MOLECULAR BIOPHYSICS AND BIOCHEMISTRY

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FACULTY OF THE DEPARTMENT OF MOLECULAR BIOPHYSICS AND BIOCHEMISTRY

Professors †Karen Anderson, Susan Baserga, †Ronald Breaker, †Gary Brudvig, Enrique De La Cruz, †Daniel DiMaio, Donald Engelman, Alan Garen, Mark Gerstein, Nigel Grindley (Emeritus), Mark Hochstrasser, Joe Howard, Anthony Koleske, William Konigsberg, †I. George Miller, †Peter Moore (Emeritus), Karla Neugebauer, †Thomas Pollard, Lynne Regan, †David Schatz, Dieter Söll, Mark Solomon, Joan Steitz, Thomas Steitz, Scott Strobel, †William Summers, Patrick Sung, Kenneth Williams (Adjunct), †Corey Wilson, †Sandra Wolin

Associate Professors Michael Koelle, Andrew Miranker, A. Elizabeth Rhoades, Yong Xiong

Assistant Professors †Richard Baxter, Christian Schieker, Matthew Simon, Chuck Sindelar

Lecturers Carol Bascom-Slack, Kaury Kucera, Aruna Pawashe

†A joint appointment with primary affiliation in another department.

The programs offered by the Department of Molecular Biophysics and Biochemistry are planned for students interested in the molecular and chemical basis of biological processes and are well suited to students hoping to attend medical school or pursue graduate studies in biochemistry, molecular biology, genetics, or biophysics. The B.S. major, designed for those with a strong commitment to research, provides an intensive introduction to laboratory techniques in biochemistry and biophysics. Students in this program usually carry out research projects in faculty laboratories during their junior and senior years. The B.A. major provides the intellectual discipline of biochemistry and biophysics for students who also wish to have sufficient time to pursue in-depth studies outside the major or who are interested in molecular biology as a liberal education; they, too, may engage in research during their junior and senior years.

Basic science prerequisites for the Class of 2016 and subsequent classes The basic science courses required of all majors include four half-term units of introductory biology (BIOL 101, 102, 103, 104); a general chemistry course with laboratory (CHEM 112, 113, or 114, 115, and 116L, 117L; or 118 and 119L); a year course in organic chemistry with laboratory (CHEM 124, 125, or 220, 230, and 222L, 223L); one term of physical chemistry (CHEM 328); two terms of calculus (MATH 112 and 115); and one year of physics (PHYS 170, 171, or 180, 181, or 200, 201). The B.A. major also requires one term of biology laboratory (MCDB 121L, 221L, E&EB 123L, or 223L). Some of the prerequisites in biology, chemistry, mathematics, and physics may be satisfied by receiving scores on Advanced Placement tests or placement examinations sufficient to earn acceleration credits in the particular subjects, even if the student does not choose to accelerate.

B.S. degree for the Class of 2016 and subsequent classes Nine courses are required beyond the prerequisites: MB&B 300, 301, 302, 360L, and 490; two additional upper-level MB&B electives, one of which must be a lecture course; one quantitative reasoning elective (e.g., MATH 120 or above, STAT 105 or 230 or above, CPSC 201 or above, or ENAS 130 or above); and one elective in the natural sciences at a level higher than required in the prerequisites. Students choose the elective courses in consultation with a faculty adviser (see below). Only two course credits of MB&B 470, 471, and 478, 479 may count toward these electives. Students may substitute CHEM 333 for MB&B 302. The quantitative reasoning requirement may not be fulfilled by Advanced Placement test scores.

B.A. degree for the Class of 2016 and subsequent classes Seven courses are required beyond the prerequisites: MB&B 251L, 300, 301, 302, and 490; one additional upper-level MB&B elective; and one quantitative reasoning elective (e.g., MATH 120 or above, STAT 105 or 230 or above, CPSC 201 or above, or ENAS 130 or above). Students choose the elective courses in consultation with a faculty adviser (see below). Students may substitute CHEM 333 for MB&B 302. The quantitative reasoning requirement may not be fulfilled by Advanced Placement test scores.

Senior requirement The senior requirement for both the B.S. and the B.A. is fulfilled by successful completion of MB&B 490, The Senior Project. Students enrolled in this course prepare a written report and make an oral presentation of a literature project. Students meet with faculty members in charge of the colloquium during the first two weeks of the spring term to agree on a topic and an approach. It is appropriate for students who took research for credit earlier in their training to write on their research topic. It is inappropriate for students to submit a revised version of a past research report or to resubmit a literature paper prepared for another course. The literature project for the senior requirement should be original work approved by the faculty member overseeing the senior colloquium.

The written report is expected to be 15–25 pages in length (double-spaced, twelve-point font exclusive of figures). A first draft of the paper is due two weeks prior to the date of the oral presentation. Faculty in charge of the program will review the draft and return it to the student with suggestions. A final draft of the paper is due the first day of the reading period in the student’s final term. Students make a fifteen-minute oral presentation during the last three weeks of their final term in a general scientific forum open to the public. Other students in the series are expected to attend all presentations.

Credit/D/Fail option Courses taken Credit/D/Fail may not be counted toward the requirements of the major.
The major for the Class of 2015 and previous classes Students who have already taken or placed out of either MCDB 120 or E&EB 122 are not required to take BIOL 101, 102, 103, or 104. Beyond the prerequisites, the requirements for the major are the same as those for the Class of 2016, except that the B.S. degree requires one additional biology elective at the 200 level or higher.

Students who have not yet taken or placed out of MCDB 120 or E&EB 122 must either take or place out of at least two of the four introductory biology modules, BIOL 101, 102, 103, 104. Beyond the prerequisites, the requirements for the major are the same as those for the Class of 2016, except that the B.S. degree requires one additional biology elective at the 200 level or higher.

Recommended courses for all classes All B.S. majors are encouraged to include MB&B 470 or 471 among their MB&B electives. The prerequisites in either general or organic chemistry should be taken in the freshman year.

Students with a strong interest in biophysics, including those planning to attend graduate school, are strongly encouraged to take courses beyond the basic requirements of the major. Such students are advised to take mathematics through differential equations (ENAS 194, MATH 246, or PHYS 301) and a full year of physical chemistry (CHEM 328 or 332, and 333). In place of one term of biophysics (MB&B 302) they may elect a full year of upper-level biophysics (MB&B 420 and graduate courses in optical spectroscopy and macromolecular interactions). Such revisions to the basic curriculum must be made in consultation with the faculty adviser.

Graduate courses in molecular biophysics and biochemistry, biology, and the biomedical sciences that may be of interest to undergraduates are listed in the bulletin of the Graduate School, and many are posted on the Biological and Biomedical Sciences Web site (http://bbs.yale.edu). Additional information is available from the directors of undergraduate and graduate studies. Undergraduates with an appropriate background may enroll with the permission of the director of graduate studies and the instructor.

Typical programs Programs with the minimal number of science courses required of B.A. and B.S. majors are shown below. Students whose scores on the Advanced Placement tests make them eligible for advanced courses are urged to replace the elementary science courses by more advanced ones in their freshman year, and to complete the required biochemistry and physics courses by the end of their sophomore and junior years, respectively. Students are permitted to take the biochemistry sequence (MB&B 300, 301) after one term of organic chemistry (CHEM 220).

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<th>Freshman</th>
<th>Sophomore</th>
<th>Junior</th>
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<tr>
<td>BIOL 101, 102, 103, 104</td>
<td>CHEM 220, 230, 222L, 223L</td>
<td>MB&amp;B 300, 301</td>
<td>CHEM 328</td>
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<td>CHEM 112, 113, 116L, 117L</td>
<td>MATH 112, 115</td>
<td>One quantitative reasoning elective</td>
<td>MB&amp;B 302</td>
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<td>And, for B.S. major: MB&amp;B 251L</td>
<td>PHYS 180, 181</td>
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<td>And, for B.S. major: MB&amp;B 360L</td>
<td>And, for B.S. major: One science elective</td>
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Combined B.S./M.S. degree program Exceptionally able and well-prepared students may complete a course of study leading to the simultaneous award of the B.S. and M.S. degrees after eight terms of enrollment. See "Simultaneous Award of the Bachelor’s and Master’s Degrees" under "Special Arrangements" in the Academic Regulations. Interested students should consult the director of undergraduate studies prior to the sixth term of enrollment for specific requirements in Molecular Biophysics and Biochemistry.

MB&B Faculty Committee on the Undergraduate Major Committee members are available for consultation throughout the year and are the only faculty advisers eligible to approve and sign MB&B majors’ course schedules at the beginning of each term. Members acting as faculty advisers are:

Class of 2014:
J. Steitz, 136E BCMM (737-4418)
C. Schlieker, 236A BASS (432-5035)

Class of 2015:
P. Sung, C 130A SHM (785-4553)
C. Sindelar, CE 25 SHM (737-4752)

Class of 2016:
M. Hochstrasser, 224 BASS (432-5101)
W. Konigsberg, CE 14A SHM (785-4599)

Class of 2017:
L. Regan, 322 BASS (432-9843)
M. Simon, 220 BASS (432-5158)

Requirements of the major
Prerequisites All classes—CHEM 112, 113, or 114, 115, and 116L, 117L (or 118, 119L); CHEM 124, 125, or 220, 230, and 222L, 223L; CHEM 328; MATH 112, 115; PHYS 170, 171, or 180, 181, or 200, 201; Class of 2016 and subsequent classes—B.S. — BIOL 101, 102, 103,
Courses

**MB&B 050a, Topics in Cancer Biology**  Sandy Chang  
Introduction to cancer as a genetic disease, with a focus on 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 freshmen with a strong background in biology and/or chemistry, typically demonstrated by a score of 4 or 5 on Advanced Placement examinations. Preregistration required; see under Freshman Seminar Program.  SC

**MB&B 104a or b / MCDB 104a or b, An Issues Approach to Biology**  Timothy Nelson  
Biological concepts taught in context of current societal issues, such as stem cell research and genetically modified organisms. Emphasis on biological literacy to enable students to evaluate scientific arguments.  SC

**MB&B 110b, Current Issues in Biological Science**  William Summers  
Students identify a scientific problem and then plan and execute a program of individualized learning aimed at the particular scientific knowledge required to understand and analyze the chosen problem. Intended to help students develop self-education skills as applied to scientific understanding, apply those skills to acquire some specific scientific knowledge, and understand the process by which scientific knowledge and understanding are achieved. For non–science majors.  SC

[ MB&B 111, The Science of Human Hormones ]

**MB&B 200b / MCDB 300b, Biochemistry**  Ronald Breaker and staff  
An introduction to the biochemistry of animals, plants, and microorganisms, emphasizing the relations of chemical principles and structure to the evolution and regulation of living systems. Prerequisites: BIOL 101, or equivalent performance on the corresponding biological sciences placement examination; one term of organic chemistry; or with permission of instructor.  SC

**MB&B 218La / HSAR 218La, Art and Biomolecular Recognition Laboratory**  Andrew Miranker and staff  
Students create and execute original projects in materials science using biotechnological tools. Introduction to the technical examination of art, with analysis of works from Yale University Art Gallery collections; the chemical basis of artist’s materials; applied techniques in biomolecular evolution. Enrollment limited. Preference to students with a high-school background or college-level course work in chemistry and/or biology.  SC

**MB&B 230b / MCDB 230b, Rain Forest Expedition and Laboratory**  Scott Strobel and staff  
Preparation for a two-week expedition to one of the world’s rain forests during spring break and for a ten-week summer laboratory experience using samples collected during the expedition. Integrated topics draw on the fields of ecology, microbiology, chemistry, pharmacology, molecular biology, and bioinformatics. Students participate in an original scientific project from field biology to natural product characterization. After one year of introductory biology or equivalent; after or concurrently with one term of organic chemistry. Limited enrollment. Funding for major travel expenses and summer research provided.  SC

**MB&B 251La / MCDB 301La, Laboratory for Biochemistry**  William Konigsberg and staff  
An introduction to current experimental methods in molecular biology. After or concurrently with MBB 200 or 300. Limited enrollment. Requires preregistration by e-mail to Aruna Pawashe and William Konigsberg prior to the first week of classes.  SC ½ Course cr

**MB&B 300a, Principles of Biochemistry I**  Michael Koelle and Matthew Simon  
Discussion of the physical, structural, and functional properties of proteins, lipids, and carbohydrates, three major classes of molecules in living organisms. Energy metabolism, hormone signaling, and muscle contraction 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 125 or 220  SC

**MB&B 301bG, Principles of Biochemistry II**  Christian Schlieker and Joan Steitz  
A continuation of MBB 300 that considers the chemistry and metabolism of nucleic acids, the mechanism and regulation of protein and nucleic acid synthesis, and selected topics in macromolecular biochemistry. Prerequisite: MBB 300 or permission of instructor.  SC
MB&B 302b, Principles of Biophysics  
Enrique De La Cruz and Chuck Sindelar
An introduction to the theoretical basis of biophysical concepts and approaches with selected examples and applications. Prerequisites: MBB 300 and CHEM 328.  SC

*MB&B 360Lb, Laboratory for Biochemistry and Biophysics  
Alan Garen and staff
An intensive introduction to the principles and applications of experimental techniques currently used in biochemistry, biophysics, and molecular biology. Recommended to be taken with or directly after MBB 301. Limited enrollment. Preregistration required during the first week of November using a sign-up sheet outside 157 OML.  SC

MB&B 420a, Macromolecular Structure and Biophysical Analysis  
Yong Xiong and staff
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: MBB 301 and 302.  SC

MB&B 425a / MCDB 425a, Basic Concepts of Genetic Analysis  
Tian Xu and staff
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 200 or equivalent.  SC

MB&B 435a, Mathematical Methods in Biophysics  
A. Elizabeth Rhoades and staff
Applied mathematical methods relevant to analysis and interpretation of biophysical and biochemical data. Statistics and error analysis, differential equations, linear algebra, and Fourier transforms. Analysis of real data from research groups in MBB. Prerequisites: MATH 120 and MBB 300 or equivalents, or with permission of instructors.  QB, SC

MB&B 443b, Advanced Eukaryotic Molecular Biology  
Mark Hochstrasser and staff
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: MBB 300 and 301, or permission of instructor.  SC

*MB&B 445b, Methods and Logic in Molecular Biology  
Anthony Koleske and staff
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: MBB 300 and 301.  SC RP

MB&B 449a, Medical Impact of Basic Science  
Joan Steitz and staff
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: MBB 300 and 301.  SC RP

MB&B 452b, Bioinformatics: Practical Application of Simulation and Data Mining  
Mark Gerstein
Techniques in data mining and simulation applied to bioinformatics, the computational analysis of gene sequences, macromolecular structures, and functional genomic 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: MBB 301 and MATH 115, or permission of instructor.  SC

*MB&B 470a and MBB 471b, Research in Biochemistry and Biophysics  
Alan Garen
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. A required organizational meeting will be held at the beginning of each term. 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. No more than two course credits count as electives toward the B.S. degree. Enrollment limited to junior and senior MBB majors. Prerequisite: MBB 251L or 360L.  SC

*MB&B 478a and MBB 479b, Intensive Research in Biochemistry and Biophysics  
Alan Garen
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. A required organizational meeting will be held at the beginning of each term. 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 MBB majors. Prerequisite: MBB 251L or 360L. 2 Course cr per term

*MB&B 490b, The Senior Project  
William Konigsberg and staff
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.