

# Microbiology and Immunology

## Degrees Offered

Doctor of Philosophy

## Program Admissions Requirements

*In addition to the general **Graduate School admission requirements**, this program has additional specific requirements.*

Students enter the graduate program in the Department of Microbiology and Immunology through the **Interdisciplinary Program in Biomedical Sciences (IDP), the Neuroscience Doctoral Program (NDP), or the Medical Scientist Training Program (MSTP)**. Students who choose a mentor in the Department of Microbiology and Immunology will enter the department upon satisfactory completion of a written and/or oral qualifying examination.

## Fields of Research

The following areas of research in the Department of Microbiology and Immunology offer excellent opportunities for graduate dissertation projects:

### Molecular Biology of Bacterial Pathogenesis

- Characterization of the molecular properties of bacterial exotoxins, with the goals of defining their mode of action and how toxins modify host cell physiology
- Identification of host and bacterial proteins involved in attachment of *Borrelia burgdorferi* and *Leptospira interrogans* to human cells, and the consequences of these interactions for the host
- Investigation of the secretion and function of bacterial virulence factors encoded by *Pseudomonas aeruginosa*
- Studies of the pathogenesis of *Mycobacterium tuberculosis*, with particular emphasis on defining the genetic determinants required for establishment, maintenance and reactivation from latent infection
- Investigation of genetic, biochemical, and signaling pathways required for antimicrobial resistance and gut colonization by enterococci

### The Microbiome

- Role of xenobiotics in disrupting gut microbiota and consequences on metabolism
- Importance of bacteriophage in regulating composition of gut microbiota
- Role of xenobiotics in disrupting the gut microbiota/metabolism,

- two-component signaling, and predatory-prey interactions
- Role of the mosquito microbiome in shaping immune responses to malaria infection

### **Molecular Genetics of Human Viruses**

- Investigation of the molecular mechanisms employed by human herpesviruses to escape detection by the immune system
- Characterization of interactions between cancer-associated gammaherpesviruses and host systems that either promote or restrict lytic and chronic gammaherpesvirus infection, with a particular interest in lipid metabolism
- Investigation of proteins involved in establishing a permissive environment for herpesvirus replication using mass spectrometry

### **Cellular and Molecular Analysis of the Immune Response**

- Autoimmunity. Investigation into roles of T cells and B cells and mechanisms of central and peripheral tolerance in autoimmune disorders including type 1 diabetes, multiple sclerosis, arthritis, and colitis
- Oncology. Basic biology and clinical utilization of T cells, B cells, and Natural Killer cells; characterization of antigen receptor signal transduction and application to tumor immunology; investigation of the immunobiology of bone marrow transplantation
- Inflammation. Basic mechanisms of immune regulation, mechanisms of inflammation; structure and function studies of adhesion molecules and integrins; immunobiology investigations of chemokines and cytokines and their receptors in inflammation, autoimmunity, host defense, and cancer
- Host Defense. Studies of MHC, antigen presentation, innate and adaptive immune responses to bacterial and viral infections, autoimmune diseases, and cancer

### **Molecular Mechanisms of Gene Expression**

- Studies of the role of cellular factors in the control of the pathologic RNA splicing program in cancer, and RNA-based therapeutics
- Studies of the mechanisms and consequences of signal transduction: endothelin-mediated signaling through small GTPases, cyclooxygenase-2, and the prevention of apoptosis.
- Study of two-component signal transduction networks in bacteria
- Studies of mosquito non-coding genetic variation in transcriptional enhancers and differential malaria susceptibility

### **Program Degree Requirements**

Students entering from the IDP, NDP, or MSTP initially take courses specific to that program. Upon entrance into the Graduate Program in

Microbiology and Immunology, students are required to complete courses in Bioethics and Microbiology/Immunology. Specific requirements are outlined below:

### **Required Courses**

Students entering from the IDP or NDP are required to take 9 credits of advance coursework as a minimum. MSTP students are required to take 6 credits of advanced coursework at a minimum. A requirement of the Microbiology and Immunology Graduate Program is to fulfill two credits in Bioethics by completing Course (10222) "Ethics and Integrity in Science" and Course (10444) "Research Ethics Discussion." For course descriptions of 10222 and 10444 see listing within the **Bioethics Program.**

All students must also complete "Techniques in Molecular and Cellular Biology" (16242), and "Seminar" (25300) for 2 semesters (1 semester if receive A or A-). Finally, students entering from the IDP or NDP need to complete (16270) "Integrated Microbiology and Immunology", (16292) "Writing a Scientific Paper", and (16293) "Writing an Individual Fellowship" which are all from the IDP. Students entering from the MSTP must also take (16217) "Foundations in Biomedical Sciences III" from the IDP.

### **Overall Courses**

#### **25210 Principles of Laboratory Animal Science. 1 credit.**

A one-credit hour course surveying the issues fundamental to the successful use and care of animals in biomedical research. Students will gain knowledge of an array of core topics in laboratory animal science, including: understanding and navigating ethical and regulatory frameworks in which animal research occurs; basic biology and care of common laboratory species; managing rodent breeding colonies; contemporary issues in laboratory rodent genetics; important sources of non-experimental variables in animals research, including nutrition, microbial status, and pain; strategies for minimizing pain and distress in animal subjects; and basic techniques in laboratory rodent handling and restraint.

#### **25230 Current Topics in Microbiology and Immunology. 3 credits.**

This advanced course consists of introductory lectures on a selected topic followed by in-depth discussions of original research articles on topics such as bacterial invasion, virulence factors, immune evasion, virus-host interactions, T-cell functions, and viral regulatory proteins.

**25251 Advanced Molecular Genetics. 3 credits.**

The primary goal of the course is to provide students with experience in the critical evaluation of data presented in original research papers. This course will consist of in-depth discussions of papers from the scientific literature covering selected topics in molecular genetics. Following an introduction to a topic by each instructor, the topic will be explored by discussion of original research papers that have contributed to our understanding of that topic. As a consequence of this paper discussion format, students should also gain an appreciation of different experimental approaches that can be taken to address specific questions in molecular genetics.

**25259 Mucosal Immunity. 1 credit. Prerequisites: 16270.**

This focused immunology course on the mucosal immune system introduces students to advanced concepts and biomedical research relevant to human health and disease at the mucosal surface.

**25260 Mucosal Pathogenesis. 1 credit. Prerequisites: 16270.**

Mucosal Pathogenesis is an upper-level, one-credit hour Microbiology course that focuses on the interactions of microbial pathogens with cells of the mucosal epithelium. Students gain a detailed and comprehensive understanding of specific infectious microbial pathogens, and the mechanisms utilized by the microorganisms to associate, invade, and/or cause disease at the mucosal surface. Microorganisms to be discussed include those that target the respiratory tract, the gastrointestinal tract, and the genital/urinary tract.

**25261 Bacterial Toxin-Mucosal Cell Interactions. 1 credit.**

*Prerequisites: 16270.*

Bacterial Toxin-Mucosal Cell Interactions is a one-credit hour upper-level Microbiology course that addresses the interactions between bacterial toxins and mucosal cells. The goal of this course is to provide students an appreciation of how bacterial toxins that target mucosal cells function as virulence factors and are utilized as vaccines and for clinical therapies. The course format includes formal lectures and paper discussions.

**25262 Tumor Immunology. 1 credit. Prerequisites: 16270.**

This focused immunology course introduces students to advanced concepts and biomedical research relevant to human health and disease.

**25263 Signaling in the Immune System. 1 credit. Prerequisites: 16270.**

This focused immunology course introduces students to advanced concepts and biomedical research relevant to human health and disease.

**25264 Developmental Immunology.** *1 credit. Prerequisites: 16270.*

This focused immunology course introduces students to advanced concepts and biomedical research relevant to human health and disease.

**25265 Immunological Tolerance.** *1 credit. Prerequisites: 16270.*

This focused immunology course introduces students to advanced concepts and biomedical research relevant to human health and disease.

**25266 Clinical Immunology.** *1 credit. Prerequisites: 16270.*

Clinical Immunology is an upper-level, one-credit hour Microbiology course that will provide advanced information and conceptual knowledge regarding the human immune system in health and disease. Specific topics will include primary and secondary immunodeficiencies, autoimmune diseases (systemic autoimmune diseases and autoimmune disease of the skin and gastrointestinal tract), atopic diseases, HLA and bone marrow transplantation. The course will comprise a combination of formal lectures by instructors, and group discussions of scientific papers from the recent literature.

**25269 Advanced Bacterial Physiology.** *1 credit. Prerequisites: 16270.*

Advanced Bacterial Physiology is a 1 credit hour Microbiology course that focuses on fundamental and diverse aspects of bacterial physiology. Students will gain an understanding of the mechanisms bacteria use to execute, coordinate and control basic cellular processes such as macromolecular synthesis, nutrient utilization and metabolism, signal transduction, and stress responses. The course focuses on critical evaluation and discussion of papers from the primary literature. These discussions will be augmented by short didactic presentations of background material by the course director to place the paper's topic and findings in context.

**25271 Membranes and Organelles.** *1 credit. Prerequisites: 16216.*

Membranes and Organelles is an upper-level, one-credit hour Cell Biology course that focuses on the topics of membrane protein trafficking and membrane biogenesis. Students will gain a detailed understanding of organelles and membrane protein trafficking and degradation, membrane vesicle fusion, secretion, and membrane biogenesis. The course will consist in part of readings of seminal papers describing the genetic screens for sec and vps mutants, as well as the Rothman in vitro vesicle fusion experiments. These experiments provide the first description of the proteins we know today to be involved in membrane protein fusion, secretion, and trafficking. After gaining grounding in the design and outcome of these historic screens, the class will focus on what is known today about the initial proteins identified in the original ground-breaking screens. The newer areas of

membrane biology will follow similar format, examining the discovery of paradigm, and delving into what is known today. Students will be evaluated by participation in paper discussion (40%) and an in-class paper presentation (60%). The course will meet twice a week for 6 weeks.

**25280 Immunology Journal Club. 1 credit.**

The purpose of this course is to learn, evaluate and present cutting edge immunological research topics from leading journals to gain knowledge of new immunological findings and to stay current with emerging technologies. Students will attend and present in a weekly independently organized immunology journal club. During the semester, students will be required to attend the journal club and write a short paragraph after each presentation regarding what they learned. This should include: The knowledge gap being addressed, the hypothesis being tested, strengths and weaknesses of the study and resulting conclusions. If a journal club is not scheduled for a particular week, the students will be required to attend an independently organized immunology work-in-progress series. For the students' presentations, students will select a research paper of immunological focus from a list of preapproved journals. While the student can choose any topic of interest, the selection will require approval from the course director. The presentation will consist of a PowerPoint style presentation including the following information: Why the student selected the article, the knowledge gap being addressed, background information supporting the hypothesis, the hypothesis being tested, discussion of the approaches and experimental data, strengths and weaknesses of the study and conclusions including potential future directions. Ultimately, this course is expected to provide students with an expanded knowledge base of current topics in the broad field of immunology.

**25289 Career Internships in the Biomedical Sciences. 0 credits.**

Career Internships in the Biomedical Sciences is a 0-credit training course that will provide students in the Graduate Program in Microbiology and Immunology with an opportunity to complete a semester-long internship in a biomedical science career outside the postdoc-faculty pathway. Currently, this new course is being developed with three internship modules (Teaching, Clinical Microbiology, and Research Core Management); however, it is expected that new internship opportunities will be developed in the future to address additional student interests. Each internship has been developed such that students will gain direct hands-on experience in the career opportunity. Each internship also includes extensive opportunity for one-on-one mentoring with individuals experienced in that career pathway (i.e. site directors, course

directors, research core managers, etc.). As part of each internship, students are required to complete a “scholarly activity” that will employ the use of information and/or techniques that have been acquired during the training period. Finally, site directors and/or other participants active in the student’s training during the internship will complete evaluations providing the student with feedback regarding their performance during the internship

**25298 Classical Papers in Microbiology and Immunology. 1 credit.**

Classical Papers in Microbiology and Immunology (M&I) is a course suitable for all students in the Microbiology and Immunology graduate program. Through this course, instructors and students will review, discuss, and critique notable papers from the last century that have made seminal contributions to the fields of molecular biology, bacteriology, virology, immunology, biochemistry, and/or genetics. The impact of these contributions in the present day will also be discussed. In addition to instructor-identified papers, students will also choose and formally present a recent paper for discussion that they feel has made a substantive contribution to the biomedical sciences. Papers to be discussed are expected to vary between semesters depending on topic of discussion and instructor(s) facilitating the discussion. Ultimately, this course is expected to provide students with an expanded knowledge base of seminal papers in the broad fields of microbiology and immunology.

**25300: Graduate Seminar. 1 credit.**

In this course, students are trained to organize and present a scientific seminar. Students identify an area of interest and select one to several reports from the literature on which to base the seminar. Students are instructed how to develop an effective introduction, how to progress through the description of scientific questions, the presentation of data figures and conclusions, and how to logically tie the data and conclusions together into a coherent and compelling story. Students are required to meet periodically with the course directors prior to their seminar to decide on the seminar topic, to discuss PowerPoint slides, and to conduct practice seminars. Students must also meet with course directors following the seminar to discuss audience comments and recommendations for improvement. Students in the Department of Microbiology and Molecular Genetics (MMG) are required to enroll and complete the seminar course twice as part of their departmental core curriculum. Only one of these seminars may be based on a topic that is related to their research program.

**25295 Reading and Research. 1-9 credit(s).**

**25299: Master Thesis. 6 credits.**

**25399: Doctoral Dissertation. 9 credits.**