Graduate Program in Biochemistry and Molecular Biophysics

Chair

- Tobin R. Sosnick

Professors

- Erin J. Adams
- Francisco Bezanilla
- Glyn Dawson, Pediatrics
- Geoffrey Greene, Ben May Department for Cancer Research
- Chuan He, Chemistry
- Robert J. Keenan
- Stephen B. H. Kent
- Anthony A. Kossiakoff
- David Kovar, Molecular Genetics & Cell Biology
- Marvin W. Makinen
- Stephen Meredith, Pathology
- Keith Moffat
- Tao Pan
- Eduardo Perozo
- Joseph A. Piccirilli
- Rama Ranganathan
- Phoebe A. Rice
- Benoit Roux
- Alex Ruthenburg, Molecular Genetics & Cell Biology
- Nancy B. Schwartz, Pediatrics
- James A. Shapiro
- Tobin R. Sosnick
- Joseph Thornton, Human Genetics

Associate Professors

- Demet Arac-Ozkan
- D. Allan Drummond
- Ronald S. Rock
- Minglei Zhao

Assistant Professors

- Axel Concepcion
- Jingyi Fei
- Cassandra Hayne
- Engin Ozkan
- Juan Mendoza, Pritzker School of Molecular Engineering

Emeritus Faculty

- Wolfgang Epstein
- Theodore L. Steck
- Edwin W. Taylor

The biochemistry and molecular biophysics graduate program is a highly interdisciplinary program of study offered by the Department of Biochemistry and Molecular Biology. The program forges a scientific culture of collaboration across the physical and biological sciences and among diverse laboratories. In this environment, students will have the opportunity to engage in research that aims to understand biological processes at the molecular level. The program is designed to encourage students to pursue research interests at the biological-physical sciences interface using diverse approaches such as structural and chemical biology, molecular and single molecule biophysics, combinatorial mutagenesis, protein engineering and RNA and DNA protein recognition.

Admission

For information about applying to our graduate program, please visit our website at http://bcmb.uchicago.edu (http://collegecatalog.uchicago.eduHttp://bcmb.uchicago.edu).

Degrees

Doctor of Philosophy

A Ph.D. program requires generally 4 to 6 years of study. In the first year, students engage in course work and small research projects in several laboratories to become acquainted with the department. Also during the first year there are many opportunities to attend departmental seminars and the Graduate Student Seminar Series and to participate in the visits of invited speakers. In the summer quarter of the first year students engage in the preliminary examination, in which they develop, write, and defend an original research proposal. After successful completion of the preliminary examination, students choose a research advisor, carry out their Ph.D. research in the advisor's laboratory, and write and orally defend a thesis.

Four of the following courses are required:

BCMB 30400	Protein Fundamentals	100
BCMB 31600	Cell Biology I	100
BCMB 30600	Nucleic Acid Structure and Function	100
BCMB 33500	Fundamentals of Biological Data Analysis	100
BCMB 32200	Biophysics of Biomolecules	100

Protein Fundamentals (Fall), Fundamentals of Biological Data Analysis (Winter), Biophysical Properties of Biomolecules (Spring), one course in Cell Biology, and one of the following: Nucleic Acids Structure and Function OR a course in Molecular Biology.

Two additional courses (BCMB 31900 – Introduction to Faculty Research, and BCMB 31800 – Current Seminar Topics in Biochemistry and Molecular Biology) are required. The introduction to faculty research course is not for credit; however, BCMB 31800 is for ½ credit. Each student is required to be a teaching assistant for a total of two quarters in their third and fourth years of residence.

The preliminary examination in BMB consists of a written research proposal that is prepared and submitted during the summer quarter of the first year (the fourth quarter in residence). Students (including ISTP students interested in joining BMB) will be permitted to take the preliminary examination only after all course and grade requirements have been met. The exam consists of a concise written research proposal and an oral defense of the proposal. Students are expected to demonstrate their ability to 1) identify a scientific problem, 2) propose experiments to address the problem, 3) interpret potential outcomes from the experiments, and 4) frame the question and results in a broader scientific context. In addition, students are evaluated on their ability to convey their ideas clearly in the written proposal and to defend the proposal orally. The chairperson of each exam committee will then contact the student regarding the outcome of their exam and provide written feedback. Two outcomes are possible: Pass or Revisions Needed. If revisions are required, the student will have the opportunity to respond to the committee's concerns and either revise portions of the proposal or re-write the entire proposal as indicated by the committee. In these cases, students will need to write a cover letter addressing the concerns of the committee and the changes that have been made. In addition, students may be required to re-defend the revisions orally with part or all of the exam committee. If a student is asked to re-write and re-defend the entire proposal, an additional faculty member will be added to the exam committee. Inadequate performance on a second exam is grounds for dismissal from the program. For continuation in the program, students must successfully pass the Preliminary Examination by the end of the fifth quarter of full-time residence as a graduate student in biochemistry and molecular biology.

During the second year, students select a thesis advisor and begin laboratory research. To complete the Ph.D. degree, they must prepare, under the general direction of an appointed doctoral committee, a dissertation based upon their original research. A public seminar describing the results of the dissertation research must be presented and the dissertation must be successfully defended before the doctoral committee.

Biochemistry and Molecular Biology Courses

BCMB 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): E. Ozkan, J. Piccirilli, D. Arac Terms Offered: Autumn
Equivalent Course(s): MGCB 30400, HGEN 30400

BCMB 30600. Nucleic Acid Structure and Function. 100 Units.
This course focuses on the biochemistry of nucleic acids. Topics include nucleic acid structure, folding, and chemistry, protein-nucleic acid interactions, non-coding RNAs, and the enzymology of key processes such as DNA replication, repair and recombination. A special emphasis is placed on primary literature.
Instructor(s): P. Rice, J. Fei Terms Offered: Autumn
Prerequisite(s): Course in biochemistry, molecular biology and organic chemistry

BCMB 30900. Electronic Instrumentation in Biophysics. 100 Units.
The purpose of this course is to acquire a basic knowledge of linear circuit analysis, analog and digital electronics with practical applications in instrumentation used in electrophysiology and biophysical research. Lectures are complemented with practical laboratories that include building and analysis of circuits and simulations in computers. Students are asked to design and build a practical instrument at the end of the course. Grading is based on class and laboratory participation, a test and on the construction of a practical device.
Instructor(s): Bezanilla, Francisco Terms Offered: Autumn
Equivalent Course(s): BPHS 30900, NEUR 30900

BCMB 31100. Evolution of Biological Molecules. 100 Units.
The course connects evolutionary changes imprinted in genes and genomes with the structure, function and behavior of the encoded protein and RNA molecules. Central themes are the mechanisms and dynamics by which molecular structure and function evolve, how protein/ RNA architecture shapes evolutionary trajectories, and how patterns in present-day sequence can be interpreted to reveal the interplay data of evolutionary history and molecular properties. Core concepts in macromolecule biochemistry (folding and stability of proteins and RNA, structure-function relationships, kinetics, catalysis) and molecular evolution (selection, mutation, drift, epistasis, effective population size, phylogenetics) will be taught, and the interplay between them explored.
Instructor(s): J. Thornton Terms Offered: Winter
Prerequisite(s): Comfort with basic computer programming (course will use Python and R); undergraduate biology, chemistry, calculus, and introductory statistics.
Equivalent Course(s): HGEN 31100, ECEV 31100

BCMB 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): MGCB 31200, DVBI 31200

BCMB 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): MGCB 31300, DVBI 31300

BCMB 31358. Simulation, Modeling, and Computation in Biophysics. 100 Units.
This course develops skills for modeling biomolecular systems. Fundamental knowledge covers basic statistical mechanics, free energy, and kinetic concepts. Tools include molecular dynamics and Monte Carlo simulations, random walk and diffusion equations, and methods to generate random Gaussian and Poisson distributors. A term project involves writing a small program that simulates a process. Familiarity with a programming language or Mathlab would be valuable.
Instructor(s): B. Roux Terms Offered: Winter
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence, BIOS 20200 and BIOS 26210-26211, or consent from instructor
Note(s): CB
Equivalent Course(s): CPNS 31358, CHEM 31358, BIOS 21358

BCMB 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): DVBI 31400, HGEN 31400, MGCB 31400

BCMB 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
Equivalent Course(s): HGEN 31600, MGCB 31600, DVBI 31600

BCMB 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, MGCB 31700

BCMB 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, MGCB 31900

BCMB 32200. Biophysics of Biomolecules. 100 Units.
This course covers the properties of proteins, RNA, and DNA, as well as their interactions. We emphasize the interplay between structure, thermodynamics, folding, and function at the molecular level. Topics include cooperativity, linked equilibrium, hydrogen exchange, electrostatics, diffusion, and binding.
Instructor(s): Sosnick, T. Terms Offered: Spring
Equivalent Course(s): BIOS 21328, BPHS 31000

BCMB 32300. Structure and Function of Membrane Proteins. 100 Units.
This course will be an in depth assessment of the structure and function of biological membranes. In addition to lectures, directed discussions of papers from the literature will be used. The main topics of the courses are: (1) Energetic and thermodynamic principles associated with membrane formation, stability and solute transport (2) membrane protein structure, (3) lipid-protein interactions, (4) bioenergetics and transmembrane transportmechanisms, and (5) specific examples of membrane protein systems and their function (channels, transporters, pumps, receptors). Emphasis will be placed on biophysical approaches in these areas. The primary literature will be the main source of reading.
Instructor(s): Perozo, E. Terms Offered: Winter
Equivalent Course(s): MGCB 32300

BCMB 32600. Methods in Structural Biology. 100 Units.
This course aims to provide students with the theoretical and applied knowledge on the use of modern structural biology methods, namely x-ray crystallography, cryo-electron microscopy and nuclear magnetic resonance spectroscopy. The course includes lectures and hands-on laboratory sessions, including a data-collection visit to the synchrotron at Argonne National Lab, collection of microscopy images at the Advanced Electron Microscopy Facility at UChicago, and data collection at our local NMR facility. The lectures will include x-ray diffraction theory, strategies to solve the phase problem, principles of electron microscopy and optics, single particle analysis, tomography, various NMR techniques and structure calculations from 3D spectra, model building and validation, and recent advances. The laboratory sessions will take registered students from sample preparation to model refinement and building using state-of-the-art experimental and computational tools. Basic knowledge of protein chemistry (as provided in BCMB 30400) strongly recommended.
Instructor(s): Minglei Zhao, Engin Özkan, Stephen Meredith, Joseph Sachleben Terms Offered: Spring

BCMB 32800. Introduction to Data Science in Biochemistry and Biophysics. 100 Units.
This course will introduce students to exploratory computational data analysis in biochemistry. We will begin with exploration of example datasets in the R programming language for statistics. We will cover approaches to wrangle data into shape for analysis, to develop models that explain trends in data sets, and finally to refining our graphical presentation and preparing analysis reports and figures for publication. A middle segment will cover best practices with tooling and and workflows, including navigating the shell in Linux/Unix/BSD systems. Finally, we will introduce students to the Julia programming language, which is useful for more complex problems where expressiveness and performance matter. The course will follow a lecture format, with live, in class exercises.
Instructor(s): Rock, R. Terms Offered: Winter

BCMB 33300. Scientific Grant Writing for Biological Sciences. 100 Units.
Establishing the skills to write clear and effective grants is an important skill for biomedical researchers, particularly those planning a career in research and development, including academia and industry. This course is designed to equip students with the skills to effectively craft successful biomedical grant proposals, specifically focused on the F31 NIH format. Throughout the course, students will learn the mechanics of biomedical scientific fellowship grant, including writing specific aims, developing the research approach, including significance and innovation. Students should already have a research project in mind and will be expected to provide feedback to their peers.
Instructor(s): Cassandra Hayne Terms Offered: Autumn

BCMB 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): MGCB 33500, DVBI 33500

BCMB 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, Clifton Ragsdale Terms Offered: Autumn
Equivalent Course(s): MGCB 38500, DVBI 38500

BCMB 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): DVBI 39500, MICR 39500, MGCB 39500

BCMB 39800. Selected Reading Topics: Biochemistry & Molecular Biology. 100 Units.
Subject matter for individual tutorial-based study is selected through prior consultation and is given under the guidance of a faculty member. The student and faculty member must indicate at time of registration whether the course will be taken on a letter grade or pass/fail basis.
Instructor(s): Staff Terms Offered: Summer,Autumn,Winter,Spring
Prerequisite(s): Consent of Department and Instructor

BCMB 39900. Intro To Research: BCMB. 300.00 Units.
Subject matter for individual tutorial-based study is selected through prior consultation and is given under the guidance of a faculty member. The student and faculty member must indicate at time of registration whether the course will be taken on a letter grade or pass/fail basis.

BCMB 40100. Research in Biochemistry and Molecular Biology. 300.00 Units.
The student conducts original investigation under the direction of a faculty member. The research is presented and defended as a dissertation in candidacy for the degree of Doctor of Philosophy.
Instructor(s): Staff Terms Offered: Autumn Spring Summer Winter
Prerequisite(s): Completion of course requirements adn Preliminary Examination at the Ph.D. level and approval of Chairman of the Department.

BCMB 70000. Advanced Study: Biochemistry & Molecular Biology. 300.00 Units.
Advanced Study: Biochemistry & Molecular Biology