Graduate Program in Biochemistry and Molecular Biophysics

Chair
• Tobin R. Sosnick

Professors
• Erin J. Adams
• Francisco Bezanilla
• Glyn Dawson, Pediatrics
• D. Allan Drummond
• 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
• Ronald S. Rock

Assistant Professors
• Demet Arac-Ozkan
• Jingyi Fei
• Engin Ozkan
• Minglei Zhou

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://molbio.bsd.uchicago.edu/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.

Classes may be substituted by graded laboratory rotations. Of the nine courses only the following are required:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
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<tbody>
<tr>
<td>BCMB 30400</td>
<td>Protein Fundamentals</td>
<td>100</td>
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<tr>
<td>BCMB 31600</td>
<td>Cell Biology I</td>
<td>100</td>
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<tr>
<td>BCMB 31200</td>
<td>Molecular Biology I</td>
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<tr>
<td>BCMB 32200</td>
<td>Biophysics of Biomolecules</td>
<td>100</td>
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Two additional courses (BCMB 31900 – Introduction to Faculty Research, affectionately called “Faculty All Stars” 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 30300. Applications of Nuclear Magnetic Resonance to Structural Biology. 50 Units.
The main objectives of the workshop are (i) to learn NMR based structure characterization methods and their applications and (ii) to become familiar with technical underpinnings of these methods so as to be able to critically appraise publications using these methods.
Instructor(s): S. Meredith; J. Sachleben Terms Offered: Autumn

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): HGEN 30400, MGCB 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, T. Pan Terms Offered: Autumn
Prerequisite(s): Course in biochemistry, molecular biology and organic chemistry

BCMB 30800. Single Molecule Biochemistry. 100 Units.
This course presents a series of advanced case studies designed to familiarize students with current single molecule research. Topics include: motor proteins and the cytoskeleton, nucleic acid processing enzymes, ion channels, and force spectroscopy and macromolecule folding.
Instructor(s): R. Rock, F. Bezanilla Terms Offered: Spring

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): A. Drummond, 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): L. Rothman-Denes 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 Terms Offered: Spring
Prerequisite(s): Molecular Biology I (MGCB 31200) or by special permission of an instructor
Equivalent Course(s): DVBI 31300, MGCB 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): BIOS 20200 and BIOS 26210-26211, or consent from instructor
Equivalent Course(s): CPNS 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.
Equivalent Course(s): HGEN 31400, DVBI 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 translocation and 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): DVBI 31600, MGCB 31600, HGEN 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: Winter
Prerequisite(s): For undergraduates: Three quarters of a Biological Sciences Fundamentals sequence.
Equivalent Course(s): MGCB 31700, BIOS 21238, DVBI 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,Winter
Equivalent Course(s): HGEN 31900, MGCB 31900, GENE 31900, DVBI 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.
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 transport mechanisms, 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): E. Perozo Terms Offered: Autumn
Equivalent Course(s): MGCB 32300

BCMB 32400. X-ray Crystallography and Cryo-Electron Microscopy. 100 Units.
The Department of Biochemistry and Molecular Biology is offering a full-credit structural biology course in the summer quarter. The course aims to provide students with the theoretical and applied knowledge on the use of modern structural biology methods, namely x-ray crystallography and cryo-electron microscopy. The course will cover both methods over three weeks of lectures and hands-on laboratory sessions, including a data-collection visit to the synchrotron at Argonne National Lab and collection of microscopy images at the Advanced Electron Microscopy Facility at UChicago. Students will be taught x-ray diffraction theory, strategies to solve the phase problem, principles of electron microscopy and optics, single particle analysis, tomography, model building and validation with both techniques, and the most recent advances and innovations in both diffraction- and EM-based methods. The laboratory sessions will take registered students from sample preparation to model refinement and building using state-of-the-art experimental and computational tools.
Instructor(s): Engin Ozkan; Minglei Zhao Terms Offered: Summer

BCMB 32500. Bioorganic Chemistry. 100 Units.
A goal of this course is to relate chemical phenomena with biological activities. We cover two main areas: (1) chemical modifications of biological macromolecules and their potential effects; and (2) the application of spectroscopic methods to elucidate the structure and dynamics of biologically relevant molecules.
Equivalent Course(s): CHEM 32500

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 Ozkan, Stephen Meredith, Joseph Sachleben Terms Offered: Spring 2019
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: Summer, Autumn, Winter, Spring
Prerequisite(s): Completion of course requirements and 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