CELLULAR AND MOLECULAR PHYSIOLOGY

Sterling Hall of Medicine B147, 203.785.4041
http://medicine.yale.edu/physiology
M.S., M.Phil., Ph.D.

Chair
Michael Caplan

Director of Graduate Studies
David Zenisek (SHM B114, 203.785.6474, david.zenisek@yale.edu)

Professors Nadia Ameen (*Pediatrics*), Peter Aronson (*Internal Medicine/Nephrology*), Angelique Bordey (*Neurosurgery*), Cecilia Canessa, Lloyd Cantley (*Internal Medicine/Nephrology*), Michael Caplan, Alan Dardik (*Surgery*), Jonathan Demb (*Ophthalmology and Visual Science*), Marie Egan (*Pediatrics*), Barbara Ehrlich (*Pharmacology*), Anne Eichmann, Tore Eid (*Laboratory Medicine*), Shuta Ishibe (*Internal Medicine/Nephrology*), Leonard Kaczmarek (*Pharmacology*), Richard Kibbey (*Internal Medicine/Endocrinology*), George Lister (*Pediatrics*), Pramod Mistry (*Internal Medicine/Digestive Diseases; Pediatrics*), Michael Nitabach, Vincent Pieribone, Patricia Preisig (*Internal Medicine/Nephrology*), W. Mark Saltzman (*Biomedical Engineering*), Joseph Santos-Sacchi (*Surgery/Otolaryngology*), Gerald Shulman (*Internal Medicine/Endocrinology*), Fred Sigworth, Susumu Tomita, C. Shan Xu, Xiaoyong Yang (*Comparative Medicine*), Lawrence Young (*Internal Medicine/Cardiology*), David Zenisek, Z. Jimmy Zhou (*Ophthalmology and Visual Science*)

Associate Professors Nii Addy (*Psychiatry*), Sviatoslav Bagriantsev, Nigel Bamford (*Neurology*), Stuart Campbell (*Biomedical Engineering*), Jean-Ju Chung, Julie Goodwin (*Pediatrics/Nephrology*), Elena Gracheva, Erdem Karatekin, Jesse Rinehart, Matthew Rodeheffer (*Comparative Medicine*), Carson Thoreen

Assistant Professors Rui Chang, Ji Yeon Kim (*Urology*), Rachel Perry, Marc Schneeberger, Hongying Shen

FIELDS OF STUDY

Fields of study range from cellular and molecular physiology to integrative medical biology. Areas of current interest include: ion channels, transporters and pumps, membrane biophysics, cellular and systems neurobiology, protein trafficking, epithelial transport, signal transduction pathways, cardiovascular biology, sensory physiology, metabolism, organ physiology, genetic models of human disease, pathophysiology, structural biology of membrane proteins, and physiological genomics.

To enter the Ph.D. program, students typically enter via the Translational Molecular Medicine, Pharmacology, and Physiology (TMMPP) track within the interdepartmental graduate program in Biological and Biomedical Sciences (BBS), https://medicine.yale.edu/bbs.

SPECIAL REQUIREMENTS FOR THE PH.D. DEGREE

Formal requirements for the Ph.D. degree include two or three terms of course work, a qualifying examination taken by the end of the second year, submission of a thesis prospectus, two terms of teaching, and completion and satisfactory defense of the thesis.

Students are expected to design a suitable program of courses in consultation with a faculty adviser. The director of graduate studies (DGS) will provide general oversight of the course selections. These courses will provide a coherent background for the expected area of thesis research and also satisfy the department's subject and proficiency requirements. Students must satisfactorily pass at least six graduate-level courses, including C&MP 550, C&MP 630, and either C&MP 560 or C&MP 580. Also during the first two terms, each student should explore research projects by performing rotations in at least three laboratories to create an informed basis upon which to select a thesis project by the end of the first year. There is no foreign language requirement. The qualifying examination, which must be passed by the end of the student's fourth term, will cover areas of physiology that complement the student's major research interest.

An important dimension of graduate training in Cellular and Molecular Physiology is the acquisition of teaching skills through participation in courses appropriate for the student's academic interests. Ph.D. students are expected to participate in two terms (or the equivalent) of teaching. Students are not expected to teach before passing the qualifying examination.

In addition to all other requirements, students must successfully complete C&MP 650, The Responsible Conduct of Research, prior to the end of their first year of study; and, in their fourth year of study, all students must successfully complete B&BS 503, RCR Refresher for Senior BBS Students.

After satisfying the departmental predissertation requirements, passing the qualifying examination, submitting a satisfactory thesis prospectus, and presenting a satisfactory report to the appropriate thesis advisory committee, students are admitted to candidacy. The completed dissertation must describe original research making a significant contribution to knowledge.

HONORS REQUIREMENT

Students must meet the Graduate School's Honors requirement by the end of the fourth term of full-time study. Students must also maintain an overall High Pass average. Student progress toward these goals is reviewed at the end of the second term. Note that Honors grades in C&MP 630 or Lab Rotations courses are not counted towards the Honors requirements.

SPECIAL REQUIREMENTS FOR M.D.–PH.D. STUDENTS

M.D.-Ph.D. students must pass at least three graduate-level courses that are not part of the Yale School of Medicine's regular M.D. program, including at least one C&MP course, preferably C&MP 560 or C&MP 580. Courses taken toward the M.D. degree can be counted toward the graduate school's Honors requirement, provided that the course carries a graduate course number and the student has registered for it as a graduate

course. Two laboratory rotations, each lasting five weeks, and one term of teaching are required.

MASTER'S DEGREES

M.Phil. See Degree Requirements under Policies and Regulations. Awarded to students who have fulfilled all the requirements for the Ph.D. except the prospectus, teaching requirement, and dissertation, normally at the end of the second year. Students are not admitted for this degree.

M.S. Awarded only to students who are not continuing for the Ph.D. degree but who have successfully completed one year of the doctoral program (i.e., passing of at least four graduate-level courses, including two Honors grades, and three successful laboratory rotations). 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 materials are available upon request to the Department Registrar, Department of Cellular and Molecular Physiology, Yale School of Medicine, PO Box 208026, New Haven CT 06520-8026.

COURSES

C&MP 506a / PATH 620a / PHAR 506a / PTB 620a, Lab Rotations Staff
Students work in laboratories of faculty of their choice. The schedule for each rotation is announced at the beginning of the fall term.

C&MP 550a / ENAS 550a / MCDB 550a / PHAR 550a / PTB 550a, Physiological Systems W. Mark Saltzman and Stuart Campbell
The course develops a foundation in human physiology by examining the homeostasis of vital parameters within the body, and the biophysical properties of cells, tissues, and organs. Basic concepts in cell and membrane physiology are synthesized through exploring the function of skeletal, smooth, and cardiac muscle. The physical basis of blood flow, mechanisms of vascular exchange, cardiac performance, and regulation of overall circulatory function are discussed. Respiratory physiology explores the mechanics of ventilation, gas diffusion, and acid-base balance. Renal physiology examines the formation and composition of urine and the regulation of electrolyte, fluid, and acid-base balance. Organs of the digestive system are discussed from the perspective of substrate metabolism and energy balance. Hormonal regulation is applied to metabolic control and to calcium, water, and electrolyte balance. The biology of nerve cells is addressed with emphasis on synaptic transmission and simple neuronal circuits within the central nervous system. The special senses are considered in the framework of sensory transduction. Weekly discussion sections provide a forum for in-depth exploration of topics. Graduate students evaluate research findings through literature review and weekly meetings with the instructor.

C&MP 560b / ENAS 570b / MCDB 560b / PHAR 560b, Cellular and Molecular Physiology: Molecular Machines in Human Disease Emile Boulpaep and Peter Takizawa
The course focuses on understanding the processes that transfer molecules across membranes at the cellular, molecular, biophysical, and physiological levels. Students learn about the different classes of molecular machines that mediate membrane transport, generate electrical currents, or perform mechanical displacement. Emphasis is placed on the relationship between the molecular structures of membrane proteins

and their individual functions. The interactions among transport proteins in determining the physiological behaviors of cells and tissues are also stressed. Molecular motors are introduced and their mechanical relationship to cell function is explored. Students read papers from the scientific literature that establish the connections between mutations in genes encoding membrane proteins and a wide variety of human genetic diseases.

C&MP 600a and C&MP 601b, Medical Physiology Case Conferences Emile Boulpaep
Two-term course taught in groups of ten to twelve students by the same group leader(s) throughout the year. Workshop format permits students to apply basic concepts of physiology to clinical syndromes and disease processes. Students are expected to participate actively in a weekly discussion of a clinical case that illustrates principles of human physiology and pathophysiology at the whole-body, system, organ, cellular, or molecular level. Prerequisites: C&MP 550 and permission of the instructor. Credit for full year only.

C&MP 610a / PTB 610a, Medical Research Scholars Program: Mentored Clinical Experience Yelizaveta Konnikova and Richard Pierce
The purpose of the Mentored Clinical Experience (MCE), an MRSP-specific course, is to permit students to gain a deep understanding of and appreciation for the interface between basic biomedical research and its application to clinical practice. The MCE is intended to integrate basic and translational research with direct exposure to clinical medicine and patients afflicted with the diseases or conditions under discussion. The course provides a foundation and a critically important forum for class discussion because each module stimulates students to explore a disease process in depth over four ninety-minute sessions led by expert clinician-scientists. The structure incorporates four perspectives to introduce the students to a particular disease or condition and then encourages them to probe areas that are not understood or fully resolved so they can appreciate the value and challenge inherent in using basic science to enhance clinical medicine. Students are provided biomedical resource material for background to the sessions as well as articles or other publicly available information that offers insight to the perspective from the non-scientific world. During this course students meet with patients who have experienced the disease and/or visit and explore facilities associated with diagnosis and treatment of the disease process. Students are expected to prepare for sessions, to participate actively, and to be scrupulously respectful of patients and patient facilities. Prior to one of the sessions students receive guidance as to what they will observe and how to approach the experience; and at the end of the session, the students discuss their thoughts and impressions. All students receive HIPAA training and appropriate training in infection control and decorum relating to patient contact prior to the course.

C&MP 629a and C&MP 630b / PATH 679a and PATH 680b / PHAR 501a and PHAR 502b / PTB 629a and PTB 630b, Seminar in Molecular Medicine, Pharmacology, and Physiology Staff
Readings and discussion on a diverse range of current topics in molecular medicine, pharmacology, and physiology. The class emphasizes analysis of primary research literature and development of presentation and writing skills. Contemporary articles are assigned on a related topic every week, and a student leads discussions with input from faculty who are experts in the topic area. The overall goal is to cover a specific topic of medical relevance (e.g., cancer, neurodegeneration) from the perspective of three

primary disciplines (i.e., physiology: normal function; pathology: abnormal function; and pharmacology: intervention). Required of and open only to Ph.D. and M.D./Ph.D. students in the Molecular Medicine, Pharmacology, and Physiology track.

C&MP 650b / PATH 660b / PHAR 580b / PTB 650b, The Responsible Conduct of Research Staff

Organized to foster discussion, the course is taught by faculty in the Pharmacology, Pathology, and Physiology departments and two or three senior graduate students. Each session is based on case studies from primary literature, reviews, and two texts: Francis Macrina's *Scientific Integrity* and Kathy Barker's *At the Bench*. Each week, students are required to submit a reaction paper discussing the reading assignment. Students take turns leading the class discussion; a final short paper on a hot topic in bioethics is required.

C&MP 710b / MB&B 710b, Electron Cryo-Microscopy for Protein Structure Determination Staff

Understanding cellular function requires structural and biochemical studies at an ever-increasing level of complexity. The course is an introduction to the concepts and applications of high-resolution electron cryo-microscopy. This rapidly emerging new technique is the only method that allows biological macromolecules to be studied at all levels of resolution from cellular organization to near atomic detail. ½ Course cr

C&MP 711b / MB&B 711b, Practical cryo-EM Workshop Yong Xiong and Franziska Bleichert

This laboratory course provides hands-on training in the practical aspects of macromolecular structure determination by cryo-electron microscopy (cryo-EM). Topics include cryo-EM data collection, image preparation and correction, single-particle picking and 2-D classification, 3-D classification, refinement and post-processing, model building, refinement and evaluation. The course includes training in the use of computer programs used to perform these calculations. Prerequisite: MB&B 710/C&MP 710. ½ Course cr