic approaches based on open-/closed-loop Brain-Computer Interfaces (BCIs) and neuromodulation for neurological and neuropsychiatric disorders. Topics include: (1) Disorders of consciousness: loss-of-consciousness in generalized epileptic and psychogenic seizures; closed-loop seizure control; Coma, medically induced coma and general anesthesia; Neuromonitoring of consciousness; (2) BCIs for auditory/visual/somatosensory disorders; (3) Movement disorders: BCIs for restoring movement/communication; adaptive-DBS for Parkinson's disease and essential tremor. (4) Neuropsychiatric disorders: DBS for major depression and obsessive compulsive disorder. To sign up, add this course to your cart. Enrollment is based on a variety of factors such as: seniority, concentration requirement.

**NEUR 1930I. Neural Correlates of Consciousness.**

This course will consider the neuroscience of consciousness from a variety of perspectives, using examples from behavior, neurophysiology, neuroimaging and neurology. The course content will focus on primary literature, using review articles for background. Students will lead discussions. Strongly Recommended: NEUR 1030. Enrollment limited to 15. DO NOT REQUEST AN OVERRIDE FOR THIS COURSE. Please see the Class Notes section for information about how to gain enrollment into this course.

Spr	NEUR1930I	S01	20086	M	4:00-6:30	(J. Sanes)
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**NEUR 1930J. C2S Neurotech: From Concept to Startup- Translating Neurotechnology.**

To provide an understanding of the process of translating neurotechnology concepts into applications that can benefit people with nervous system disorders. Emphasizing principles useful to (1) recognize viable neuroscience concepts that can be applied to human nervous system disorders and (2) implement the essential engineering and clinical steps to translate concepts into real world, useful solutions. This is for students interested in translational neuroscience research in academia or in entrepreneurship and commercialization of neurotech innovations. Please request override via Courses@Brown.

**NEUR 1930L. Neurobiology of Love.**

The goal of this course is to explore the underlying neurobiological principles of love and attachment. Topics include the relevant brain areas, the role of sensation and perception in love and attachment; how love and attachment influence action and behavior; plasticity and learning in these systems; and relevant neurodiversity related to love and attachment. You will gain a deeper understanding of concepts and principles that apply throughout the brain. You will gain experience with primary literature and learn about the relevant experimental techniques. There will be an emphasis on how the neurobiology of love is portrayed in the popular press. **DO NOT REQUEST AN OVERRIDE FOR THIS COURSE.** Please see the Class Notes section for information about how to gain enrollment into this course.

Fall	NEUR1930LS01	10115	TTh	1:00-2:20(06)	(M. Linden)
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**NEUR 1930N. Region of Interest: Amygdala.**

An in-depth exploration of the amygdala. Topics will include: cell types and properties; synaptic properties; plasticity; connections to other brain areas; sub-divisions within the area; the region's role in sensation and perception; the region's role in action and behavior; the region's role in learning and memory; and diseases and disorders. Students will gain a deeper understanding of concepts and principles that apply throughout the brain. Students will gain experience with primary literature and learn about techniques for studying the area.

**NEUR 1930Z. Cells and Circuits of the Nervous System.**

Selected topics on the biology of neurons and neuronal networks emphasizing primary research literature about neuronal excitability, synaptic mechanisms and plasticity, and diverse sensory, motor, and cognitive functions of neural circuits in vertebrate brains. Offered alternate years. Limit 15. To sign up, add this course to your primary cart. Enrollment decision will be made based on seniority, concentration requirement, etc.

**NEUR 1940B. Deep Learning in Neuroethology.**

Critical readings class will examine neural mechanisms for natural behavior (neuroethology) through reading classic studies and following current research. The course will emphasize the application of deep learning methods to movement patterns, spatial orientation, and social communication. DeepLabCut is one of several new programs that empower students and researchers to take advantage of deep learning methods for behavioral neuroscience. The course will teach how to replace single-parameter data analysis with deep learning methods to identify underlying patterns. Prerequisites are Introductory Neuroscience (NEUR0010) and prior training in Matlab or computer programming languages. **DO NOT REQUEST AN OVERRIDE FOR THIS COURSE.** Please see the Class Notes section for information about how to gain enrollment into this course.

Spr	NEUR1940ES01	20087	M	3:00-5:30(13)	(J. Simmons)
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**NEUR 1940C. Topics in Visual Physiology.**

Selected topics in visual physiology are examined through a close and critical reading of original research articles. Emphasizes the anatomical and physiological bases of visual function. Appropriate for graduate students and undergraduates with a strong neuroscience background. Offered in alternate years. (Previously offered as NEUR 2120.)

**NEUR 1940D. Higher Cortical Function.**

This reading course examines a series of high-level neurocognitive deficits from the perspectives of popular science and basic neuroscience. Prerequisite: NEUR 1030. Instructor permission required. Sign-up sheet in Sidney Frank Hall, Room 315 beginning on the first day of registration.

**NEUR 1940E. Molecular Neurobiology: Genes, Circuits and Behavior.**

In this seminar course, we will discuss primary research articles, both recent and classical, covering topics ranging from the generation of neuronal diversity to the control of behavior by specific neural circuits. Instructor permission required; enrollment limited to 15. Sign-up sheet in Sidney Frank Hall, Room 315 beginning on the first day of registration.

**NEUR 1940G. Drugs and the Brain.**

This is a seminar course devoted to the reading and analyzing of original research articles dealing with the interaction between drugs and the brain. This will include drugs used to analyze normal brain function, as well as drugs of abuse and drugs used for therapeutic purposes. This course is intended for undergraduate and graduate students with a strong background in neuropharmacology. To express interest, please add this course to your primary cart. The decision will be made based on a variety of factors including, but not limited to seniority, concentration requirement. Limited to 15.

**NEUR 1940I. Neural Correlates of Consciousness.**

This course will consider the neuroscience of consciousness from a variety of perspectives, using examples from behavior, neurophysiology, neuroimaging and neurology. The course content will focus on primary literature, using review articles for background. Students will lead discussions. Sign-up sheet in Sidney Frank Hall, Room 315 beginning on the first day of registration. Prerequisite: NEUR 0010, 1020, and 1030. Enrollment limited to 15. Instructor permission required.

**NEUR 1970. Independent Study.**

Laboratory-oriented research in neuroscience, supervised by staff members. A student, under the guidance of a neuroscience faculty member, proposes a topic for research, develops the procedures for its investigation, and writes a report of the results of his or her study. Independent study may replace only one required course in the neuroscience concentration. Prerequisites include NEUR 0010, 1020 and 1030. Section numbers vary by instructor. Please check Banner for the correct section number and CRN to use when registering for this course. Permission must be obtained from the Neuroscience Department.

**NEUR 2010. Graduate Proseminar in Neuroscience.**

A study of selected topics in experimental and theoretical neuroscience. Presented by neuroscience faculty, students, and outside speakers. A required course for all students in the neuroscience graduate program.

**NEUR 2020. Graduate Proseminar in Neuroscience.**

See Graduate Pro-Seminar In Neuroscience (NEUR 2010) for course description.

**NEUR 2030. Advanced Molecular and Cellular Neurobiology I.**

Focuses on molecular and cellular approaches used to study the CNS at the level of single molecules, individual cells and single synapses by concentrating on fundamental mechanisms of CNS information transfer, integration, and storage. Topics include biophysics of single channels, neural transmission and synaptic function. Enrollment limited to graduate students.

Fall	NEUR2030	S01	10116	TTh	9:00-12:00	(A. Hart)
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**NEUR 2040. Advanced Molecular and Cellular Neurobiology II.**

This course continues the investigation of molecular and cellular approaches used to study the CNS from the level of individual genes to the control of behavior. Topics include patterning of the nervous system, generation of neuronal diversity, axonal guidance, synapse formation, the control of behavior by specific neural circuits and neurodegenerative diseases. Enrollment is limited to graduate students.

Spr	NEUR2040	S01	20088	W	2:00-5:00	(G. Barnea)
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**NEUR 2050. Advanced Systems Neuroscience.**

Focuses on systems approaches to study nervous system function. Lectures and discussions focus on neurophysiology, neuroimaging and lesion analysis in mammals, including humans. Cognitive neuroscience approaches will become integrated into the material. Topics include the major sensory, regulatory, and motor systems. Enrollment limited to graduate students.

Fall	NEUR2050	S01	10117	W	1:00-4:00	(T. Desrochers)
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**NEUR 2060. Advanced Systems Neuroscience.**

Focuses on cognitive approaches to study nervous system function. Lectures and discussions focus on neurophysiology, neuroimaging and lesion analysis in mammals, including humans. Computational approaches will become integrated into the material. Topics include the major cognitive systems, including perception, decisions, learning and memory, emotion and reward, language, and higher cortical function. Instructor permission required.

Spr	NEUR2060	S01	20089	M	2:00-5:00	(D. Sheinberg)
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**NEUR 2100. NeuroPracticum.**

Intensive laboratory experience appropriate for graduate students with basic background in cellular and molecular neuroscience. This short course includes electrophysiology, and other fundamental techniques. Laboratory exercises run in January and are supplemented by informal lectures. Enrollment requires instructor permission and is limited to 24 graduate students. Prerequisite: NEUR2030. S/NC course

**NEUR 2110. Statistical Neuroscience.**

An introduction to the statistical modeling of multiscale neural dynamics in networks of neurons and large-scale brain networks with a focus on stochastic processes and random dynamical systems. Analysis of dynamical and statistical network properties: stationarity, directed transfer functions, stability and bifurcations, phase transitions. Related applications to prediction, control, low-dimensional representation, probabilistic neural population encoding and decoding are introduced as well. This is a course for senior undergraduate and graduate students with a background in systems/computational neuroscience and/or applied math/biomedical engineering. Lectures are accompanied by hands-on Python/Matlab-based applications to real and simulated neural data. Topics include: (1) Time and spectral domain models of network dynamics based on multivariate neural time series and point process observations with exogenous inputs; vector autoregressive processes, nonlinear Hawkes processes; stability, transfer functions; (2) Identification of directed interactions in networks of neurons and brain inter-areal communication (Granger causality, transfer entropy, ODE networks); (3) Collective dynamics and low-dimensional representations of network dynamics; (4) Prediction, neural population encoding and decoding for brain-computer interfaces: Bayesian probabilistic approaches based on linear/nonlinear state-space models, machine learning; (5) Data assimilation methods for modeling neural network dynamics. Example datasets include neuronal spike trains, local field potentials, ECoG/SEEG. PREREQUISITES: Introduction to statistics and probability, calculus and linear algebra; Python/Matlab programming language; familiarity with stochastic processes, difference/differential equations and related math background is helpful. Instructor permission required.

Fall	NEUR2110	S01	10118	F	1:00-2:30	(W. Truccolo)
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Fall	NEUR2110	S01	10118	W	1:00-2:30	(W. Truccolo)
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**NEUR 2120. Topics in Visual Physiology.**

Selected topics in visual physiology are examined through a close and critical reading of original research articles. Emphasizes the anatomical and physiological bases of visual function. Primarily for graduate students with a strong background in neuroscience and a working knowledge of the anatomy and physiology of the mammalian visual system. Offered in alternate years. Instructor permission required.

**NEUR 2160. Neurochemistry and Behavior.**

Examines behavior from a neurochemical perspective via readings and discussions based on original research articles. Intended primarily for graduate students with a strong background in neurochemistry and neuropharmacology and advanced undergraduates with an appropriate background. Offered alternate years. Sign-up sheet in Sidney Frank Hall, Room 315 beginning on the first day of registration.

**NEUR 2450. Exchange Scholar Program.****NEUR 2920. Behavior: A Genetic and Molecular Perspective.**

Many of the cellular and molecular mechanisms that underlie behavior are conserved across species. This seminar course draws on work in invertebrate and vertebrate species to examine the genes and molecules that have been implicated in diverse behaviors. Topics to be discussed include circadian rhythms, pair bonding, migration, and aggression. Each week, students will read two to three papers from the primary literature and actively participate in class discussion. Prerequisites: NEUR 0010 and NEUR 1020 (undergraduate students) or NEUR 2030 (graduate students). Enrollment limited to 13. Instructor permission required.

**NEUR 2930C. Historical Foundations of the Neurosciences.**

Two year sequence starting Fall 2010; students register for one year at a time. The first year (2010-2011) will examine the history of basic neuroscientific concepts from the late Greeks (Galen) to the later 19th century, up to Cajal (neuron doctrine) and Sherrington (reflexes and integration). Since the seminar meets only monthly, it must be taken in the Fall and Spring semesters to receive a semester's credit. For credit, a substantial paper (approximately 15 pages) is required at the end of the Spring semester. Primarily for graduate students in neuroscience, cognitive science, and psychology. Others may be admitted after discussion with the instructor. Auditors are welcome if they share in the rotating duty of presenting seminars. Sign-up sheet in Sidney Frank Hall, Room 315 beginning on the first day of registration.

**NEUR 2930E. Bench to Bedside: Unraveling Diseases of the Nervous System.**

Enrollment restricted to graduate students.

**NEUR 2930F. Disease, Mechanism, Therapy: Harnessing Basic Biology for Therapeutic Development.**

The recent surge in understanding the cellular and molecular basis of neurological disease has opened the way for highly targeted drug discovery and development. In this course we will use several case studies to illuminate how mechanistic insights are being translated into novel therapeutic approaches. Instructor permission required. Enrollment limited to 15 Graduate students. Sign-up sheet in Sidney Frank Hall, Room 315 beginning on the first day of registration.

**NEUR 2940A. Advanced Molecular Neurobiology.**

No description available.

**NEUR 2940G. Historical Foundations of the Neurosciences II.**

Continuation of a two year sequence focusing on the conceptual foundations in the history of neuroscience, from the late nineteenth century to the present. Primarily for graduate students in neuroscience, cognitive science, and psychology, but senior undergraduates may be admitted with written permission from the instructor. Seminar meets monthly, and must be taken for the full year to receive one semester credit.

**NEUR 2940H. Ethics and Skills Workshop.**

The ethics and skills workshops will be lead by faculty trainers in the Neuroscience Graduate Program. We will cover the following or similar topics over a two year period: Plagiarism, scientific accuracy, data ownership, expectations of advisory committees and mentors, authorship disagreements, and conflicts among lab members. Enrollment restricted to graduate students.

**NEUR 2940I. Neural Correlates of Consciousness.**

Will consider the neuroscience of consciousness from a variety of perspectives, using examples from behavior, neurophysiology, neuroimaging and neurology. The course content will focus on primary literature, using review articles for background. Students will lead the discussions. Primarily for graduate students. Senior undergraduates neuroscience concentrators and others may be admitted after discussion with the instructor. Instructor permission required. S/NC

**NEUR 2970. Preliminary Examination Preparation.**

For graduate students who have met the tuition requirement and are paying the registration fee to continue active enrollment while preparing for a preliminary examination.

Fall	NEUR2970	S01	16604	Arranged	(A. Fleischmann)
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Spr	NEUR2970	S01	25261	Arranged	(A. Fleischmann)
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**NEUR 2980. Graduate Independent Study.**

Section numbers vary by instructor. Please check Banner for the correct section number and CRN to use when registering for this course. S/NC

**NEUR 2990. Thesis Preparation.**

For graduate students who have met the residency requirement and are continuing research on a full time basis.

Fall NEUR2990 S01 16605 Arranged (A. Fleischmann)

Spr NEUR2990 S01 25262 Arranged (A. Fleischmann)

**NEUR XLIST. Courses of Interest to Neuroscience Concentrators.**