Computational Neuroscience

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

Computational neuroscience is a relatively new interdisciplinary area of inquiry that is concerned with how components of animal and human nervous systems interact to produce behaviors. It relies on quantitative and modeling approaches to understand the function of the nervous system and to design human-made devices that duplicate behaviors. Course work in computational neuroscience can prepare students for graduate studies in neurobiology or psychology, in the mathematical or engineering sciences, or in areas of medicine such as neurology or psychiatry. It can lead either to traditional academic careers or to opportunities in the corporate world.

An undergraduate degree in computational neuroscience is not available at the University of Chicago, but a minor in computational neuroscience is offered by the Biological Sciences Collegiate Division. This minor is a good option for students who are majoring in biological sciences and are interested in mathematical approaches to biology; or for students who are majoring in computer science, mathematics, physics, psychology, or statistics and are interested in neuroscience. For details, see the Biological Sciences section in this catalog.

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 biological sciences.

Summary of Requirements for the Minor in Computational Neuroscience

BIOS 24231	Methods in Computational Neuroscience	100
BIOS 24232	Computational Approaches to Cognitive Neuroscience	100
BIOS 24408	Modeling and Signal Analysis for Neuroscientists	100
BIOS 26210-26211	Mathematical Methods for Biological Sciences I-II	200
Total Units		500

Instead of completing a formal minor, students can easily fashion an organized course of study in computational neuroscience by selecting appropriate general education courses and electives.

For updated information on computational neuroscience activities and undergraduate programs, visit neuroscience.uchicago.edu.

Suggested General Education Courses

Students majoring in biological sciences typically take BIOS 20150 How Can We Understand the Biosphere? and BIOS 20151 Introduction to Quantitative Modeling in Biology (Basic) or BIOS 20152 Introduction to Quantitative Modeling in Biology (Advanced).

One of the following sequences:		200
MATH 15100-15200	Calculus I-II	
MATH 16100-16200	Honors Calculus I-II	
SOSC 14100-14200-14300	Mind I-II-III	300

Computational Neuroscience Courses

BIOS 24231. Methods in Computational Neuroscience. 100 Units.
Topics include (but are not limited to): Hodgkin-Huxley equations, Cable theory, Single neuron models, Information theory, Signal Detection theory, Reverse correlation, Relating neural responses to behavior, and Rate vs. temporal codes.
Instructor(s): S. Bensmaia Terms Offered: Winter. L.
Prerequisite(s): BIOS 26210 and BIOS 26211 which must be taken concurrently, or consent of instructor.
Equivalent Course(s): PSYC 24231, CPNS 34231

BIOS 24232. 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: Spring. L.
Prerequisite(s): BIOS 26210, a course in systems neuroscience, and knowlege using Matlab, or consent of instructor.
Equivalent Course(s): PSYC 34410, CPNS 33200, ORGB 34650

BIOS 24408. 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. L.
Prerequisite(s): Undergraduates: Biology Major - BIOS 26210 and 26211, or consent of instructor. Neuroscience Major - NSCI 20130
Equivalent Course(s): CPNS 32111, NSCI 24000

BIOS 26210-26211. Mathematical Methods for Biological Sciences I-II.

BIOS 26210. Mathematical Methods for Biological Sciences I. 100 Units.
This course builds on the introduction to modeling course biology students take in the first year (BIOS 20151 or 152). It begins with a review of one-variable ordinary differential equations as models for biological processes changing with time, and proceeds to develop basic dynamical systems theory. Analytic skills include stability analysis, phase portraits, limit cycles, and bifurcations. Linear algebra concepts are introduced and developed, and Fourier methods are applied to data analysis. The methods are applied to diverse areas of biology, such as ecology, neuroscience, regulatory networks, and molecular structure. The students learn computations methods to implement the models in MATLAB.
Instructor(s): D. Kondrashov Terms Offered: Autumn. L.
Prerequisite(s): BIOS 20151 or BIOS 20152 and three quarters of a Biological Sciences Fundamentals sequence or consent of the instructor
Equivalent Course(s): PSYC 36210, CPNS 31000

BIOS 26211. Mathematical Methods for Biological Sciences II. 100 Units.
This course is a continuation of BIOS 26210. The topics start with optimization problems, such as nonlinear least squares fitting, principal component analysis and sequence alignment. Stochastic models are introduced, such as Markov chains, birth-death processes, and diffusion processes, with applications including hidden Markov models, tumor population modeling, and networks of chemical reactions. In computer labs, students learn optimization methods and stochastic algorithms, e.g., Markov Chain, Monte Carlo, and Gillespie algorithm. Students complete an independent project on a topic of their interest.
Instructor(s): D. Kondrashov Terms Offered: Winter. L.
Prerequisite(s): BIOS 26210 or equivalent.
Equivalent Course(s): PSYC 36211, CPNS 31100

BIOS 26211. Mathematical Methods for Biological Sciences II. 100 Units.
This course is a continuation of BIOS 26210. The topics start with optimization problems, such as nonlinear least squares fitting, principal component analysis and sequence alignment. Stochastic models are introduced, such as Markov chains, birth-death processes, and diffusion processes, with applications including hidden Markov models, tumor population modeling, and networks of chemical reactions. In computer labs, students learn optimization methods and stochastic algorithms, e.g., Markov Chain, Monte Carlo, and Gillespie algorithm. Students complete an independent project on a topic of their interest.
Instructor(s): D. Kondrashov Terms Offered: Winter. L.
Prerequisite(s): BIOS 26210 or equivalent.
Equivalent Course(s): PSYC 36211, CPNS 31100

Font Notice

This document should contain certain fonts with restrictive licenses. For this draft, substitutions were made using less legally restrictive fonts. Specifically:

Times was used instead of Trajan.

Times was used instead of Palatino.

The editor may contact Leepfrog for a draft with the correct fonts in place.