

Ph.D. Program Information

Last Updated Thursday, September 03 2009

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The Department offers a Ph.D. program that has a standard completion time of 5.5 to six years. [Note: We do not admit students who wish to take the terminal Master's degree. However, when a student experiences a significant change in career orientation after successful completion of the oral exam, a M.A. degree may be awarded.]

The Department provides as much flexibility as possible to students as they develop their scientific interests. Individual curricula and research are arranged in consultation with the student's academic Adviser and Thesis Mentor, and formal course work is usually taken during the first two to three semesters at Berkeley. Because the emphasis of the program is largely on training in research, requirements are defined on the basis of individual needs, enabling students to select from the wide range of courses offered by the Department. Other courses of interest to students are offered in the departments of: Chemistry, Plant and Microbial Biology, Integrative Biology, Physics, Nutritional Sciences and Toxicology, Bioengineering, Public Health and Biomedical and Environmental Health Sciences. While some students elect to concentrate their coursework in specialized research topics, many students choose to construct programs that will provide them with intensive study in more general areas of molecular and cell biology.

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Lab Rotations and Presentations

The first year course work, particularly FERPs (Faculty Evening Research Presentations) and SERPs (Student Evening Research Presentations), set the groundwork for new students in the department. During the first 10 weeks of the Fall semester, faculty discuss the research taking place in their laboratories, providing a great opportunity to hear about research being done throughout the department. In SERPs, each student describes the overall objectives of his/her first rotation project, the experimental approaches used, and the results obtained. There is a second round of SERPs in the Spring in which each student presents the work accomplished during the second rotation period. Both FERPs and SERPs evening forums begin with dinner and bring the class together as a whole. SERPs is moderated by faculty instructors and is designed to both familiarize students with and instruct them in the skills necessary to present research findings in a clear and incisive manner. FERPs and SERPs are part of the MCB 293A-C series with section C being training in the ethical conduct of research. Credit and grades for the research conducted during the rotations are provided through enrollment in 291A-B with each mentor grading individual rotations and the Head Graduate Adviser reviewing all comments and grades for the final course grade..

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Coursework

In addition to the courses mentioned above, students are also required to take a minimum of three courses (with a grade of B or better) offered by least two of the five divisions. (Courses required by the department are listed below with a plus (+). Courses marked below with one or two asterisks meet the requirement; two stars indicate that the course is highly recommended by the Division). All such course work must be completed prior to taking the oral (a.k.a. qualifying) exam in the spring semester of the second year. With the approval of the student's academic Adviser, a course offered by another department may be substituted for one of the three required departmental courses. Some Divisions may set additional course requirements as appropriate to their disciplinary areas. Following the successful completion of the oral

examination, all students must enroll in three semesters of special topics seminars (MCB 290) offered by faculty in areas of current research in the field of molecular and cell biology (typically 6 offerings per semester).

Course Descriptions

MCB 200** Advanced Biochemistry and Molecular Biology

General course for first-year graduate students. Recent advances in the study of the structural, functional, and genetic characteristics of prokaryotic and eukaryotic cells and their viruses, macromolecular syntheses, regulation of gene expression, chromosome organization, cell signaling, proliferation, and differentiation. Admission to the course requires formal consent of the instructors, except for MCB graduate students and graduate students in the laboratories of MCB faculty. Enrollment is restricted to 45. Auditors are not permitted in the discussion sessions.

MCB 206*Physical Biochemistry

Application of modern physical concepts and experimental methods to the analysis of the structure, function, and interaction of large molecules of biological interest.

MCB C209 Dietary Determinants of Cancer, Heart Disease, and Aging

The influence of diet on DNA damage, cancer, and aging will be discussed with an emphasis on micronutrient deficiencies as a major contributor to DNA damage, cancer, and aging. The influence of diet on atherosclerotic heart disease will be covered with an emphasis on the role of dietary constituents proposed to have either toxic or preventive effects in the artery wall. Readings will consist of papers from the literature. Also listed as Nutritional Sciences and Toxicology C210.

MCB 210X Foundations of Biochemistry and Molecular Biology

General course for first-year graduate students (except those in MCB laboratories). Prokaryotic and eukaryotic molecular biology; biological macromolecules; DNA replication, recombination, and repair; chromosome organization and mechanics; transcription, gene regulation; protein synthesis, intracellular protein trafficking; molecular basis of cellular ultrastructure; hormone action, signal transduction mechanisms, cell cycle control; modern methods.

MCB 211* An Introduction to Structural Biology and Physical Biochemistry

This course is for Molecular and Cell Biology graduate students. It will teach principles of protein and nucleic acid structure and outline basic experimental methods for conformation studies. The classical problems of structural biology, as well as new approaches and methods, will be emphasized. Courses 111 and 211 are taught concurrently. Students enrolled in 211 will also be required to attend a weekly discussion section and to prepare a mini-grant proposal.

MCB C212A* Chemical Biology I - Structure, Synthesis and Function of Biomolecules

This course will present the structure of preteins, nucleic acids, and oligosaccharides from the perspective of organic

chemistry. Modern methods for the synthesis and purification of these molecules will also be presented. Also listed as Chemistry C271A.

MCB C212B* Chemical Biology II - Enzyme Reaction Mechanisms

This course will focus on the principles of enzyme catalysis. The course will begin with an introduction of the general concepts of enzyme catalysis which will be followed by detailed examples that will examine the chemistry behind the reactions and the three-dimensional structures that carry out the transformations. Also listed as Chemistry C271B.

MCB C212C* Chemical Biology III - Contemporary Topics in Chemical Biology

This course will build on the principles discussed in Chemical Biology I and II. The focus will consist of case studies where rigorous chemical approaches have been brought to bear on biological questions. Potential subject areas will include signal transduction, photosynthesis, immunology, virology, and cancer. For each topic, the appropriate bioanalytical techniques will be emphasized. Also listed as Chemistry C271C.

MCB C214* Protein Chemistry, Enzymology, and Bio-organic Chemistry

The topics covered will be chosen from the following: protein structure, protein-protein interactions; enzyme kinetics and mechanism; enzyme design. Intended for graduate students in chemistry, biochemistry, and molecular and cell biology. Also listed as Chemistry C230.

MCB 215 Molecular Biology of Animal Viruses Workshop

This workshop for graduate students will parallel 115 which should be taken concurrently. Emphasis in the workshop will be on the review of a current research topic as presented in the recent professional literature. A formulation of a seminar and/or paper relevant to this topic will be required.

MCB C216 Microbial Diversity Workshop

This workshop for graduate students will parallel C116, Microbial Diversity, which should be taken concurrently. Emphasis in the workshop will be on review of research literature and formulation of paper pertinent to research in microbial diversity. Also listed as Plant and Microbial Biology C216.

217A-217C* Selected Topics in Biochemistry and Molecular Biology. (1;1;1) Course may be repeated for credit with change in contents. Course may be repeated for credit. Three hours of lecture per week for five weeks. Prerequisites: Consent of instructor. Recent advances. Topics changed each year. 217A, 217B, 217C are three sections of five weeks each. The sections are taught in tandem and may be taken individually. Must take all three sections for course to count as core. (F,SP) Staff

MCB 218 & MCB 219 Research Review in Biochemistry and Molecular Biology

Review of current literature and discussion of original research (Group Meeting).

MCB 230** Advanced Cell Biology

Advanced treatment of topics in cell biology.

MCB 230X** Foundation in Cell Biology

General course for first-year graduate students (except those in molecular and cell biology laboratories). The assembly of supramolecular structures; membrane structure and function; the cell surface; cytoplasmic membranes; the cytoskeleton and cell motility; the eukaryotic genome, chromatin, and gene expression; the cell cycle; organelle biogenesis differentiation; and morphogenesis.

MCB 231** Advanced Stem Cell and Developmental Biology

Principles of animal development will be set forth from the classical and recent experimental analysis of induction, localization, patterning mutants, axis formation, regional gene expression, and cell interactions. Early development of selected vertebrates and invertebrates will be described. Basic experimental methods and new approaches will be presented. A weekly discussion section with readings from the research literature is required. Students will prepare a mini grant proposal.

MCB 236 Advanced Mammalian Physiology

Principles of mammalian (primarily human) physiology emphasizing physical, chemical, molecular, and cellular bases of functional biology. The following topics will be covered: cellular and membrane ion and nonelectrolyte transport; cell and endocrine regulation; autonomic nervous system regulation; skeletal, smooth, and cardiac muscle; cardiovascular physiology; respiration; renal physiology; gastrointestinal physiology. Discussion section will study advanced physiological topics, including: presentations by the faculty; problem sets; discussion of the primary literature and of reviews; two presentations by each student on topics in current physiological research.

MCB C237 Stem Cells and Directed Organogenesis

This course will teach the main concepts and key methods of human embryonic stem cell (hESC) derivation, propagation and characterization focusing on currently developing stem cell technologies. The course will teach the in vitro techniques used in embryonic stem cell research and stem cell engineering. Specific examples include a choice of substrates and biomaterials for in vitro expansion and sustained pluripotency of ESC; controlled and normalized ecto-, meso- and endoderm formation in 3D embryoid bodies, directed tissue specific differentiation of hESCs and conventional as well as single-cell microfluidics-based analysis of hESC gene expression. Comparison between hESCs and adult organ stem cells, e.g. skeletal muscle satellite cells, in self-renewal, pluripotency and in tissue-specific differentiation will be discussed based on the experimental evidence obtained in class. Also listed as Bioengineering C218.

MCB 237SC Current Ethical, Legal, and Social Issues in Stem Cell Research

The course will cover key topics in the ethical, social, and legal aspects of stem cell research and medicine, including informed consent, egg and tissue donation, access to medical care, intellectual property, governmental and institutional regulations, and international perspectives on stem cell research. Required for CIRM scholars. Molecular and Cell Biology graduate students and trainees cannot substitute this course for 293C.

MCB 239 Research Review in Cell and Developmental Biology (Group Meeting).

MCB 240** Advanced Genetic Analysis

Principles and practice of classical and modern genetic analysis as applied to eukaryotic organisms, including yeast, nematodes, *Drosophila*, mice and humans; isolation and analysis of mutations; gene mapping; suppressor analysis; chromosome structure; control of gene expression; and developmental genetics.

MCB 241* General Genetics Workshop

This course is for Molecular and Cell Biology graduate students. It will teach in-depth introduction to genetics, including mechanisms of inheritance; gene transmission and recombination; transposable DNA elements; gene structure, function, and regulation; and developmental genetics. Some exams may be given in the evening. Courses 140 and 241 are taught concurrently. Students enrolled in 241 will also be required to participate in a one-hour specialized discussion section per week, led by the course instructor. This section will cover methodological background and will be based on the primary literature of the field.

MCB C245 Mechanisms of Developmental Evolution

Synthesis of modern research on the molecular genetics of developmental evolution. Topics include the origin of animals, the evolution of body plan, the role of transcriptional regulation in morphological evolution, and genome evolution. Also listed as Integrative Biology C266.

MCB 248* Advanced Genetics, Genomics and Development

Three five-week sections covering the principles and practice of i) modern genetic analysis as applied to eukaryotic organisms, ii) animal developmental biology, and iii) genome sequence analysis. This course will focus on the essential concepts and intellectual underpinnings of these areas, with a particular emphasis on their intersection.

MCB 249 Research Review in Genetics and Development (Group Meeting).

MCB 250* Advanced Immunology

Molecular and cellular analysis of the immune response. Structure and function of antibodies and antibody genes including antibody-antigen reactions, principles of molecular recognition, recombination and regulation of antibody genes, and the immunoglobulin class switch; B cell differentiation, activation, and tolerance. Structure and function of T cell receptors and T cell receptor genes; antigen processing and presentation, and role of MHC molecules in guiding T cell recognition; T cell activation, development, positive selection, and tolerance. Analysis of T cells, natural killer cells, and tumor surveillance.

MCB 251 The Regulation of Immune System Development and Function

This is an advanced seminar course which will consider current research questions and experimental approaches in molecular and cellular immunology. Each registrant will present a 30-minute research talk describing the problems they are studying, the approach they are taking, their preliminary data, and technical problems. Other course participants (including basic immunology faculty) will provide criticism and suggestions.

MCB 254 Cancer and Immunobiology

Emphasis will be on the treatment or prevention of cancer based on rational approaches derived from recent advances in tumor immunology. The course will examine the application of basic research in immune regulation to more applied studies in animal models and clinical trials. Introductory lectures by instructor followed by student presentations of original literature and lectures by invited speakers engaged in translational and clinical research in tumor immunotherapy.

MCB 259 Research Review in Immunology & Pathogenesis (Group Meeting)

MCB 260** Principles of Neuroscience

Comprehensive survey of the current state of knowledge in molecular, cellular, developmental, integrative and behavioral aspects of neurobiology.

MCB C261* Advanced Cellular Neurobiology

Physical-chemical basis of membrane potentials, electrotonus, action potential generation and propagation, synaptic transmission, sensory receptor function, and volume conductor potentials. Also listed as Neuroscience C261.

MCB C262* Advanced Topics in Systems Neuroscience

Advanced coverage of current research problems in systems-level neuroscience, and experimental and computational techniques used for these studies. Also listed as Neuroscience C262.

MCB C263* Advanced Developmental Neurobiology

Advanced level coverage of current research problems in the embryonic and post-embryonic development of invertebrate and vertebrate nervous systems. Also listed as Neuroscience C263.

MCB 269 Research Review in Neurobiology (Group Meeting)

IDS 282 Tumor Biology Seminars

Reviews and reports of current research in tumor biology.

MCB 280 A-F Selected Topics in Molecular and Cell Biology

This modular course focuses on fundamental principles, essential concepts, and recent advances in select topics in molecular and cell biology. Topics include Genomics and Computational Biology, Molecular Evolution, Neurons and Synapses, Microbiology and Immunology, Macromolecular Structure and Function, and Scientific Writing. The purpose of the course is to provide a unique opportunity for graduate student to gain both breadth and depth in a variety of topics in molecular and cell biology. The course will also offer senior graduate students the opportunity to delve into new areas of research to help define potential postdoctoral research topics.

Each module is three hours of lecture and one hour of discussion per week for 5 weeks. Sections are taught in tandem and may be taken individually. Three modules may be taken in lieu of a core course. Course may be repeated for credit with change of content.

MCB 280A Molecular Evolution

MCB 280B Genomics and Computational Biology

MCB 280C Microbiology and Immunology

MCB 280D Neurons and Synapses

MCB 280E Macromolecular Structure and Function

MCB 280F Scientific Writing

MCB 290+ Graduate Seminar (usually 4 to 6 seminars per semester)

Graduate student presentations on selected research topics in molecular and cell biology. Several sections covering different topics offered each semester. Concurrent enrollment in more than one section is permitted. List of topics to be announced before each semester.

MCB 291+ Rotation Research

Three ten-week laboratory rotations during the first year of the program. Closely supervised experimental work under the direction of an individual faculty member; an introduction to experimental methods and research approaches in particular areas of molecular and cell biology. Each rotation involves an individual research project selected by the chosen faculty mentor and the student. In recognition of the fact that a student's scientific interests often evolve considerably during the first few months in the program, each rotation is arranged just prior to the start of each ten-week period. This gives students sufficient opportunities to explore all the options for laboratories in which thesis research might be pursued. Rotation in a particular laboratory does not constitute a commitment on the part of the student or faculty mentor regarding the ultimate choice of thesis laboratory. When the cycle of rotations ends in April, students select and join the thesis laboratories where they will pursue research projects for their doctoral dissertations.

MCB 292+ Dissertation Research

Laboratory research, conferences. Individual research under the supervision of a faculty member.

MCB 293A-B+ Research Seminar (FERPs/SERPs)

Seminar for first-year students only on presentation and evaluation of results in area of student's first and second rotation projects. The first part of the course in the Fall semester includes presentation by faculty of the research areas under investigation in their laboratories.

MCB 293C+ Responsible Conduct of Research

This course covers topics in the responsible conduct of research drawing from case studies from the Association of American Medical Colleges and the NIH. Students will review case studies in preparation for class discussion. Required of all MCB graduate and post doctoral students funded on NIH training grants. One session usually features a guest lecturer on a topic relevant to the course.

MCB 295 Careers for Life Sciences Ph.D.'s

This course is designed to assist graduate students in the biological sciences with planning their post-doctoral careers. Weekly guest speakers will present their experiences in a variety of career areas and/or offer training in: academia; job searches; setting up a laboratory; patent law/technology transfer; public policy/regulatory affairs; bioinformatics; science writing/technical support; forensic science; postdoctoral positions in industry; teaching, and other topics of interest. Postdoctoral researchers are invited.

MCB 297** Methods and Logic in Biology

The focus of this course will be some of the papers in the scientific literature that provide the discoveries and methods critical to modern molecular and cell biology. Students will learn how to dissect published literature to evaluate precisely what constitutes an important paper. The themes in this course will be broadly applicable to all students interested in modern experimental biology. Students will meet and discuss the themes of a series of papers first by themselves (with assistance of a faculty member) and then participate in an in-depth dissection lead by the staff.

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Teaching

Anticipating future careers which may include teaching, all graduate students participate in undergraduate instruction by serving as Graduate Student Instructors (GSIs) for two semesters. Typically a student teaches during the Fall semester of the second year and the Spring semester of the third year in the doctoral program. These assignments usually include both lecture and laboratory courses and are, in most instances, based upon student preferences. Students who have passed their oral exams (i.e. advanced to candidacy) can also organize seminars for junior- and senior-level undergraduates for additional teaching experience (and credit for one of the three required MCB 290 seminars). A student may also be allowed to serve as a GSI for a third semester if they obtain the approval of their thesis mentor and Dissertation Committee (see policy).

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Oral/Qualifying Examination

During the second year, each student takes an oral/qualifying examination, usually held during the Spring semester. In this exam, the student demonstrates his/her ability to recognize research problems of fundamental importance, to propose appropriate experimental approaches to address these problems, and to display comprehensive knowledge of his/her disciplinary area and related subject areas. The oral examination itself is administered by a committee composed of four faculty approved by the Graduate Division with three faculty from MCB and one from another department on campus.

Though general knowledge in the field is tested, the examination is organized primarily around two written research propositions: one on a topic that represents the student's doctoral dissertation research; and, the other on a subject that is in an area outside of the thesis topic. The two propositions are prepared in the format of research grant proposals and are presented to the members of the committee in advance of the examination. Though the examination is intended to be challenging, it is unusual for a student not to pass. Passage of the examination is required before a student is advanced to candidacy for the doctoral degree (see Policy).

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Research, Dissertation and Beyond

The Department is full of opportunities for expanding research in the areas of molecular and cell biology as well as in the expanding and emerging fields of structural biology, genomics, evolution and development, and computational biology. Students may join journal clubs and/or participate in laboratory group meetings of faculty whose work interests them, but in whose laboratories they are not currently conducting research. Many laboratories share research meetings and there are many area meetings between Stanford, UC San Francisco and UC Berkeley.

After advancing to candidacy a student meets each Fall semester with their Thesis Committee to discuss the dissertation project, to review results, and to chart research directions and timelines for the following year up to the completion of the dissertation. In the final year, students complete a dissertation based on original laboratory research.

It is also during the final year that most students present at national conferences and begin their search for a post-doctoral position and funding. The MCB 295 careers course offered in the spring is useful for those looking beyond academia as well as those planning to stay within academia. The campus also has a dedicated biological and physical sciences Ph.D. counselor in the Career Center to help students with the job search including resume writing, interviewing skills, conducting the job search, creating a teaching portfolio and more.

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