Graduate Program in Cell and Molecular Biology

Chair

- Michael Glotzer

Professors

- Douglas K. Bishop, Radiation & Cellular Oncology
- Edwin L. Ferguson
- Richard Fehon
- Margaret Gardel, Physics
- Benjamin Glick
- Michael Glotzer
- Jean Greenberg
- Sally Horne-Badovinac
- David Kovar
- Stephen J. Kron
- Ed Munro
- Ilaria Rebay, Ben May Department for Cancer Research
- John Reinitz, Statistics
- Lucia Rothman-Denes
- Michael Rust
- Jonathan P. Staley
- Aaron Turkewitz

Associate Professors

- Robert Carrillo
- Ellie Heckscher
- Paschalis Kratsios
- Heng-Chi Lee
- Jocelyn Malamy
- Alex Ruthenburg

Assistant Professors

- Noah Mitchell
- Sampriti Mukherjee
- David Pincus

Emeritus Faculty

- Kwen Sheng Chiang
- Wolfgang Epstein
- Rochelle Easton Esposito
- Robert Haselkorn
- Robert Josephs
- Gayle K. Lamppa
- Anthony Mahowald
- Terence E. Martin
- Laurens J. Mets
- Bernard Roizman, Microbiology
- Theodore L. Steck, Biochemistry & Molecular Biology
- Ursula B. Storb
- Bernard S. Strauss
- Edwin W. Taylor

In the graduate program in cell and molecular biology, the Ph.D. degree places great emphasis on rigorous, didactic preparation in cell biology, molecular biology, and genetics, and focuses on choosing questions, defining experimental approaches, and interpreting data. Once qualified, advanced students choose from a wider range of opportunities for research in cell biology, molecular biology, genetics, developmental biology, plant biology, and microbiology. Of special interest is the design of interdisciplinary programs that emphasize the frontiers of biology.

The Degree of Doctor of Philosophy

The graduate program in cell and molecular biology offers a program of study leading to the Doctor of Philosophy in molecular genetics and cell biology. A Ph.D. candidate must fulfill certain formal coursework requirements, pass one preliminary and one qualifying examination, and present a satisfactory dissertation describing the results of original research.

The program expects knowledge of and proficiency in cell biology, molecular biology, and genetics. This requirement will normally be met by fulfilling the formal coursework described here, but detailed degree programs are flexible. Courses taken at other institutions, in other departments, or as part of the Pritzker School of Medicine curriculum may substitute for CMB courses with approval of the curriculum committee. To fulfill the requirements for a Ph.D., nine graded courses are required. In the program in cell and molecular biology, a student must take one course in each of three areas during the first year:

- Cell biology
- Molecular biology
- Genetics

In addition to these core courses, a second course in one of these areas is required to develop greater proficiency in a subdiscipline. The total of four required courses can be selected from among the following courses:MGCB 31200 Molecular Biology I MGCB 31300 Molecular Biology-II, MGCB 31400 Genetic Analysis of Model Organisms, MGCB 31600 Cell Biology I, and MGCB 31700 Cell Biology II. Three additional graded electives must be taken, one of which may be a reading course. The electives can be selected according to the student's interests and the availability of courses.

A student is also required to do three laboratory rotations before selecting an advisor and laboratory to pursue a Ph.D. dissertation. These rotations will be graded, and two will count towards the nine courses required for the Ph.D. All students are required to serve as a teaching assistant for two quarters.

Students select a thesis advisor and begin laboratory research by the tenth month of the first year. To complete the Ph.D. degree, they must prepare, under the general direction of an appointed doctoral committee, a dissertation based on their original research. Students are also required to submit, if not publish, at least one first-author paper prior to their defense. A public seminar describing the results of the dissertation research must be presented and the dissertation must be successfully defended before the doctoral committee.

Admissions

For information about applying to our graduate program, please visit our website https://camb.uchicago.edu/. (http://molbio.bsd.uchicago.edu/)

Molecular Genetics and Cell Biology Courses

MGCB 30000. Exploratory Data Analysis in R. 50 Units.
This course will introduce students to exploratory data analysis in the sciences using the R programming language. We will begin with exploration of example datasets, using plotting tools in R to visualize distributions of measured values and relationships between measured variables. We will learn to use basic tools in R to import and clean up messy datasets encountered in the wild, represent these data within standardized data tables, and then manipulate data within these tables to compute or extract features of interest. We will introduce simple programming techniques involving flow control, direct indexing of data structures, and user-defined functions, to tackle more advanced situations, and we will learn to refine our graphical presentation and prepare figures for publication. Throughout the course, we will introduce ways to organize code and methods in scripts, notebook-style documents, and projects to create reproducible analysis workflows. Finally, we will learn how to work with a personal computer or a remote system from the command line when more computational power is needed for a given problem. The course will be taught in a flipped format, with prerecorded video lectures followed by in-class live programming exercises. The majority of the work will occur in these live group sessions, with additional problems assigned as solo homework. Grading will be P/F, and the course will meet over a 4-week segment in the middle of the fall quarter.
Instructor(s): Ronald Rock and Ed Munro Terms Offered: Autumn. Offered from October 27 – November 19
Equivalent Course(s): BCMB 30000

MGCB 30400. Protein Fundamentals. 100 Units.
The course covers the physical chemical phenomena that define protein structure and function. Topics include: three-dimensional structures of proteins; the principles of protein folding, molecular motion and molecular recognition; protein evolution, design and engineering; enzyme catalysis; regulation of protein function;

proteomics and systems biology. Undergraduates are highly recommended to take BIOS 20200 (Introduction to Biochemistry) or equivalent before taking this course.
Instructor(s): M. Sotomayor, J. Piccirilli, D. Arac Terms Offered: Autumn
Equivalent Course(s): BCMB 30400, HGEN 30400

MGCB 31200. Molecular Biology I. 100 Units.
Nucleic acid structure and DNA topology; methodology; nucleic-acid protein interactions; mechanisms and regulation of transcription in eubacteria, and of replication in eubacteria and eukaryotes; mechanisms of genome and plasmid segregation in eubacteria.
Instructor(s): Bishop, D, Fei, J, Lee H.C., Rice, P, Ruthenburg, A Terms Offered: Winter
Equivalent Course(s): BCMB 31200, DVBI 31200

MGCB 31300. Molecular Biology-II. 100 Units.
The content of this course covers the mechanisms and regulation of eukaryotic gene expression at the transcriptional and post-transcriptional levels. Our goal is to explore research frontiers and evolving methodologies. Rather than focusing on the elemental aspects of a topic, the lectures and discussions highlight the most significant recent developments, their implications and future directions.
Instructor(s): J. Staley, A. Ruthenburg, H.C. Lee Terms Offered: Spring
Prerequisite(s): Molecular Biology I (MGCB 31200) or by special permission of an instructor
Equivalent Course(s): DVBI 31300, BCMB 31300

MGCB 31400. Genetic Analysis of Model Organisms. 100 Units.
Fundamental principles of genetics discussed in the context of current approaches to mapping and functional characterization of genes. The relative strengths and weaknesses of leading model organisms are emphasized via problem-solving and critical reading of original literature.
Instructor(s): Pincus, D, Ferguson, E, Lee, H.C, Zhang, X Terms Offered: Autumn
Equivalent Course(s): HGEN 31400, BCMB 31400, DVBI 31400

MGCB 31600. Cell Biology I. 100 Units.
Eukaryotic protein traffic and related topics, including molecular motors and cytoskeletal dynamics, organelle architecture and biogenesis, protein translocationand sorting, compartmentalization in the secretory pathway, endocytosis and exocytosis,and mechanisms and regulation of membrane fusion.
Instructor(s): A. Turkewitz, B. Glick Terms Offered: Autumn
Prerequisite(s): For Undergraduates- PQ: Completion of one course each in cellular & molecular biology, genetics, chemistry and biochemistry, or consent of the instructor.
Equivalent Course(s): BIOS 21228, HGEN 31600, BCMB 31600, DVBI 31600

MGCB 31700. Cell Biology II. 100 Units.
This course covers the mechanisms with which cells execute fundamental behaviors. Topics include signal transduction, cell cycle progression, cell growth, cell death, cancer biology, cytoskeletal polymers and motors, cell motility, cytoskeletal diseases, and cell polarity. Each lecture will conclude with a dissection of primary literature with input from the students. Students will write and present a short research proposal, providing excellent preparation for preliminary exams.
Instructor(s): M. Glotzer, D. Kovar Terms Offered: Spring
Prerequisite(s): For undergraduates: Three quarters of a Biological Sciences Fundamentals Sequence.
Equivalent Course(s): DVBI 31700, BIOS 21238, BCMB 31700

MGCB 31900. Introduction to Research. 100 Units.
Lectures on current research by departmental faculty and other invited speakers. A required course for all first-year graduate students.
Instructor(s): Staff Terms Offered: Autumn
Equivalent Course(s): GENE 31900, DVBI 31900, HGEN 31900, BCMB 31900

MGCB 32100. Senior Graduate Student Ethics. 100 Units.
This course explores specific ethical dilemmas that may arise in laboratory settings. The format of this course will provide opportunities for all students to voice their questions and opinions. Student groups of 4-5 will act as a review board during each session. Class time will center around the case, the conclusions of the review board, and the steps that should be taken to remedy the situation, if any. Faculty will guide and stimulate discussion in each case. Faculty will also provide any relevant University bylaws and/or NIH guidelines. Following the session, review board members will submit a formal 1-2 page justified decision in writing to the instructor. Successful completion of the course requires active participation in group presentations and general class discussions as well as joint submission of review board summaries.
Instructor(s): K. Moffat Terms Offered: Spring

MGCB 33500. Fundamentals of Biological Data Analysis. 100 Units.
The primary goals of this course are to provide first-year trainees in MCB graduate programs with a common grounding in the core tools of modern quantitative data analysis as used in molecular and cellular biology and a shared quantitative mindset and commitment to rigorous reproducible science. Our goal is not to be comprehensive, but to provide students with the conceptual foundations and practical skills they are most likely to need, regardless of research area. The expectation is that they will build upon these foundations through advanced courses, workshops and in-lab training. The course will emphasize building reproducible "data

analysis workflows" that go from raw data to insights about biological process and function, and presenting those insights in rigorous and informative ways. The course will use R as the primary programming language because of its widespread use and suitability for quantitative statistical data visualization and analysis, but the majority of skills that students learn will be readily transferrable to other programming languages.
Instructor(s): Munro, Ed Rust, Michael Terms Offered: Winter
Equivalent Course(s): BCMB 33500, DVBI 33500

MGCB 35420. Stochastic Processes in Gene Regulation. 100 Units.
This didactic course covers the fundamentals of stochastic chemical processes as they arise in the study of gene regulation. The central object of study is the Chemical Master Equation and its coarse-grainings at the Langevin/ Fokker-Planck, linear noise, and deterministic levels. We will consider both mathematical and computational approaches in contexts where there are both single and multiple deterministic limits.
Terms Offered: TBD
Prerequisite(s): Consent of instructor.
Equivalent Course(s): ECEV 35420, CAAM 35420, STAT 35420

MGCB 36100. Plant Development and Molecular Genetics. 100 Units.
Genetic approaches to central problems in plant development will be discussed. Emphasis will be placed on embryonic pattern formation, meristem structure and function, reproduction, and the role of hormones and environmental signals in development. Lectures will be drawn from the current literature; experimental approaches (genetic, cell biological, biochemical) used to discern developmental mechanisms will be emphasized. Graduate students will present a research proposal in oral and written form; undergraduate students will present and analyze data from the primary literature, and will be responsible for a final paper.
Instructor(s): J. Greenberg Terms Offered: Spring
Prerequisite(s): For undergraduates only: Three quarters of a Biological Sciences Fundamentals Sequence including BIOS 20171, BIOS 20187, or BIOS 20235.
Note(s): E.
Equivalent Course(s): DVBI 36100, ECEV 32900, BIOS 23299

MGCB 36400. Developmental Mechanisms. 100 Units.
This course provides an overview of the fundamental questions of developmental biology, with particular emphasis on the genetic, molecular and cell biological experiments that have been employed to reach mechanistic answers to these questions. Topics covered will include formation of the primary body axes, the role of local signaling interactions in regulating cell fate and proliferation, the cellular basis of morphogenesis, and stem cells.
Instructor(s): E. Ferguson, R. Fehon Terms Offered: Winter
Prerequisite(s): For undergraduates only: Three quarters of a Biological Sciences Fundamentals Sequence including BIOS 20189, or BIOS 20235. AND CONSENT OF INSTRUCTOR
Equivalent Course(s): DVBI 36400, BIOS 21237

MGCB 38500. Comparative Developmental Biology @ MBL. 100 Units.
This intensive comparative developmental biology course is designed for graduate students in their second or later year of Ph.D studies. The two-week-long course will provide exposure to a combination of well-established and emerging developmental systems. Students will develop advanced experimental embryology skills-many of which are transferable across organisms-in the handling and cellular/genetic manipulation of embryos, including microinjection, lineage tracing, microdissection, cell transplantation, in situ hybridization, CRISPR/ Cas mutagenesis, and 3D in vivo imaging. Students will develop an enhanced appreciation of the advantages each species offers, will be trained to think more comparatively (in a phylogenetic context), and will gain an appreciation of how best to select the appropriate species to address a specific question. They will be exposed to classic, recent, and developing methodologies and techniques and will learn about exciting ongoing research using these approaches. Developing and completing a short independent or team-based research project will enhance skills in hypothesis generation and experimental design.
Instructor(s): Victoria Prince, Nipam Patel, Karen Echeverri, Amy Herbert Terms Offered: Autumn
Equivalent Course(s): DVBI 38500, BCMB 38500

MGCB 39200. Readings: MGCB. 100 Units.
Reading course in an area of developmental biology of special interest to the student. Must be prearranged with a faculty member and preapproved by the chair of the Curriculum Committee.

MGCB 39500. UChicago Microscopy Course. 100 Units.
The UChicago Microscopy Course is a residential research course hosted at the Marine Biological Laboratory in Woods Hole, MA. The course is designed for graduate students in year two or beyond. Travel and lodging costs will be covered in full. This intensive two-week boot camp course will teach both conceptual foundations and practical approaches to modern light microscopy, using a variety of microscopes and specimens. The central goal is to empower students to identify and master imaging strategies that are best suited to address their specific experimental problems of interest, now and in the future. Core topics will include: (a) fundamentals of microscope design, image formation, contrast, and resolution; (b) common approaches to transmitted light (e.g. phase contrast, DIC, and polarization) and fluorescence microscopy (e.g. laser scanning or spinning disk confocal, light sheet and TIRF), (c) fluorescent probes and multispectral imaging; and (d) cameras and detectors, signal: noise and strategies for optimal sampling in space and time. More advanced topics will include single-molecule approaches, super-resolution, and photokinetics (e.g.FRAP, photoactivation, and optogenetics). In the

first half of the course, daily lectures will introduce basic concepts, followed by intensive hands-on experience with different specimens, microscopes, and imaging modalities. In the second half, students will explore more advanced topics of interest through a set of modular projects.
Instructor(s): Ed Munro, Rick Fehon, Abishek Kumar Terms Offered: Autumn
Equivalent Course(s): MICR 39500, DVBI 39500, BCMB 39500

MGCB 39900. Tutorial: MGCB. 100 Units.

MGCB 47000. Thesis Research: MGCB. 300.00 Units.
Laboratory research for senior graduate students.

MGCB 47100. Non-Thesis Rsch: MGCB. 300.00 Units.
Laboratory research for first and second year graduate students.

MGCB 70000. Advanced Study: Molecular Genetics & Cell Biology. 300.00 Units.
Advanced Study: Molecular Genetics & Cell Biology