

PATHOLOGY AND MOLECULAR MEDICINE

140 Brady Memorial Laboratory

<https://medicine.yale.edu/pathology/training/graduateprogram>

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

Chair

Chen Liu

Director of Graduate Studies

Themis Kyriakides

Professors Nita Ahuja (*Surgery*), Ranjit Bindra (*Therapeutic Radiology*), Marcus Bosenberg (*Dermatology*), Richard Bucala (*Internal Medicine*), Sandy Chang (*Laboratory Medicine*), Keith Choate (*Dermatology*), Vishwa Deep Dixit, Rong Fan (*Biomedical Engineering*), Carlos Fernandez-Hernando (*Comparative Medicine*), Gary Friedlaender (*Orthopedics and Rehabilitation*), Patrick Gallagher (*Pediatrics*), Erica Herzog (*Internal Medicine*), Robert Homer, Steven Kleinstein, Yuval Kluger, Christine Ko (*Dermatology*), Diane Krause (*Laboratory Medicine*), Themis Kyriakides, Francis Lee (*Orthopaedics and Rehabilitation*), Chen Liu, Vincent Marchesi, Gilbert Moeckel, Ruth Montgomery (*Rheumatology*), Jon Morrow, Jordan Pober (*Immunobiology*), Katerina Politi, David Rimm, David Stern, Yajaira Suarez (*Comparative Medicine*), Qin Yan

Associate Professors Demetrios Braddock, Karin Finberg, Joanna Gibson, Stephanie Halene (*Hematology*), Anita Huttner, Ryan Jensen (*Therapeutic Radiology*), Samuel Katz, Peggy Myung (*Dermatology*), Don Nguyen, Manoj Pillai (*Hematology*), Kurt Schalper, Yibing Qyang (*Internal Medicine*), Silvia Vilarinho (*Internal Medicine*), Dean Yimlamai (*Pediatrics*)

Assistant Professors Arnaud Augert, Mathieu Bakhoun (*Ophthalmology and Visual Sciences*), Gianfilippo Coppola, William Damsky (*Dermatology*), Marcello DiStasio, Romina Fiorotto (*Internal Medicine*), Salil Garg (*Lab Medicine*), Pallavi Gopal, Brian Hafler (*Neurology*), Albert Higgins-Chen (*Psychiatry*), Won Jae Huh, Jeffrey Ishizuka (*Medical Oncology*), Nelson LaMarche, Stephania Libreros, Yang Liu, Caleigh Mandel-Brehm, Sathish Ramakrishnan, Jenny Huanjiao Zhou

FIELDS OF STUDY

Fields include molecular medicine with an emphasis on disease mechanisms and therapies, including cancer; biology, biochemistry, genetics, and pathology of molecules, cells, tissues, and organ systems, including plasma membrane dynamics, mitochondrial dysfunction, signal transduction, and response to stimuli of connective tissue; assembly of viruses and their interactions with animal cells; somatic cell genetics and birth defects; biology of endothelial cells; and computational and high-throughput approaches to understanding disease pathology.

To enter the Ph.D. program, students apply to an interest-based track, usually the Translational Molecular Medicine, Pharmacology, and Physiology track (TMMPP), within the interdepartmental graduate program in Biological and Biomedical Sciences

(BBS), <https://medicine.yale.edu/bbs>. After successful completion of year one, BBS students will choose a department to join.

SPECIAL REQUIREMENTS FOR THE PH.D. DEGREE

Course Requirements Pathology and Molecular Medicine students are required to complete the following core requirements: pass PATH 640, Developing and Writing a Scientific Research Proposal; PATH 650, Biology of Cancer; PATH 679 and PATH 680, Seminar in Molecular Medicine, Pharmacology and Physiology (if not already taken in first year) and PATH 690, Molecular Mechanisms of Disease. In addition, students must take two graduate-level electives, which can include courses in biochemistry, genetics, immunology, cell biology, and pathology, to be chosen in consultation with the director of graduate studies (DGS), based on the student's background and interest. All requirements of the graduate school must be met including the school's two Honors Grade 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. Students are also required to complete three laboratory rotations. In their first year, students must successfully complete PATH 660, Responsible Conduct of Research. In their fourth year of study, all students must successfully complete B&BS 503, RCR Refresher for Senior BBS Students.

Teaching Requirements In accordance with the BBS program, Ph.D. students are expected to participate in two terms (or the equivalent) as a Teaching Fellow. Teaching assignments in fulfillment of the requirement must be approved in advance by the DGS. Pathology students do not teach in year one and two unless special circumstance and approved by the DGS.

Qualifying Examination The qualifying examination of the Pathology and Molecular Medicine graduate program comprises: (1) enrollment in the BBS/Pathology course PATH 640, Developing and Writing a Scientific Research Proposal in the fall term of year two and preparation of a proposal on the topic of the student's research; students will receive assistance from a faculty member who will later be part of the qualifying committee; (2) two literature reading periods in the spring term of year two that are specifically related to the grant proposal; and (3) an oral exam in which the student is examined by the qualifying exam committee on the research proposal, the reading periods, and general knowledge of experimental pathology. This exam is usually taken in the second term of the second year and is described below.

The qualifying examination committee, consisting of three faculty members, will be chosen to examine the student. At least two of the committee members must have appointment in the Department of Pathology (one primary required). The thesis adviser is not on the exam committee. The membership of the committee must be approved by the DGS. The student will read with two committee members. The faculty member who assisted the student during the proposal writing period will serve as the third person on the committee. At the oral exam, one member of the committee will be selected as the chairperson responsible for documenting the results of the exam for submission to the DGS. Members of the exam committee should have expertise in areas chosen for reading.

Prospectus and Admission to Candidacy Upon successful completion of the qualifying examination, the student will constitute a dissertation committee including

at minimum three members in addition to the dissertation/thesis adviser. At least two of the committee members must be Pathology department faculty. The membership of the committee must be approved by the DGS. The student will prepare a written thesis prospectus, consisting of a summary of background information in the field of interest, the specific questions to be answered, a rationale for choosing those questions, and a research plan for addressing those questions. Upon completing the course requirement with at least two terms of Honors, passing the qualifying examination, and submitting a thesis prospectus, students will be admitted to candidacy. This should take place by the end of the third year. Students must then submit a written thesis describing the research and present a thesis research seminar.

M.D.-PH.D. STUDENTS

M.D.-Ph.D. students must satisfy all the requirements listed above for the Ph.D. with the following modifications: Two laboratory rotations are required. Serving as a teaching fellow for one term is required. Five courses are required for the Ph.D., including PATH 640, Developing and Writing a Scientific Research Proposal; PATH 650, Biology of Cancer; PATH 679 and PATH 680, Seminar in Molecular Medicine, Pharmacology and Physiology; and PATH 690, Molecular Mechanisms of Disease. With DGS approval, an equivalent for PATH 660 is allowed.

See Graduate School Degree Requirements under Policies and Regulations.

MASTER'S DEGREES

See Graduate School Degree Requirements under Policies and Regulations.

M. Phil. See Degree Requirements under Policies and Regulations. The M. Phil. is awarded only to students who are continuing for the Ph.D. Students are not admitted for this degree. Students will be automatically petitioned by the university for a M.Phil. after successful completion of the requirements at the end of the third year. No additional action is required on the part of the student.

M.S. Students are not admitted for this degree. On a case-by-case basis and subject to faculty vote, students who are not continuing for the Ph.D. may be considered for an M.S. degree if they have successfully completed the course requirements for the Ph.D. degree listed above and received a grade of Honors in at least two courses to meet the graduate school's requirements. Students who meet this criterion are eligible to petition for the M.S. degree.

Additional information can be found on the Pathology and Molecular Medicine graduate-student website, <https://medicine.yale.edu/pathology/training/graduateprogram>.

PATH 620a / C&MP 506a / 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.

PATH 630b / ENAS 535b, Biomaterial-Tissue Interactions Themis Kyriakides
Study of the interactions between tissues and biomaterials, with an emphasis on the importance of molecular- and cellular-level events in dictating the performance and longevity of clinically relevant devices. Attention to specific areas such as biomaterials

for tissue engineering and the importance of stem/progenitor cells, as well as biomaterial-mediated gene and drug delivery.

PATH 640a / B&BS 640a, Developing and Writing a Scientific Research Proposal

Katerina Politi

The course covers the intricacies of scientific writing and guides students in the development of a scientific research proposal on the topic of their research. All elements of an NIH fellowship application are covered, and eligible students submit their applications for funding. Enrollment limited to twelve. Required of second-year graduate students in Pathology and Molecular Medicine. Registration allowed by prior authorization from course directors only.

PATH 650b, Biology of Cancer David Stern

A comprehensive survey of cancer research from the cellular to the clinical level. The relation of cancer to intracellular and intercellular regulation of cell proliferation is emphasized, as are animal models for cancer research. Background in molecular genetics and cell biology is assumed. Open to advanced undergraduates with permission of the organizers.

PATH 660b / C&MP 650b / 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.

PATH 679a and PATH 680b / C&MP 629a and C&MP 630b / 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.

PATH 681a, Advanced Topics in Cancer Biology Kurt Schalper

This advanced course focuses on readings and discussion on three or four major topics in cancer biology, such as targeted therapy, tumor immunology, tumor metabolism, and genomic evolution of cancer. For each topic, the class starts with an interactive lecture, followed by critical analysis of primary research literature. Recent research articles are assigned, and a student leads discussions with input from faculty who are experts in the topic area. Prerequisite: PATH 650 or permission of the instructor. Open to all Ph.D., M.D./Ph.D., and M.P.H. students and to advanced undergraduates at the discretion of the instructor.

PATH 690a / PTB 690a, Molecular Mechanisms of Disease Demetrios Braddock

This course covers aspects of the fundamental molecular and cellular mechanisms underlying various human diseases. Many of the disorders discussed represent major forms of infectious, degenerative, vascular, neoplastic, and inflammatory disease. Additionally, certain rarer diseases that illustrate good models for investigation and/or application of basic biologic principles are covered in the course. The objective is to highlight advances in experimental and molecular medicine as they relate to understanding the pathogenesis of disease and the formulation of therapies.