INTERDEPARTMENTAL NEUROSCIENCE PROGRAM

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M.S., M.Phil., Ph.D.

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Associate Professors Nii Addy (*Psychiatry*; *Cellular and Molecular Physiology*), Meenakshi Alreja (*Psychiatry*; *Neuroscience*), Alan Anticevic (*Psychiatry*; *Psychology*), Sviatoslav Bagriantsev (*Cellular and Molecular Physiology*), Abhishek Bhattacharjee (*Computer Science*), Thomas Biederer (*Neurology*; *Neuroscience*), William Cafferty (*Neurology*; *Neuroscience*), Rui Chang (*Cellular and Molecular Physiology*; *Neuroscience*), Steve Chang (*Psychology*; *Neuroscience*), Damon Clark (*Molecular, Cellular, and Developmental Biology*; *Physics*), Philip Corlett (*Psychiatry*; *Psychology*), Marcelo de Oliveira Dietrich (*Comparative Medicine*; *Neuroscience*), George Dragoi (*Psychiatry*; *Neuroscience*), Tore Eid (*Laboratory Medicine*; *Neurosurgery*), Irina Esterlis (*Psychiatry*; *Psychology*), Sourav Ghosh (*Neurology*; *Pharmacology*), Pallavi Gopal (*Pathology*), Junjie Guo (*Neuroscience*), Marc Hammarlund (*Genetics*; *Neuroscience*), Michelle Hampson (*Radiology and Biomedical Imaging*; *Psychiatry*; *Child Study Center*), Michael Higley (*Neuroscience*), Avram Holmes (*Psychology*), Erdem Karatekin (*Cellular and Molecular Physiology*; *Molecular Biophysics and Biochemistry*), In-Jung Kim (*Ophthalmology and Visual Science*; *Neuroscience*), Hedy Kober (*Psychiatry*; *Psychology*), Smita Krishnaswamy (*Genetics*; *Computer Science*), Ifat Levy (*Comparative Medicine*; *Psychology*; *Neuroscience*), Janghoo Lim (*Genetics*; *Neuroscience*), John Murray (*Psychiatry*; *Neuroscience; Physics*), Dhasakumar Navaratnam (*Neurology*; *Neuroscience*), Timothy Newhouse (*Chemistry*), In-Hyun Park (*Genetics*), Maria Piñango (*Linguistics*), Helena Rutherford (*Child Study Center*; *Psychology*), Dustin Scheinost (*Radiology and Biomedical Imaging*; *Child Study Center*; *Statistics and Data Science*), Justus Verhagen (*Neuroscience*), Shaul Yogev (*Neuroscience*), Weimin Zhong (*Molecular, Cellular, and Developmental Biology*), Jiangbing Zhou (*Neurosurgery*; *Biomedical Engineering*)

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and Biochemistry), Albert Powers (*Psychiatry*; *Psychology*), Hyojung Seo (*Psychiatry*; *Neuroscience*), David van Dijk (*Internal Medicine*; *Computer Science*), Ilker Yildirim (*Psychology*)

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 coursework, graduate students participate in student research talks, as well as mentoring and outreach activities.

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

SPECIAL REQUIREMENTS FOR THE PH.D. DEGREE

Each entering student is assigned a pre-thesis faculty adviser who is responsible for establishing the student's initial course of study and for monitoring the student's progress. This adviser will subsequently be modified to a faculty committee 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 four core required courses: Bioethics in Neuroscience (INP 5580), Principles of Neuroscience (INP 5701), Foundations of Cellular and Molecular Neurobiology (INP 5702), and Foundations of Systems Neuroscience (INP 5703), all completed in the first year of enrollment.

During the second or third year of enrollment, students are required to take one course on quantitative techniques (including, but not limited to, INP 7560, PSYC 2100, PSYC 5580, INP 7562, INP 7575, INP 7599, PSYC 2610) as well as one elective course selected from a broad set of neuroscience-related courses. Collectively, these courses are designed to ensure broad competence in modern neuroscience.

Additional degree requirements are successful completion of both terms of Lab Rotations for First-Year Students (INP 6511, INP 6512), which includes rotating in at least three labs; both terms of Second-Year Thesis Research (INP 6513, INP 6514); and RCR Bioethics Refresher course (INP 5503) completed during the fourth year of enrollment.

The graduate school uses grades of Honors, High Pass, Pass, and Fail and requires two course grades of Honors during the first two years of study. Students are expected to maintain at least a High Pass average.

In accordance with the expectations of the BBS program, Ph.D. students are also expected to participate in two terms (or the equivalent) of teaching.

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. After admission to candidacy, thesis committee meetings are required at six-month intervals.

Also required for graduation are 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: one term as a Teaching Fellow; two laboratory rotations while in the medical school prior to degree-program track affiliation; and three courses (Principles of Neuroscience, INP 5701; Structural and Functional Organization of the Human Nervous System, INP 9510; one elective graduate-level course).

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, but have successfully completed all of the requirements other than the thesis prospectus and defense. This includes a passing grade in the required and elective courses, a minimum of two Honors grades, passing a qualifying examination, and successful completion of both terms of Lab Rotation for First-Year Students (INP 6511, INP 6512) and both terms of Second-Year Thesis Research (INP 6513, INP 6514). 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 562b / AMTH 765b / CB&B 5620b / ENAS 5620b / INP 7562b / MB&B 5620b / PHYS 5620b, Modeling Biological Systems II Thierry Emonet, Jing Yan, and Damon Clark

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 5701a, Principles of Neuroscience William Cafferty, Ifat Levy, and Junjie Guo

General neuroscience seminar: lectures, readings, and discussion of selected topics in neuroscience. Emphasis is on how approaches at the molecular, cellular, physiological, and organismal levels can lead to understanding of neuronal and brain function.

INP 5702a, Foundations of Cellular and Molecular Neurobiology Shaul Yogev and James Jeanne

A comprehensive overview of cellular and molecular concepts in neuroscience. Each exam (of three) covers one-third of the course (cell biology, electrophysiology, and synaptic function) and is take-home, with short answer/essay questions.

INP 6511a, Lab Rotations for First-Year Students Marina Picciotto

Required of all first-year neuroscience-track graduate students. Rotation period is one term. Grading is Satisfactory/Unsatisfactory.

INP 6513a, Second-Year Thesis Research Marina Picciotto
Required of all second-year INP graduate students. Grading is Satisfactory/Unsatisfactory.

INP 6519a, Tutorial Marina Picciotto
By arrangement with faculty and approval of DGS.

INP 7562b / AMTH 765b / CB&B 5620b / ENAS 5620b / INP 562b / MB&B 5620b / PHYS 5620b, Modeling Biological Systems II Thierry Emonet, Jing Yan, and Damon Clark
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 7575a / CPSC 5750a / ECE 5750a, Computational Vision and Biological Perception Steven Zucker
An overview of computational vision with a biological emphasis. Suitable as an introduction to biological perception for computer science and engineering students, as well as an introduction to computational vision for mathematics, psychology, and physiology students.

INP 9510a, Structural and Functional Organization of the Human Nervous System Thomas Biederer
An integrative overview of the structure and function of the human brain as it pertains to major neurological and psychiatric disorders. Neuroanatomy, neurophysiology, and clinical correlations are interrelated to provide essential background in the neurosciences. Lectures in neurocytology and neuroanatomy survey neuronal organization in the human brain, with emphasis on long fiber tracts related to clinical neurology. Lectures in neurophysiology cover various aspects of neural function at the cellular and systems levels, with a strong emphasis on the mammalian nervous system. Clinical correlations consist of sessions applying basic science principles to understanding pathophysiology in the context of patients. Seven three-hour laboratory sessions are coordinated with lectures throughout the course to provide an understanding of the structural basis of function and disease. Case-based conference sections provide an opportunity to integrate and apply the information learned about the structure and function of the nervous system in the rest of the course to solving a focused clinical problem in a journal club format. Variable class schedule; contact course instructors. This course is offered to graduate and M.D./Ph.D. students only and cannot be audited.

INP 9585b / BENG 5485b, Fundamentals of Neuroimaging Fahmeed Hyder, Elizabeth Goldfarb, and Douglas Rothman
The neuroenergetic and neurochemical basis of several dominant neuroimaging methods, including fMRI. Topics range from technical aspects of different methods to interpretation of the neuroimaging results. Controversies and/or challenges for application of fMRI and related methods in medicine are identified.

INP 9640a, Current Topics in Neuroscience Junjie Guo
In this course, students select three modular "mini-courses" from a list of mini-courses spanning a wide range of topics and techniques in molecular, cellular, systems, and behavioral neuroscience. Prerequisites: INP 5702 and INP 5703 or INP 9720, MCDB 7200, or MCDB 3200.