Members of the Department of Molecular Biophysics and Biochemistry (MB&B) are united by a common view that processes in biology are understood when molecular, chemical, kinetic, and thermodynamic contributions to mechanisms have been elucidated. Correspondingly, our faculty and students are joined by a shared fascination with biochemistry, physical chemistry, structural biology, computation, spectroscopy, macromolecular engineering, imaging and the molecular basis of disease. Three quarters of our graduates matriculate into PhD, MD, and MD/PhD programs. Recent graduates have joined companies specializing in finance, management consulting, biotechnology and pharma. Others have matriculated in law or business school and doctoral programs in the humanities. Still others have performed public service, entered secondary education, or joined the United States armed forces as officers.

Information about the major is pending and will be available the second week of April.

The Department of Molecular Biophysics and Biochemistry (MB&B) is for students interested not just in what life is, but also in how it works. MB&B invites interested students to join the department and share in its fascination with biochemistry, biophysical chemistry, structural biology, computation, spectroscopy, macromolecular engineering, imaging and the molecular basis of disease. For example biochemistry was used to determine the building blocks of DNA and that DNA carries genetic information; biophysics was used to determine the atomic structures and chemical mechanisms by which two meters of this information, encoding six billion letters, is compressed one-million fold, stored and read inside every cell of the body.

The major offers B.A., B.S., and B.S./M.S. degrees to directly engage students’ specific interests.

To maximize elective opportunities both within the major and for other aspects of a liberal arts education, first years interested in the MB&B major should start by taking the most advanced chemistry courses for which they are eligible. Most MB&B students take General Chemistry, CHEM 161 and CHEM 165, with the associated labs in their first year. Others, who place into Organic Chemistry, take CHEM 174 and the associated lab, in their first year.

First-year students are encouraged to visit the MB&B web page for undergraduates, and to contact the director of undergraduate studies (MBBUndergrad@yale.edu) if they have any questions.

FACULTY OF THE DEPARTMENT OF MOLECULAR BIOPHYSICS AND BIOCHEMISTRY

**Professors** †Karen Anderson, Susan Baserga, †Ronald Breaker, †Gary Brudvig, †Sandy Chang, Enrique De La Cruz, †Daniel DiMaio, Donald Engelman, Mark Gerstein, Nigel Grindley (Emeritus), †Sharon Hammes-Schiffer, Mark Hochstrasser, Jonathon Howard, Michael Koelle, Anthony Koleske, William Konigsberg, †Mark Lemmon, †Patrick Loria, †L. George Miller, Andrew Miranker, †Peter Moore (Emeritus), Karla Neugebauer, †Thomas Pollard, Lynne Regan (Emeritus), †Karen Reinisch, †David Schatz, Robert Schulman (Emeritus), †Frederick Sigworth, Dieter Söll, Mark Solomon, Joan Steitz, Scott Strobel, Yong Xiong

**Associate Professors** Julien Berro, †Titus Boggon, Wendy Gilbert, Christian Schlieker, Matthew Simon, †Shervin Takyar, †Yongli Zhang

**Assistant Professors** Franziska Bleichert, Allison Didychuk, †Luisa Escobar-Hoyos, Lilian Kabeche, †Erdem Karatekin, Nikhil Malvankar, †Wei Mi, Candice Paulsen, †Sarah Slavoff, Kai Zhang

**Adjunct Professors** Kenneth Williams, Carl Zimmer

**Lecturer** Aruna Pawashe

†A joint appointment with primary affiliation in another department.

View Courses

Courses

* **MB&B 050b, Topics in Cancer Biology** Sandy Chang

Introduction to cancer as a genetic disease, with a focus on major discoveries in cancer biology that offer mechanistic insights into the disease process. A brief history of cancer; influence of the genomic revolution on cancer diagnostics; molecular defects underlying specific cancers; current and future cancer therapeutics. Patient case studies highlight specific molecular pathways and treatment strategies. Enrollment limited to first-year students with a strong background in biology and/or chemistry, typically demonstrated by a score of 5 on Advanced Placement examinations. Preregistration required; see under First-Year Seminar Program.  WR, SC

**MB&B 105a / MB&B 105a, Biology, the World, and Us** Staff

Biological concepts taught in context of current societal issues, such as emerging diseases, genetically modified organisms, green energy, and the human brain and its disorders. Emphasis on biological literacy to enable students to evaluate scientific arguments.  SC
MB&B 110, Current Issues in Biological Science

MB&B 230, Rain Forest Expedition and Laboratory

MB&B 251La or b / MCDB 301La or b, Laboratory for Biochemistry

An introduction to current experimental methods in molecular biology, biophysics, and biochemistry. Limited enrollment. Prerequisite: BIOL 101. SC ½ Course cr

MB&B 268b, Identity, Society, and STEM

Enrique De La Cruz and Andrew Miranker

Matters of personal and group identity underpin the development of science as a discipline, the lived experience of its practitioners, and the achievement of excellence by diverse cultures collaborating on research, teaching in schools, treating the sick, promoting business, and setting government policy. Yale STEM students who are actively engaged in the study of any aspect of identity and society, whether contemporary or historical, learn how STEM is intertwined with these interests. To achieve this goal, students in this course must be simultaneously enrolled in a full-credit, humanities course at Yale. Instructor permission is required and is based on a proposal (250 words) that makes a compelling case for exploring STEM’s engagement with the concurrent humanities course. Students use knowledge from the humanities course to develop a unique project that can include anecdotal sources, but must also include elements of formal scholarship learned in class. Primary scientific literature and publicly available data relevant to students’ projects in any given semester are engaged and discussed during seminar-styled class meetings. Dissemination of projects take several forms including one appropriate for the public or popular press, a flash talk presentation open to the Yale community, and lastly a formal term-paper. Prerequisite: BIOL 101 (or permission of the instructor). SC ½ Course cr

MB&B 275a, Biology at the Molecular Level

Enrique De La Cruz and Andrew Miranker

An introductory course for students to learn the key concepts from physics and physical chemistry that govern the structure and function of biomolecules in biology and medicine. Emphasis is placed on atomic-scale biomolecular motions, energy, reaction rates and mechanisms; core elements that underpin the exquisite specificity and regulated control of life processes. This course prepares students for upper level course content where these concepts are revisited. Connections to medicine and research are made through the use of practical examples, laboratory-based activities and training in biologically relevant areas of math, statistics and computer programming. This course is open to all Yale students. For MB&B majors, this course is accepted as fulfillment of one semester of MB&B’s two-semester requirement in physical chemistry. Prerequisites: BIOL 101-102, MATH 112 (or equivalent), college level General Chemistry, and high school Physics. SC 0 Course cr

MB&B 300a, Principles of Biochemistry I

Staff

Discussion of the physical, structural, and functional properties of proteins, lipids, and carbohydrates, three major classes of molecules in living organisms. Energy metabolism and hormone signaling as examples of complex biological processes whose underlying mechanisms can be understood by identifying and analyzing the molecules responsible for these phenomena. After BIOL 101; after or concurrently with CHEM 175 (or CHEM 125) or 220. SC 0 Course cr

MB&B 301b, Principles of Biochemistry II

Christian Schlieker, Karla Neugebauer, and Franziska Bleichert

Building on the principles of MB&B 300 through study of the chemistry and metabolism of DNA, RNA, and proteins. Critical thinking emphasized by exploration of experimental methods and data interpretation, from classic experiments in biochemistry and molecular biology through current approaches. Prerequisite: MB&B 300 or permission of instructor. SC 0 Course cr

MB&B 330a / BENG 230a / MCDB 330a / NSCI 324a, Modeling Biological Systems I

Staff

Biological systems make sophisticated decisions at many levels. This course explores the molecular and computational underpinnings of how these decisions are made, with a focus on modeling static and dynamic processes in example biological systems. This course is aimed at biology students and teaches the analytic and computational methods needed to model genetic networks and protein signaling pathways. Students present and discuss original papers in class. They learn to model using MatLab in a series of in-class hackathons that illustrate the biological examples discussed in the lectures. Biological systems and processes that are modeled include: (i) gene expression, including the kinetics of RNA and protein synthesis and degradation; (ii) activators and repressors; (iii) the lysogeny/lysis switch of lambda phage; (iv) network motifs and how they shape response dynamics; (v) cell signaling, MAP kinase networks and cell fate decisions; and (vi) noise in gene expression. Prerequisites: MATH 115 or 116. BIOL 101-104, or with permission of instructors. This course also benefits students who have taken more advanced biology courses (e.g. MCDB 200, MCDB 310, MB&B 300/301). Q8, SC 0 Course cr

* MB&B 364a / MCDB 364a, Light Microscopy: Techniques and Image Analysis

Mark Mooseker

A rigorous study of principles and pertinent modalities involved in modern light microscopy. The overall course learning objective is to develop competencies involving advanced light microscopy applications common to multidisciplinary research. Laboratory modules coupled with critical analysis of pertinent research papers cover all major light microscope methods — from the basics (principles of optics, image contrast, detector types, fluorescence, TIS and TIRF, to more recent advances, including: superresolution, lightsheet, FLIM/FRET, motion analysis and force measurements. This course is capped at 8 students to promote interactions and ensure a favorable hands-on experience. Priority for enrollment is given to students who are planning on using these techniques in their independent research. Prerequisites: MCDB 205, PHYS 170/171 or above, either CHEM 161/165 or above; with CHEM 134L, 136L or permission from the instructor. SC

MB&B 365b, Biochemistry and Our Changing Climate

Karla Neugebauer

Climate change is impacting how cells and organisms grow and reproduce. Imagine the ocean spiking a fever: cold-blooded organisms of all shapes, sizes and complexities struggle to survive when water temperatures go up 2-4 degrees. Some organisms adapt to extremes,
while others cannot. Predicted and observed changes in temperature, pH and salt concentration do and will affect many parameters of the living world, from the kinetics of chemical reactions and cellular signaling pathways to the accumulation of unforeseen chemicals in the environment, the appearance and dispersal of new diseases, and the development of new foods. In this course, we approach climate change from the molecular point of view, identifying how cells and organisms from microbes to plants and animals respond to changing environmental conditions. To embrace the concept of "one health" for all life on the planet, this course leverages biochemistry, cell biology, molecular biophysics, and genetics to develop an understanding of the impact of climate change on the living world. We consider the foundational knowledge that biochemistry can bring to the table as we meet the challenge of climate change. Prerequisites: MB&B 300, MB&B 301, MB&B 200, or permission of the instructor.

**MB&B 420a, Macromolecular Structure and Biophysical Analysis** Yong Xiong and Jonathan Howard  
Analysis of macromolecular architecture and its elucidation using modern methods of structural biology and biochemistry. Topics include architectural arrangements of proteins, RNA, and DNA; practical methods in structural analysis; and an introduction to diffraction and NMR. Prerequisites: MB&B 301 and 302. SC

* **MB&B 425a / MCDB 425a, Basic Concepts of Genetic Analysis** Jun Lu  
The universal principles of genetic analysis in eukaryotes. Reading and analysis of primary papers that illustrate the best of genetic analysis in the study of various biological issues. Focus on the concepts and logic underlying modern genetic analysis. Prerequisite: MCDB 202 or pre-approval of instructor. SC

**MB&B 431b, Illuminating Biomolecular Mechanism with Structure** Charles Sindelar, Julien Berro, and Nikhil Malvankar  
This class focuses on methods for observing biomolecular structure and dynamics on the atomic and near-atomic length scales. Upon completion of the class, students have a working understanding of the theory that underpin methods such as cryo-electron microscopy and optical spectroscopy. All methods introduced are anchored to fundamental processes in biology and to biomedical advances through guided discussion of ground-breaking studies in contemporary primary literature. Prerequisite: MB&B 275, 301, or permission of the instructor. Enrolled students should have an introductory level understanding of Fourier transforms, linear/matrix algebra and multivariate calculus, but note, portions of class time are used to review the small subset of relevant mathematics essential for this course. QR, SC

**MB&B 433a, Quantitative Approaches in Biophysics and Biochemistry** Julien Berro, Nikhil Malvankar, and Yong Xiong  
An introduction to quantitative methods relevant to analysis and interpretation of biophysical and biochemical data. Topics include statistical testing, data presentation, and error analysis; introduction to mathematical modeling of biological dynamics; analysis of large datasets; and Fourier analysis in signal/image processing and macromolecular structural studies. Instruction in basic programming skills and data analysis using MATLAB; study of real data from MB&B research groups. Prerequisites: MATH 120 and MB&B 300 or equivalents, or with permission of instructors. QR, SC

**MB&B 443b, Advanced Eukaryotic Molecular Biology** Mark Hochstrasser, Wendy Gilbert, and Matthew Simon  
Selected topics in regulation of chromatin structure and remodeling, mRNA processing, mRNA stability, translation, protein degradation, DNA replication, DNA repair, site-specific DNA recombination, and somatic hypermutation. Prerequisites: MB&B 300 and 301, or permission of instructor. SC RP

* **MB&B 445b, Methods and Logic in Molecular Biology** Wendy Gilbert, Julien Berro, and Mark Hochstrasser  
An examination of fundamental concepts in molecular biology through analysis of landmark papers. Development of skills in reading the primary scientific literature and in critical thinking. Prerequisites: MB&B 300 and 301. SC RP

**MB&B 449a, Medical Impact of Basic Science** Joan Steitz, Karla Neugebauer, Seyeddtaghi Takyar, George Miller, David Schatz, Sandy Chang, Daniel DiMaio, and Franziska Bleichert  
Examples of recent discoveries in basic science that have elucidated the molecular origins of disease or that have suggested new therapies for disease. Readings from the primary scientific and medical literature, with emphasis on developing the ability to read this literature critically. Prerequisites: MB&B 300 and 301 or equivalents, or permission of instructor. SC

**MB&B 452b / MCDB 452b / S&DS 352b, Biomedical Data Science, Mining and Modeling** Mark Gerstein  
Techniques in data mining and simulation applied to bioinformatics, the computational analysis of gene sequences, macromolecular structures, and functional genomics data on a large scale. Sequence alignment, comparative genomics and phylogenetics, biological databases, geometric analysis of protein structure, molecular-dynamics simulation, biological networks, microarray normalization, and machine-learning approaches to data integration. Prerequisites: MB&B 301 and MATH 115, or permission of instructor. SC

* **MB&B 459b / ENGL 459b / EVST 215b, Writing about Science, Medicine, and the Environment** Carl Zimmer  
Advanced non-fiction workshop in which students write about science, medicine, and the environment for a broad public audience. Students read exemplary work, ranging from newspaper articles to book excerpts, to learn how to translate complex subjects into compelling prose. Admission by permission of the instructor only. Applicants should email the instructor at carl@carlzimmer.com with the following information: 1. One or two samples of nonacademic, nonfiction writing. (No fiction or scientific papers, please.) Indicate the course or publication, if any, for which you wrote each sample. 2. A note in which you briefly describe your background (including writing experience and courses) and explain why you'd like to take the course. WR RP

* **MB&B 460Lb, Biochemical Analytics Laboratory** Staff  
This is a project-oriented lab based around DNA aptamer design and microfluidics. Often referred to as lab-on-a-chip, these are mainstays of contemporary efforts in biomedical and environmental diagnostics. Students learn cutting-edge molecular evolution
techniques to optimize DNA structures that can recognize and bind selectively to a molecular target. Students further learn from each other as they each report on their progress. Useful and transferrable skills include biomolecular engineering, next generation DNA sequencing, and assays using microfluidic devices built in collaboration with the Yale Center for Engineering, Innovation, and Design. Prerequisite or taken concurrently: MB&B 251L/MCDB 301L or equivalent. SC ½ Course cr

* MB&B 470a and MB&B 471b, Research in Biochemistry and Biophysics for the Major Staff
Individual laboratory projects under the supervision of a faculty member. Students must submit an enrollment form that specifies the research supervisor by the date that course schedules are due. Students are expected to commit at least ten hours per week to working in a laboratory. Written assignments include a research proposal, due near the beginning of the term, and a research report that summarizes experimental results, due before the beginning of the final examination period. Students receive a letter grade. Up to 2 credits of MB&B 470/471 may be counted toward the MB&B major requirements. Enrollment limited to MB&B majors. Prerequisite: MB&B 251L or permission of the instructor. SC

* MB&B 472b and MB&B 473b, Research in Biochemistry and Biophysics Staff
Individual laboratory projects under the supervision of a faculty member. Students must submit an enrollment form that specifies the research supervisor by the date that course schedules are due. Students are expected to commit at least ten hours per week to working in a laboratory. Written assignments include a research proposal, due near the beginning of the term, and a research report that summarizes experimental results, due before the beginning of the final examination period. Students are graded pass/fail. Taken after students have completed two credits of MB&B 470 and 471. These courses do not count toward the major requirements. Prerequisites: MB&B 470, 471 and 251L or permission of the instructor. SC

* MB&B 478a and MB&B 479b, Intensive Research in Biochemistry and Biophysics for the Major Staff
Individual laboratory projects under the supervision of a faculty member. Students must submit an enrollment form that specifies the research supervisor by the day that course schedules are due. Students are expected to commit at least twenty hours per week to working in a laboratory. Written assignments include a research proposal, due near the beginning of the term, and a research report that summarizes experimental results, due before the beginning of the final examination period. No more than two course credits count as electives toward the B.S. degree. Enrollment limited to senior MB&B majors. Prerequisite: MB&B 251L or 360L. 2 Course cr per term

* MB&B 490b, The Senior Project Dieter Soll and Nikhil Malvankar
Colloquium for fulfillment of the senior requirement. The course involves a written and an oral presentation of a senior paper in an area of biochemistry or biophysics. The topic is selected in consultation with the faculty members in charge of the course.