

## DEPARTMENT OF BIOLOGY

---

### Graduate Study

The Department of Biology offers graduate work leading to the Doctor of Philosophy. Students may choose from among the following fields of specialization.

**Biochemistry, Biophysics, and Structural Biology** focus on improving our understanding of molecular processes central to life. Using *in vitro* approaches, biochemists and biophysicists analyze the mechanisms of biological information transfer, from maintenance and replication of the genome to protein synthesis, sorting, and processing. Structural biologists elucidate the molecular shapes of biological macromolecules and complexes and determine how structure enables function. Applying principles and tools from chemistry and physics, biochemists and biophysicists elaborate the details of protein and nucleic acid folding and interactions, biomolecular dynamics, catalysis, and macromolecular assembly.

**Cancer Biology** involves the discovery of genes implicated in cancer, the identification of cell biological processes affected during tumorigenesis, and the development of potential new therapeutic targets. Cancer biologists employ genetic approaches, including classical genetics, to determine the components of growth control pathways in model organisms, cloning of human oncogenes and tumor suppressor genes, and generating mutant mouse strains to study these and other cancer-associated genes. They also perform biochemical and cell biological studies to elucidate the function of cancer genes, the details of proliferation, cell cycle and cell death pathways, the nature of cell-cell and cell-matrix interactions, and the mechanisms of chromosome stability and of DNA repair, replication, and transcription.

**Cell Biology** is the study of processes carried out by individual cells, such as cell division, organelle inheritance and biogenesis, signal transduction, and motility. These processes are often affected by components in the environment, including nutrients, growth signals, and cell-cell contact. Cell biologists study these processes using single-celled organisms, such as bacteria and yeast; multicellular organisms, such as zebrafish and mice; established mammalian tissue culture lines; and primary cell cultures derived from recombinant animals.

**Computational Biology** applies quantitative methods to the study of molecular, cellular, and organismal biology. Computational biologists develop and apply models, analyze data, and run simulations to study nucleic acid and protein sequences, biomolecular structures and functions, cellular information processing, tissue morphogenesis, and emergent behaviors.

**Genetics** is the study of genes, genetic variation, and heredity in living organisms that range in complexity from viruses to single-celled organisms to multicellular organisms, including humans.

Geneticists seek to understand the transmission of genes by analyzing DNA replication, DNA repair, chromosome segregation, and cell division. They also use genetic and genomic tools to identify and analyze the genes and gene regulators required for normal biological processes, including development, sex determination, and aging, as well as for the etiology of disease.

**Human Disease** applies molecular genetics to the problems of human disease. The range of disease areas includes developmental defects, cancer, atherosclerosis and heart disease, neuromuscular diseases, and diseases of other organ systems. Researchers use genetic and genomic strategies to identify, isolate, and characterize genes that cause and contribute to the etiology of human diseases. They explore the mechanisms underlying developmental defects and diseases through the comparison of the genetic pathways in humans and model organisms. They also isolate cells from affected patients to generate novel assay systems to examine gene-function-pathology relationships.

**Immunology** focuses on the genetic, cellular, and molecular mechanisms by which organisms respond to and eliminate infections by a large number of pathogens. The immune response requires an elaborate collaboration of different cells of the immune system, including macrophages, B lymphocytes, and T lymphocytes. Immunologists study the role of the immune system not just in response to infection but also in a range of human diseases, including cancer.

**Microbiology** is the study of microscopic organisms, such as bacteria, viruses, archaea, fungi, and protozoa. Exploiting sophisticated genetic, molecular biological, and biochemical systems available for microorganisms, microbiologists obtain high-resolution insights into the fundamental processes necessary for life and explore ways to manipulate microorganisms to achieve particular desired ends. They also determine how aspects of the microbial life cycle and lifestyle enable their survival within particular biological niches and facilitate interactions with their environment.

**Neurobiology** seeks to understand how the remarkable diversity in neuronal cell types and their connections are established and how changes in them underlie learning and thinking. Neurobiologists identify and characterize the molecules involved in specifying neuronal cell fate in vertebrates and invertebrates, and in guiding axons to their correct targets.

**Stem Cell and Developmental Biology** explores how a germ line stem cell develops into a multicellular organism, which requires that cells divide, differentiate, and assume their proper positions relative to one another as they produce organ systems and entire organisms. Stem cells are unusual cells in the body that retain the capacity to both self-renew and differentiate. Stem cell researchers identify the molecular mechanisms underlying stem cell renewal and differentiation, and use stem cells for disease modeling and regenerative medicine.

**Admission Requirements for Graduate Study**

In the Department of Biology, the Master of Science is not a prerequisite for a program of study leading to the doctorate.

The department modifies the General Institute Requirements for admission to graduate study as follows: 18.01 Calculus, 18.02 Calculus; one year of college physics; 5.12 Organic Chemistry I; and professional subjects including general biochemistry, genetics, and physical chemistry. However, students may make up some deficiencies over the course of their graduate work.

**Doctor of Philosophy**

The General Degree Requirements for the Doctor of Philosophy (<https://catalog.mit.edu/mit/graduate-education/general-degree-requirements>) are listed under Graduate Education. In the departmental program, each graduate student is expected to acquire solid foundations sufficient for approaching biological questions using the methods of biochemistry, genetics, and quantitative analysis. Most students take subjects in these areas during the first year. All students are required to take three subjects:

7.50	Method and Logic in Molecular Biology	12
7.51	Principles of Biochemical Analysis	12
7.52	Genetics for Graduate Students	12

7.50 is a seminar designed specifically to introduce graduate students to in-depth discussion and analysis of topics in molecular biology.

Students have a choice of several elective subjects, which have been designed for the entering graduate student. One of the elective subjects must focus on computational and quantitative approaches to biology. Typically, students choose one of the following subjects:

7.571 & 7.572	Quantitative Analysis of Biological Data and Quantitative Measurements and Modeling of Biological Systems	12
7.81[[	Systems Biology	12

In addition to providing a strong formal background in biology, the first-year program serves to familiarize the students with faculty and students in all parts of the department.

**Interdisciplinary Programs****Joint Program with the Woods Hole Oceanographic Institution**

The Joint Program with the Woods Hole Oceanographic Institution (WHOI) (<http://mit.who.edu>) is intended for students whose primary career objective is oceanography or oceanographic engineering. Students divide their academic and research efforts between the campuses of MIT and WHOI. Joint Program students are assigned an MIT or WHOI faculty member as academic advisor; thesis

research may be advised by MIT or WHOI faculty. Pre-candidacy, students are typically in residence at MIT. Once they achieve candidacy, they are expected to live near the same campus as their advisor (MIT or WHOI). Students in the applied ocean science and engineering discipline follow a program similar to that of other students in their home department. MIT-WHOI Joint Program students in other disciplines follow the curriculum set out in their discipline's handbook. The program is described in more detail (<https://catalog.mit.edu/interdisciplinary/graduate-programs/joint-program-woods-hole-oceanographic-institution>) under Interdisciplinary Graduate Programs.

**Master of Engineering in Computer Science and Molecular Biology (Course 6-7P)**

The Departments of Biology and Electrical Engineering and Computer Science jointly offer a Master of Engineering in Computer Science and Molecular Biology (6-7P) (<https://catalog.mit.edu/degree-charts/master-computer-science-molecular-biology-course-6-7p>). A detailed description of the program (<https://catalog.mit.edu/interdisciplinary/graduate-programs/computer-science-molecular-biology>) requirements may be found under the section on Interdisciplinary Programs.

**Financial Support**

Students who are accepted into the graduate program are provided with support from departmental training grants, departmental funds for teaching assistants, and research grants. In addition, some students bring National Science Foundation and other competitive fellowships. Through these sources, full tuition plus a stipend or salary for living expenses are provided.

Students are encouraged to apply for outside fellowships for which they are eligible, such as the NSF Fellowships. Information regarding graduate student fellowships is available at most colleges from the career planning office.

**Inquiries**

Additional information regarding graduate academic programs, research activities, admissions, financial aid, and assistantships may be obtained from the Biology Education Office ([gradbio@mit.edu](mailto:gradbio@mit.edu)), Room 68-120, 617-253-3717.