INTERDEPARTMENTAL NEUROSCIENCE PROGRAM

Sterling Hall of Medicine L-200, 203.785.5932
http://medicine.yale.edu/innp
M.S., M.Phil., Ph.D.

Director of Graduate Studies
Charles Greer (Neurosurgery; Neuroscience)
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Professors
Amy Arnsten (Neuroscience; Psychology), Anton Bennett (Pharmacology; Comparative Medicine), Hal Blumenfeld (Neurology; Neuroscience), Angélique Borday (Neurosurgery; Cellular & Molecular Physiology), Tyrone Cannon (Psychology; Psychiatry), John Carlson (Molecular, Cellular, & Developmental Biology), B.J. Casey (Psychology), Marvin Chun (Psychology; Neuroscience), Lawrence Cohen (Cellular & Molecular Physiology), R. Todd Constable (Radiology & Biomedical Imaging; Neurosurgery), Michael Crair (Neuroscience; Ophthalmology & Visual Science), Pietro De Camilli (Cell Biology; Neuroscience), Nihal DeLanerolle (Neurosurgery; Neuroscience), Sabrina Diana (Obstetrics, Gynecology, & Reproductive Sciences; Comparative Medicine; Neuroscience), Ralph DiLeone (Psychiatry; Neuroscience), Ronald Duman (Psychiatry; Neuroscience), Barbara Ehrlich (Pharmacology; Cellular & Molecular Physiology), Paul Forscher (Molecular, Cellular, & Developmental Biology), Charles Greer (Neurosurgery; Neuroscience), Jaime Grutzenider (Neurology; Neuroscience), Murat Gunel (Neurosurgery; Genetics; Neuroscience), David Hafler (Neurology; Immunobiology), Joy Hirsch (Psychiatry; Comparative Medicine; Neuroscience), Tamas Horvath (Comparative Medicine; Neuroscience; Obstetrics, Gynecology, & Reproductive Sciences), Arthur Horwich (Genetics; Pediatrics), Jonathan Howard (Molecular Biophysics & Biochemistry; Physics), Fahmee Hyder (Radiology & Biomedical Imaging; Biomedical Engineering), Elizabeth Jonas (Internal Medicine; Neuroscience), Leonard Kaczmarek (Pharmacology; Cellular & Molecular Physiology), Haig Keshishian (Molecular, Cellular, & Developmental Biology), Jeffery Kocsis (Neurology; Neuroscience), Michael Koelle (Molecular Biophysics & Biochemistry), Anthony Koleske (Molecular Biophysics & Biochemistry; Neuroscience), John Krystal (Psychiatry; Neuroscience), Robert LaMotte (Anesthesiology; Neuroscience), Daeyeol Lee (Neuroscience; Psychology), Paul Lombroso (Child Study Center; Neuroscience; Psychiatry), Laura Manelidies (Neuropathology), Gregory McCarthy (Psychology), Mark Moosiek (Molecular, Cellular, & Developmental Biology; Cell Biology), Evan Morris (Radiology & Biomedical Imaging; Biomedical Engineering; Psychiatry), Angus Nairn (Psychiatry; Pharmacology), Michael Nitaichesk (Cellular & Molecular Physiology; Genetics), Marina Picciotto (Psychiatry; Pharmacology; Neuroscience), Vincent Pierbunge (Cellular & Molecular Physiology; Neuroscience), Marc Potenza (Psychiatry; Child Study Center; Neuroscience), Pasko Rakic (Neuroscience; Neurology), Robert Roth, Jr. (Psychiatry), Gary Rudnick (Pharmacology), W. Mark Saltzman (Biomedical Engineering; Cellular & Molecular Physiology; Chemical & Environmental Engineering), Laurie Santos (Psychology), Joseph Santos-Sacchi (Surgery; Cellular & Molecular Physiology; Neuroscience), Nenad Sestan (Neuroscience; Comparative Medicine; Genetics; Psychiatry), Gordon Shepherd (Neuroscience), Fred Sigsworth (Cellular & Molecular Physiology; Biomedical Engineering), Dana Small (Psychiatry; Psychology [Assoc. Prof.]), Stephen Strittmatter (Neurology; Neuroscience), Jane Taylor (Psychiatry; Psychology), Susumu Tomita (Cellular & Molecular Physiology; Neuroscience), Nicholas Turk-Browne (Psychology), Flora Vaccarino (Child Study Center; Neuroscience), Christopher van Dyck (Psychiatry; Neuroscience; Neurology), Stephen Waxman (Neurology; Pharmacology; Neuroscience), Robert Wyman (Molecular, Cellular, & Developmental Biology), David Zenisek (Cellular & Molecular Physiology; Ophthalmology & Visual Science), Z. Jimmy Zhou (Ophthalmology & Visual Science; Cellular & Molecular Physiology; Neuroscience), Steven Zucker (Computer Science; Biomedical Engineering)

Associate Professors
Nii Addy (Psychiatry; Cellular & Molecular Physiology), Meenakshi Alreja (Psychiatry; Neuroscience), Sviatoslav Bagriantsiev (Cellular & Molecular Physiology), Charles Bruce (Neuroscience), William Cafferty (Neurology), Jessica Cardin (Neuroscience), Sreeganga Chandra (Neurology; Neuroscience; Molecular, Cellular, & Developmental Biology), Damon Clark (Molecular, Cellular, & Developmental Biology; Physics), Daniel Colon-Ramos (Cell Biology; Neuroscience), Kelly Cosgrove (Psychiatry; Radiology & Biomedical Imaging; Neuroscience), Jonathan Demb (Ophthalmology & Visual Science; Cellular & Molecular Physiology), Tore Eid (Laboratory Medicine; Neurosurgery), Thierry Emonet (Molecular, Cellular, & Developmental Biology; Physics), Sourav Ghosh (Neurology), Elena Gracheva (Cellular & Molecular Physiology; Neuroscience), Marc Hammarlund (Genetics; Neuroscience), Michael Higley (Neuroscience), Erdem Karatekin (Cellular & Molecular Physiology; Molecular Biophysics & Biochemistry), In-Jung Kim (Ophthalmology & Visual Science; Neuroscience), Hedy Kober (Psychiatry), Iaf Levy (Comparative Medicine; Neuroscience), Chiang-shan Ray Li (Psychiatry; Neuroscience), Janghoo Lim (Genetics; Neuroscience), Angeliki Louvi (Neurosurgery; Neuroscience), Dhasakumar Navaratnam (Neurology; Neuroscience), Timothy Newhouse (Chemistry), Kevin O’Connor (Neurology), Maria Piñango (Linguistics), Christopher Pittenger (Psychiatry; Child Study Center; Psychology), Michael Schwartz (Neuroscience), Justus Verhagen (Neuroscience), Weimin Zhong (Molecular, Cellular, & Developmental Biology; Jiangbing Zhou (Neurosurgery; Biomedical Engineering)

Assistant Professors
Alan Anticevic (Psychiatry; Psychology), Rui Chang (Cellular & Molecular Physiology; Neuroscience), Steve Chang (Psychology; Neuroscience), Philip Corlett (Psychiatry), Marcelo de Oliveira Dietrich (Comparative Medicine; Neuroscience), George Dragoi (Psychiatry; Neuroscience), Dylan Gee (Psychology), Jason Gerrard (Neurosurgery; Neuroscience), Junjie Guo (Neuroscience), Ellen Hoffman (Child Study Center), Avram Holmes (Psychology), Monika Jadi (Psychiatry), James Jeane (Neuroscience), Kristopher Kahle (Neurosurgery; Pediatrics; Cellular & Molecular Physiology), Alex Kwan (Psychiatry; Neuroscience), John Murray (Psychiatry), Anirvan Nandy (Neuroscience), Hyeju Sung (Psychiatry), Shaull Yoge (Neuroscience)
FIELDS OF STUDY
The Interdepartmental Neuroscience Program (INP) offers flexible but structured interdisciplinary training for independent research and teaching in neuroscience. The goal of the program is to ensure that degree candidates obtain a solid understanding of cellular and molecular neurobiology, physiology and biophysics, neural development, systems and behavior, and neural computation. In addition to course work, graduate students participate in an annual research-in-progress talk and a regular journal club, organize the Interdepartmental Neuroscience Program Seminar Series, and attend other seminar programs, named lectureships, symposia, and an annual research retreat.

SPECIAL ADMISSIONS REQUIREMENTS
Applicants to the Interdepartmental Neuroscience Program should have a B.S. or B.A. Most applicants have had course work in neuroscience, psychobiology, physiological psychology, mathematics through calculus, general physics, general biology, general chemistry, organic chemistry, biochemistry, computer science, or engineering. Deficiencies in these areas can be corrected through appropriate course work in the first year of residence. Laboratory research experience is desirable but is not a formal requirement. Three letters of recommendation, transcripts of undergraduate grades, and a statement of interest must accompany the application. The GRE General Test, or a pertinent GRE Subject Test, is no longer required, and scores will not be considered if submitted.

To enter the Interdepartmental Neuroscience Ph.D. program, students apply to the Neuroscience track within the program in Biological and Biomedical Sciences (BBS), http://bbs.yale.edu.

SPECIAL REQUIREMENTS FOR THE PH.D. DEGREE
Each entering student is assigned a faculty advisory committee to provide guidance. This committee is responsible for establishing the student's course of study and for monitoring the student's progress. This committee will be subsequently modified to include faculty with expertise in the student's emerging area of interest. Although each student's precise course requirements are set individually to take account of background and educational goals, the course of study is based on a model curriculum beginning with five core required courses: Bioethics in Neuroscience (INP 580), Principles of Neuroscience (INP 701), Foundations of Cellular and Molecular Neurobiology (INP 702), Foundations of Systems Neuroscience (INP 703), and Comparative Neuroanatomy (INP 704), all completed in the first year of enrollment. During the second year of enrollment, students are required to take an advanced course on quantitative techniques. Collectively, these courses are designed to ensure broad competence in modern neuroscience. Students are also required to complete at least three additional elective courses from a broad set of neuroscience-related courses. The Graduate School uses grades of Honors, High Pass, Pass, and Fail and requires two term grades of Honors during the first two years of study. Students are expected to maintain at least a High Pass average. Additional degree requirements are successful completion of both terms of Lab Rotation for First-Year Students (INP 511, INP 512); both terms of Second-Year Thesis Research (INP 513, INP 514); and RCR Refresher for Senior BBS Students (B&B 503), completed during the fourth year of enrollment. This will ensure that degree candidates obtain a solid background in systems, cellular, and molecular approaches to neuroscience. Admission to candidacy requires passing a qualifying examination normally given during the second year, and submission of a dissertation prospectus (NIH NRSA grant format) before the end of the third year. In accordance with the expectations of the BBS program, Ph.D. students are expected to participate in two terms (or the equivalent) of teaching. Thesis committee meetings are required at six-month intervals. Also required is the completion and satisfactory defense of the thesis.

Requirements for M.D./Ph.D. students are the same as for Ph.D. students with the following differences: three courses are required (INP 701; Structural and Functional Organization of the Human Nervous System [INP 510]; and one elective graduate-level course). M.D./Ph.D. students are required to serve for one term as teaching assistants; however, two terms of teaching are preferred.

MASTER’S DEGREES
M.Phil. See Degree Requirements under Policies and Regulations.

M.S. Awarded only to students who are not continuing for the Ph.D. degree and have successfully completed the equivalent of 30 credit hours in the doctoral program. This includes a passing grade in the five required courses plus two elective courses, a minimum of two Honors grades, and successful completion of both terms of Lab Rotation for First-Year Students (INP 511, INP 512) and both terms of Second-Year Thesis Research (INP 513, INP 514). Students are not admitted for this degree. Students who are eligible for or who have already received the M.Phil. will not be awarded the M.S.

Program information is available at http://medicine.yale.edu/inp.

COURSES
INP 530a / PSYC 530a, Foundations of Neuroscience: Biological Bases of Human Behavior Avram Holmes
The purpose of this course is to provide students with an understanding of the biological factors underlying human cognition and behavior. Particular emphasis is placed on the mechanisms associated with individual differences in healthy functions (including emotion regulation, stress sensitivity, higher cognition, reward sensitivity, impulsivity, and social functions) and their relations with psychiatric and neurological disorders. Biological factors to be covered include genetic, neuroanatomical, neurophysiological, neurochemical, hormonal, and neuropsychological influences. Several of the initial sessions are devoted to basic topics (e.g., neurons, neuronal signaling, brain systems), before we begin our discussion of the neural basis of behavior and cognition. We also cover seminal work on animal
models for mechanistic insights into the neurobiology of human behavior. Graduate students with any neuroscience research interest are encouraged to take this course. Required of Psychology Ph.D. students in the neuroscience area.

**INP 562b / AMTH 765b / CB&B 562b / ENAS 561b / MB&B 562b / MCDB 562b / PHYS 562b, Modeling Biological Systems II**  
Damon Clark, Thierry Emonet, and Jonathon Howard

This course covers advanced topics in computational biology. How do cells compute, how do they count and tell time, how do they oscillate and generate spatial patterns? Topics include time-dependent dynamics in regulatory, signal-transduction, and neuronal networks; fluctuations, growth, and form; mechanics of cell shape and motion; spatially heterogeneous processes; diffusion. This year, the course spends roughly half its time on mechanical systems at the cellular and tissue level, and half on models of neurons and neural systems in computational neuroscience. Prerequisite: a 200-level biology course or permission of the instructor.

**INP 720a, Neurobiology**  
Haig Keshishian and Paul Forscher

Examination of the excitability of the nerve cell membrane as a starting point for the study of molecular, cellular, and intracellular mechanisms underlying the generation and control of behavior.