INTERDEPARTMENTAL NEUROSCIENCE PROGRAM

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

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(*Molecular Biophysics and Biochemistry*), Albert Powers (*Psychiatry*; *Psychology*), Hyojung Seo (*Psychiatry*; *Neuroscience*), David van Dijk (*Internal Medicine*; *Computer Science*), Ilker Yildirim (*Psychology*), Shaul Yogev (*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 coursework, 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.

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

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 initial course of study and for monitoring the student's progress. This committee will subsequently be 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 four core required courses: Bioethics in Neuroscience (INP 580), Principles of Neuroscience (INP 701), Foundations of Cellular and Molecular Neurobiology (INP 702), and Foundations of Systems Neuroscience (INP 703), 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 560, PSYC 200a, INP 558, INP 562, INP 575, INP 599, PSYC 261a, and others with director's approval) 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. 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.

Additional degree requirements are successful completion of both terms of Lab Rotations for First-Year Students (INP 511, INP 512), which includes rotating in at least three labs; both terms of Second-Year Thesis Research (INP 513, INP 514); and RCR Refresher for Senior BBS Students (INP 503) completed during the fourth year of enrollment.

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.

Thesis committee meetings are required at six-month intervals after admission to candidacy. Also required 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: two laboratory rotations are completed while in the medical school prior to degree-program affiliation; three courses are required (Principles of Neuroscience, INP 701; Structural and Functional Organization of the Human Nervous System, INP 510; and one elective graduate-level course). Both terms of Second-Year Thesis Research (INP 513, INP 514) are required. 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 four required courses plus one 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 503b, Bioethics Refresher Course Marina Picciotto and Jessica Cardin
The required fourth-year bioethics refresher course runs during the spring semester. This involves both an independent component based around a series of videos on ethics and an in-person discussion component. The requirement is that we have eight hours of in-person instruction time. We have a two-hour component based on video content generated by the BBS and three classroom sessions of two hours each. These sessions are NIH-mandated, so please plan to attend.

INP 510a, 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 511a and INP 512b, Lab Rotations for First-Year Students Staff
Required of all first-year Neuroscience track graduate students. Rotation period is one term. Grading is Satisfactory/Unsatisfactory.

INP 513a and INP 514b, Second-Year Thesis Research Staff
Required of all second-year INP graduate students. Grading is Satisfactory/ Unsatisfactory.

INP 519a, Tutorial Staff
By arrangement with faculty and approval of DGS.

INP 521b, Neuroimaging in Neuropsychiatry II: Clinical Applications Maggie Davis and Irina Esterlis
Neuroimaging methodologies including Positron Emission Tomography (PET), Single Photon Emission Computed Tomography (SPECT), Magnetic Resonance Imaging (MRI), functional Magnetic Resonance Imaging (fMRI), and Magnetic Resonance Spectroscopy (MRS) are rapidly evolving tools used to study the living human brain. Neuroimaging has unprecedented implications for routine clinical diagnosis, for assessment of drug efficacy, for determination of psychotropic drug occupancy, and for the study of pathophysiological mechanisms underlying neurologic and psychiatric disorders. The course is designed to provide an overview of the application of state-of-the-art neuroimaging methods to research in neurologic and psychiatric disorders.

INP 542b, Developing and Writing Fellowship Proposals Ifat Levy and Dustin Scheinost
In this course, students learn how fellowship award review panels are run and what the selection criteria are. The NIH National Research Service Award (NRSA) Fellowship is used as the main framework for learning. Students develop NIH-style Biosketches, learn to generate key points in the NIH Research Training Plan, and learn how to write a Specific Aims page and what to consider for the Project Narrative. Through student-led groups, students learn how to critique Specific Aims pages, with input from instructors, and then develop Project Narratives with specific focuses on effective communication of the underlying hypotheses, impact and significance, and experimental plans.

INP 552a, Critical Thinking in Learning and Memory George Dragoi
Are you interested in a neuroscience approach and its dual perspectives to understanding neuronal ensemble mechanisms underlying learning and episodic memory formation? This course aims to engage students in critical thinking of classic neuroscience readings in learning and memory. Pairs of key studies in the field of learning and memory are discussed and debated either as dual perspectives on a given topic or as complementary approaches to aspects of learning and memory. The course goals are twofold: first, to develop and further students' critical thinking in neuroscience and related fields; second, to acquire key concepts and knowledge in the field of learning and memory. The focus is on studies revealing the role of medial

temporal lobe and limbic structures in learning and memory, primarily in humans and rodents.

INP 562b / AMTH 765b / CB&B 562b / ENAS 561b / MB&B 562b / MCDB 562b / PHYS 562b, Modeling Biological Systems II Thierry Emonet
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 575a / CPSC 575a / ENAS 575a, 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 585b / ENAS 585b, Fundamentals of Neuroimaging Fahmeed Hyder 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 701a, 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 702a, Foundations of Cellular and Molecular Neurobiology Janghoo Lim, 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 720a / MCDB 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.