Micheal K. Bongers 

under the direct supervision of a faculty member. In the third year, students organize their thesis committee and prepare a dissertation with the variety of research opportunities available in the program. Students must take a minimum of four courses, three of which have to be in microbiology. Students must study tailored to the individual's background and career goals. A program of course work may include general microbiology, virology, molecular biology is recommended; the GRE General Test or MCAT is required.

To enter the Ph.D. program, students apply to the Microbiology track within the interdepartmental graduate program in the Biological Medicine/Infectious Diseases

Associate Professors

Stavroula Hatzios (Molecular, Cellular, & Developmental Biology), Nikhil Malvankar (Molecular Biophysics & Biochemistry), Noah Palm (Immunobiology), E. Hesper Rego (Microbial Pathogenesis), Aaron Ring (Immunobiology)

FIELDS OF STUDY

The Graduate Program in Microbiology is a multidisciplinary, interdisciplinary Ph.D. program in training and research in the study of microorganisms and their effects on their hosts. The faculty of the program share the view that understanding the biology of microorganisms requires a multidisciplinary approach; therefore, the Microbiology graduate program emphasizes the need for strong multidisciplinary training. The program is designed to provide individualized education in modern microbiology and to prepare students for independent careers in research and teaching. Students can specialize in various areas, including bacteriology, virology, microbe-host interactions, microbial pathogenesis, cell biology and immunobiology of microbial infections, microbial genetics and physiology, parasitology, microbiome, and microbial ecology and evolution.

SPECIAL ADMISSIONS REQUIREMENTS

To enter the Ph.D. program, students apply to the Microbiology track within the interdepartmental graduate program in the Biological and Biomedical Sciences (BBS), http://bbs.yale.edu. An undergraduate major in biology, biophysics, biochemistry, microbiology, or molecular biology is recommended; the GRE General Test or MCAT is required.

SPECIAL REQUIREMENTS FOR THE PH.D. DEGREE

Course work generally occupies the first two years of study. Each student, together with a faculty committee, outlines a course of study tailored to the individual's background and career goals. A program of course work may include general microbiology, virology, parasitology, and/or microbial genetics, as well as complementary courses in such areas as epidemiology, cell biology, immunology, biochemistry, and genetics. Students must take a minimum of four courses, three of which have to be in microbiology. Students must receive a grade of Honors in two full-term courses. All students participate in three laboratory rotations (MBIO 670, MBIO 671, and MBIO 672), with different faculty members, in their area of interest. Laboratory rotations ensure that students quickly become familiar with the variety of research opportunities available in the program. An individualized qualifying exam on topics selected by each student, in consultation with the faculty, is given before the end of the second year. Students then undertake an original research project under the direct supervision of a faculty member. In the third year, students organize their thesis committee and prepare a dissertation
prospectus, which is submitted to the Graduate School after approval by their committee. The student is then admitted to candidacy. Upon completion of the student's research project, the Ph.D. requirements conclude with the writing of a dissertation and its oral defense.

An important aspect of graduate training in microbiology is the acquisition of teaching skills through participation in courses appropriate for the student's scientific interests. These opportunities can be drawn from a diverse menu of lecture, laboratory, and seminar courses given at the undergraduate, graduate, and medical school levels. Ph.D. students are expected to participate in two terms (or the equivalent) of teaching. Students are not permitted to teach during their first year.

In addition to all other requirements, students must successfully complete IBIO 601, Fundamentals of Research: Responsible Conduct of Research, prior to the end of their first year of study. This requirement must be met prior to registering for a second year of study. In their fourth year of study, all students must successfully complete B&B 503, RCR Refresher for Senior BBS Students.

**MASTER’S DEGREES**

**M.Phil.** The M.Phil. degree can be awarded to Ph.D. students who have been admitted to candidacy. See Degree Requirements under Policies and Regulations.

**M.S.** This degree may only be granted to students who are withdrawing from the Ph.D. program prior to advancing to candidacy. To be eligible for this degree, a student must have completed at least four graduate-level term courses at Yale, chosen from a number of main courses including, but not limited to: MBIO 685, MBIO 530, MBIO 734, MBIO 680, and CBIO 602. Two of these four courses must be related to microbiology. Students must have received at least one Honors or two High Pass grades. In addition, students must have received a Satisfactory grade in the following courses: IBIO 601, MBIO 701, MBIO 702, MBIO 670, MBIO 671, and MBIO 672. Students who are eligible for or who have already received the M.Phil. will not be awarded the M.S.

**COURSES**

**MBIO 530a / IBIO 530a / MCDB 530a, Biology of the Immune System**  Eric Meffre, David Schatz, Peter Cresswell, Joao Pedro Pereira, Ruslan Medzhitov, Akiko Iwasaki, Craig Roy, Noah Palm, Susan Kaech, Kevan Herold, Carla Rothlin, and Carrie Lucas
The development of the immune system. Cellular and molecular mechanisms of immune recognition. Effector responses against pathogens. Immunologic memory and vaccines. Human diseases including allergy, autoimmunity, cancer, immunodeficiency, HIV/AIDS.

**MBIO 561a / CB&B 561a / MB&B 561a / MCDB 561a / PHYS 561a, Introduction to Dynamical Systems in Biology**  Damon Clark, Kathryn Miller-Jensen, and Jonathan Howard
Study of the analytic and computational skills needed to model genetic networks and protein signaling pathways. Review of basic biochemical concepts including chemical reactions, ligand binding to receptors, cooperativity, and Michaelis-Menten enzyme kinetics. Deep exploration of biological systems including: kinetics of RNA and protein synthesis and degradation; transcription activators and repressors; lysogeny/lysis switch of lambda phage and the roles of cooperativity and feedback; network motifs such as feed-forward networks and how they shape response dynamics; cell signaling, MAP kinase networks and cell fate decisions; bacterial chemotaxis; and noise in gene expression and phenotypic variability. Students learn to model using MATLAB in a series of in-class hackathons that illustrate biological examples discussed in lectures.

**MBIO 601b, Fundamentals of Research: Responsible Conduct of Research**  Staff
A weekly seminar presented by faculty trainers on topics relating to proper conduct of research. Required of first-year Immunobiology students, first-year CB&B students, and training grant-funded postdocs. Pass/Fail. 6 Course cr

**MBIO 670a and MBO 671b and MBIO 672b, Laboratory Rotations**  Walther Mothes
Rotation in three laboratories. Required of all first-year graduate students.

**MBIO 680b, Advanced Topics in Tropical Parasitic Diseases**  Christian Tschudi
An introductory topic-based course in modern parasitology. For each topic there is an introductory lecture followed by a journal club-like discussion session of relevant papers selected from the literature. The course provides an introduction to basic biological concepts of parasitic eukaryotes causing diseases in humans. Topics include strategies used by parasitic eukaryotes to establish infections in the host and approaches to disease control, through either chemotherapy, vaccines, or genomics. In addition, emphasis is placed on evaluating the quality and limitation of scientific publications and developing skills in scientific communication. Prerequisite: permission of the instructor.

**MBIO 685b, The Biology of Bacterial Pathogens II**  Andrew Goodman
This interdisciplinary course focuses on current topics related to host-pathogen interactions. Each week a lecture is given on the topic, followed by student presentations of seminal papers in the field. All participants are required to present a paper.

**MBIO 686a, The Biology of Bacterial Pathogens**  Eduardo Groisman
The course provides an introduction to basic principles in bacterial pathogenesis. Topics focus on the bacterial determinants mediating infection and pathogenesis, as well as strategies to prevent and treat diseases. Each week a lecture is given on the topic, followed by student presentations of seminal papers in the field. All participants are required to present a paper.

**MBIO 700b, Seminal Papers on the Foundations of Modern Microbiology**  Priti Kumar
A required course for Microbiology first- and second-year students; not for credit. The course is offered every other year, alternating with MBIO 703, so that it can be taken once during each student’s tenure in the program. Students present and discuss papers describing fundamental discoveries in areas related to microbiology. The goal is to familiarize students with the process of scientific discovery, and
with the history of major developments in the field. Topics include important discoveries involving major human pathogens, fundamental processes in molecular biology, and the development of technology that has a major impact on current biomedical research.

**Course descriptions**

**MBIO 701a and MBIO 702b, Research in Progress**  Walther Mothes
All students, beginning in their third year, are required to present their research once a year at the Graduate Student Research in Progress. These presentations are intended to give each student practice in presenting the student’s own work before a sympathetic but critical audience and to familiarize the faculty with the research.

**MBIO 703a and MBIO 704b, Microbiology Seminar Series**  Walther Mothes
All students are required to attend all Microbiology seminars scheduled throughout the academic year. Microbiologists from around the world are invited to describe their research.