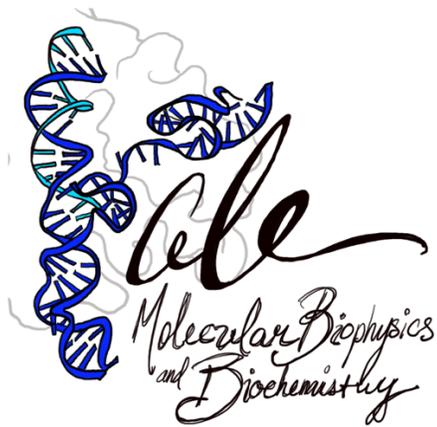


The Molecular Basis of Life

Undergraduate BA, BS and BS/MS Programs

Student Handbook for 2021-2022



The MB&B major from 10,000ft

For students first matriculating on or after Fall 2021

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 mechanism 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.

The focal point of BA, BS and BS/MS degrees in Molecular Biophysics and Biochemistry are:

Two semesters of **Biochemistry**

Two semesters of **Biophysics**

One semester of **Humanities**

Other MB&B requirements:

- support these courses, for example as pre-requisites or accompanying labs
- teach advanced insights that make use of these underpinnings
- teach the technology that enabled the scholarship behind these classes

Some additional requirements exist within MB&B because they:

- are requirements for some medical schools (waivable by MB&B Director of Undergraduate Studies (DUS))
- are part of interdepartmental efforts to add breadth to your understanding of the biological sciences (waivable by the MB&B DUS)
- are part of Yale's degree requirements (**not-waivable**)

Biochemistry in MB&B is a two semester sequence, MB&B 300 and 301.

Waivers for alternative courses are not allowed for these two courses.

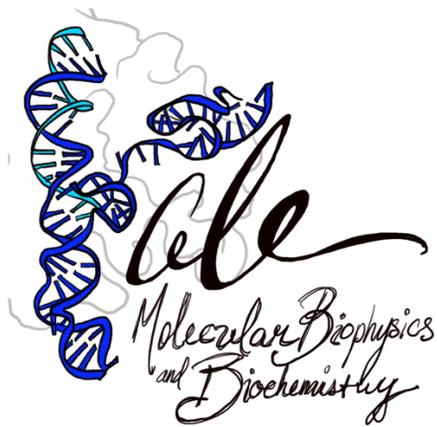
We recommend this sequence be taken in year 3.

Biophysics training in MB&B starts with MB&B 275 "Biology at the Molecular Level".

MB&B 275 should be taken in the fall of year 2 with a second semester usually taken in year 4. MB&B 275 must be followed by one semester of any 300+ level course at Yale that places strong emphasis on thermodynamics. CHEM 332 is typical and preferred, CHEM 328 is a frequent alternative. CENG 300, APHY 420, MENG211 and others are also acceptable.

Humanities training is required in MB&B because science is a human activity. We invite students to take the initiative and engage this interface by taking any full credit, Yale humanities course they feel can be paired with MB&B 268, "Society, Identity and STEM"

Substitutions to this approach include MB&B 107 and several courses in the department of the History of Science.



The MB&B major from 10,000ft

For students first matriculating **before** Fall 2021

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 mechanism 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.

The focal point of BA, BS and BS/MS degrees in Molecular Biophysics and Biochemistry are:

Two semesters of **Biochemistry**

Two semesters of **Biophysics**

Other MB&B requirements:

- support these courses, for example as pre-requisites or accompanying labs
- teach advanced insights that make use of these underpinnings
- teach the technology that enabled the scholarship behind these classes

Some additional requirements exist within MB&B because they:

- are requirements for some medical schools (waivable by MB&B Director of Undergraduate Studies (DUS))
- are part of interdepartmental efforts to add breadth to your understanding of the biological sciences (waivable by the MB&B DUS)
- are part of Yale's degree requirements (**not-waivable**)

Biochemistry in MB&B is a two semester sequence, MB&B 300 and 301.

Waivers for alternative courses are not allowed for these two courses.

We recommend this sequence be taken in year 3.

Biophysics training in MB&B starts ideally with MB&B 275 "Biology at the Molecular Level".

MB&B 275 should be taken in the fall of year 2 with a second semester usually taken in year 4. MB&B 275 must be followed by one semester of any 300+ level course at Yale that places strong emphasis on thermodynamics. CHEM 332 is typical and preferred, CHEM 328 is a frequent alternative. CENG 300, APHY 420, MENG211 and others are also acceptable.

Additional options through this requirement exist, most typically beginning with CHEM 332 or CHEM 328 with options for fulfilling the second semester at the 300+ level in MB&B or Chemistry

The MB&B Major at a Glance

The Molecular Biophysics and Biochemistry (MB&B) major is for students captivated by biology and for whom mechanistic understanding is primarily satisfied by engaging the subject at a molecular level. MB&B fosters creativity by integrating the scholarly and practical approaches of many disciplines. The result is a proud history of graduates who have leveraged their training for careers in medicine, research, entrepreneurship, pharma, teaching, consulting, journalism, law, policy and public service.

Curriculum

- Core required course sequences in Biochemistry and Biophysics
- A required laboratory course with flexibility that allows premedical students to take as fulfilling medical school chemistry lab credit or biology lab credit
- Majors can take two terms of Research for Credit for a letter grade (MB&B 470/471)
 - Can be expanded upon for your senior requirement
 - Can be leveraged to waive out of required laboratory courses
- Electives (two are required) that span deep dives in biological concepts, tools and methods for quantitative biology as well as coursework with cross-listings to Education Studies, English and History of Art.
- Option to pursue a 4-year dual BS/MS degree

Advising

The Director of Undergraduate Studies (Andrew Miranker) and Registrar (Liz Vellali) oversee an advising structure that includes 6 faculty members and four peer-mentors.

Faculty: Two MB&B faculty members serve as academic advisors for each graduating class. Majors pick their advisor when they join the department and see that advisor regularly until they graduate. The faculty advisors are the primary point of contact for majors and should be regularly consulted for current information, advice, reference letters, and signing of their course schedules.

Class of 2022: Professors **Michael Koelle** (CE28 SHM) and **Candice Paulsen** (234 BASS)

Class of 2023: Professors **Mark Hochstrasser** (228 Bass) and **Lillian Kabeche** (Location TBA). Note, these advisors are for freshman interested in knowing more about MB&B in advance of choosing a major.

Class of 2024: Professors **Andrew Miranker** (318 Bass) and **Franziska Bleichert** (345 YSB)

Class of 2021: Professors **Joe Howard** (C-149 YSB) and **Kai Zhang** (340 YSB).

You can also contact the DUS and Registrar directly at MBBUndergrad@yale.edu or 203-737-2060

Peer Mentors: A set of four junior and senior MB&B majors serve as peer mentors for students who are considering or entering the MB&B major. Peer mentors can give fellow students a sense of the experience of majoring in MB&B and practical advice on navigating the requirements and electives in our program. Feel free to contact any of these students for one-on-one advice, or attend one of their “peer-mentor dinners” which occur about once/month

Raquel Sequeira	raquel.sequeira@yale.edu	Class of 2022	Timothy Dwight College
Mehana Daftary	mehana.daftary@yale.edu	Class of 2022	Benjamin Franklin College
Daniel Guerra	Daniel.guerra@yale.edu	Class of 2022	Trumbull College
Sol Bloomfield	sol.bloomfield@yale.edu	Class of 2023	Pierson College
Alice Zhang	alice.l.zhang@yale.edu	Class of 2023	Timothy Dwight College

Working in a Research Lab

Do work-study a lab, secure a paid summer internship, or take Research for Credit (MB&B 470/471). Ask your advisor for tips on finding a lab, pay attention to our weekly newsletter and see other advice in this handbook.

Noteworthy:

- Study halls during reading week attended faculty. Refreshments served!
- Monthly dinners hosted by Peer Mentors
- Weekly newsletter highlighting opportunities, events and pictures of the DUS’ and Registrar’s cats
- Undergraduate Research Symposia

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FRONT COVER

Nucleic acid inspired graphic drawn by **Anna-Sophia Boguraev**, Class of 2020

Introduction

The undergraduate programs offered by the department of Molecular Biophysics & Biochemistry (MB&B) are for students interested not just in what life is, but also in how it works. We seek to understand life at a mechanistic level by studying how the extraordinarily complex molecules found in living organisms create structures, carry out chemistry, and store and utilize information to generate the remarkable properties of living organisms. The term “Biochemistry” in our name refers to the discipline that identifies and studies the molecules and chemical reactions in biological organisms. “Molecular Biophysics” uses the methods of physics to determine how the molecules identified by biochemists actually work by determining their three-dimensional structures and mechanisms of action. For example, biochemistry was used to discover DNA and the fact that it carries genetic information, while biophysics was used to discover its double-helix structure. Biochemistry and biophysics are rapidly advancing areas of science that underlie the current dramatic progress in medicine.

Our undergraduate degree programs are well suited for students planning to attend medical and/or graduate school in biochemistry, molecular biology, genetics, genomics, or biophysics. The MB&B major differs from the major in Molecular, Cellular, and Developmental Biology (MCDB) in that MB&B places its central focus on studying biology using the tools of chemistry, physics, and biochemistry. MB&B students thus carry out more in-depth coursework in these areas, and typically take less coursework in other areas such as organismal biology, cell biology, and genetics.

MB&B majors first acquire a broad foundation in chemistry, mathematics, physics, and biology, and then, starting in the sophomore or junior year, focus intensively on biochemistry and biophysics. Seniors choose among a wide range of opportunities: independent research projects, courses at the Graduate School or the Medical School, and advanced elective classes in Yale College.

Designed for students with a strong interest in research, the B.S. degree program provides an extensive 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. degree requires 2 fewer courses than the B.S., but still provides the intellectual discipline of biochemistry and biophysics for students who also want to have sufficient time to pursue in-depth studies outside the major.

The four-year B.S./M.S. involves graduate-level coursework and intensive research similar to that carried out in the first year of a Ph.D. program. The B.S./M.S. is particularly suited for students who will not pursue a Ph.D. in the sciences, but who are going on to careers (e.g. business or legal aspects of the biotechnology industry) in which they will benefit from advanced scientific training.

Of the seniors majoring in MB&B each year, about two-thirds go to medical school. Of the other third, some enter graduate school, others seek employment in university labs or in the biotechnology industry, and some attend law or business school. Our alumni include many distinguished leaders in science and medicine.

Director of Undergraduate Studies (DUS)

Andrew Miranker, BASS 318 (432-8954), MBBUndergrad@yale.edu

DUS Registrar

Elizabeth Vellali, CE26A SHM (737-2060) MBBUndergrad@yale.edu

Other information

This handbook along with a wealth of other information and forms can be found on the MB&B web site.

<https://mbb.yale.edu/academic-programs>

MB&B Faculty Advisor System

All majors should get to know their faculty advisor in addition to meeting with them for signing of course schedules. Entering freshmen should meet with their college advisor for signing of course schedules, but also consult one of the freshman MB&B Faculty Advisors assigned to their class for current information and advice. Faculty advisors selected in sophomore year remain your advisor until graduation.

Class of 2022: Professors **Michael Koelle** (CE28 SHM) and **Candice Paulsen** (234 BASS)

Class of 2023: Professors **Mark Hochstrasser** (228 Bass) and **Lillian Kabeche** (Location TBA). Note, these advisors are for freshman interested in knowing more about MB&B in advance of choosing a major.

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Class of 2021: Professors **Joe Howard** (C-149 YSB) and **Kai Zhang** (340 YSB).

Note, these advisors are for freshman interested in knowing more about MB&B in advance of choosing a major.

Note: Students who apply and are admitted to the BS/MS program switch to a 2-person advising committee system that includes the original advisor and the DUS.

Bios, research and additional contact information for each of these faculty in MB&B can be found here:

<https://mbb.yale.edu/people/faculty>

Peer Mentors

A set of four junior and senior MB&B majors serve as peer mentors for students who are considering or entering the MB&B major. Peer mentors can give fellow students a sense of the experience of majoring in MB&B and practical advice on navigating the requirements and electives in our program. Peer mentors offer advice on which classes to take, experiences to consider and anything pertaining to the major. They can provide advice on how to take advantage of the many academic resources available to you, such as peer tutors, college tutors, teaching fellows, faculty office hours, etc. Peer mentors also host informal community-building get-togethers in the department for prospective and current majors. If you have not yet declared an MB&B major and want to be invited to these events, please email MBBUndergrad@yale.edu.

Peer mentors for 2021-2022

Raquel Sequeira, raquel.sequeira@yale.edu, Class of 2022, Timothy Dwight College

Raquel is interested in energetics at all levels, from physics to ecology, and especially how energy is transferred and transformed across those levels. She has done research in epigenetics and now works on modeling electron transport. Raquel is also a student of philosophy and literature, with a focus on Shakespeare scholarship and performance. She hopes to unite her passions for science and humanities in her work.

Mehana Daftary, mehana.daftary@yale.edu Class of 2022, Benjamin Franklin College

Mehana is interested in biochemistry and disease mechanisms, and how our learning can inform rational drug development. She works at the Crews lab assisting in the development of PROTACS, which are chimeric complexes designed to specifically ubiquitinate and degrade target proteins. She is passionate about public health and epidemiology and hopes to continue to explore these interests during the rest of her time at Yale. Outside of academic interests, Mehana is the Yale Campus Girl Scout Secretary, serves as a coordinator for the Yale Community Kitchen, and is an officer in the Glee Club.

Daniel Guerra, daniel.guerra@yale.edu, Class of 2022, Trumbull College

Daniel has been invested in learning about the crossover of the physical sciences and engaging in humanities at Yale. He has done research on the mechanisms of diabetes and recently worked in the lab of former MB&B professor Dr. Patrick Sung, focusing on tumor suppressors BRCA1 and BRCA2 and DNA repair processes. Outside of science, Daniel serves on YCC, as the Creative Director for Y Fashion House, and Publicity Director/Choreographer for Yale Danceworks.

Solomon (Sol) Bloomfield, sol.bloomfield@yale.edu, Class of 2023, Pierson College Sol is interested in exploring the biochemistry of the natural world and applying it to human health. This has led him to study the immune response to different types of cancer cell death at the Rothlin-Ghosh lab and marine natural product drug leads at the Scripps

Institute of Oceanography. Outside of MB&B, Sol serves as the student coach of the Yale Men's Club Water Polo Team, is a FOOT leader, and is a member of the Helix Incubator and the Yale Bridge Club.

Alice Zhang, Alice.l.zhang@yale.edu, Class of 2023, Timothy Dwight College As an MB&B and Anthropology major, Alice is particularly interested in biochemical explanations for disease, but also how cultural and social factors can impact how people view health and their access to healthcare. She conducts research in the Paulsen Lab, focusing on a particular mutation of the TRPA1 pain receptor (the “wasabi receptor”) and characterizing mutant channel activity, trafficking, and other relevant properties. Outside of class, Alice likes to go birding, visit natural history museums, dabble in arts and crafts, and read.

Degree Roadmap

Molecular Biophysics and Biochemistry			
Degrees Offered	BA Molecular Biophysics and Biochemistry	BS Molecular Biophysics and Biochemistry	BS/MS Molecular Biophysics and Biochemistry
Prerequisites for entering the major	Two terms of General Chemistry with lab		
	Introductory Biology BIOL 101, 102, 103, and 104		
	Two terms of Calculus MATH 112, 116		
	One term of Organic Chemistry with lab		
Requirements for each degree	11 course credits (including senior req)	13 course credits (including senior req)	12.5 course credits (including senior req) and 8 graduate courses
	Core Biochemistry and Biophysics Courses MB&B 251L, 300, 301, and 268 (taken concurrently with a humanities course elective)		
	Second term of Organic Chemistry and MB&B 275 or one term of physical chemistry		
	Two terms of Physics numbered PHYS 170 or higher		
	1 MB&B upper-level elective and 1 QR elective	MB&B 302 or equivalent, 2 MB&B upper-level electives, 1 QR elective, and 1 natural science elective	
	Core Biochemistry and Biophysics Courses MB&B 251L, 300, 301, and 268 (taken concurrently with a humanities course elective)		
Senior Requirements	Senior Project (MB&B 490)		Intensive Research (MB&B 570a and MB&B 571b)

Updated Spring 2021

The Bachelor of Arts Degree

The B.A. program provides the intellectual discipline of biophysics and biochemistry for students who want to have sufficient time for in-depth studies outside the major or who are interested in molecular biology as part of a liberal education and may not want to go on to graduate work in any of the natural sciences. B.A. program majors have an opportunity to carry out research in faculty laboratories after they have completed their required MB&B laboratory course. In the absence of Advanced Placement (AP) in any of the natural sciences or mathematics, completion of at least 19.5 science credits is required for the B.A. major.

Requirements for the B.A. program in the MB&B Major

The table shows the MB&B course requirements in the Basic Sciences (Part A) and in the Advanced Sciences (Part B) for the B.A. degree. Courses prefixed with a star (*) may be waived by receiving scores on AP tests or placement exams sufficient to earn acceleration credits in the particular subjects, even if the student does not choose to accelerate. Note that you can find a complete list of MB&B courses, including electives, at the end of this handbook.

Bold letters after the number of credits indicate footnotes.

Part A. Basic Sciences Credits

Introductory Biology:

*BIOL 101, 102, 103, and 104 2

Chemistry:

*General: CHEM 161, 165, or 163, 167; and 134L, 136L 3a

Organic: CHEM 174, 175, or 220, 221, and 222L, 223L 3b

Physical: CHEM 328 (may substitute CHEM 332) 1c

Physics:

*PHYS 170, 171, or 180, 181, or 200, 201 2

Mathematics:

*Calculus: MATH 112 and either MATH 115 or 116 2d

Total Course Credits in Basic Science (Maximum) 13

Part B. Advanced Sciences and Senior Requirement

MB&B:

Biochemistry: MB&B 300, 301, and 251L (0.5 credit) 2.5f

Biophysics: MB&B 302 (may substitute CHEM 333) 1

MB&B Elective: MB&B 107 or any 200+ level MB&B course 1

MB&B 490b (Senior requirement) 1g

Quantitative reasoning (QR) elective 1e

Total Course Credits in Advanced Science 6.5

Total Credits Required for B.A. Degree 19.5

a: (For class of 2018 and earlier, the previously offered general chem. courses will be accepted: 112, 113, or 114, 115, & 116L, 117L; or 118 & 119L)

b: Only students having AP for CHEM 113 are eligible for CHEM 174. By taking freshman organic chemistry (CHEM 174, 175) in the fall followed by organic chemistry (CHEM 221b) in the spring of the freshman year, a student is able to take MB&B 300a/301b in the sophomore rather than the junior year.

c: CHEM 328a is the standard one-term physical chemistry course that should be taken by most MB&B majors. A small number of students with especial interest in physical chemistry may want to take CHEM 332a instead of CHEM 328a. Taking CHEM 332a gives students the option to take a second term of physical chemistry, CHEM 333b, as a substitute for the biophysics course MB&B 302b. Aside from the more fundamental treatment given in Chem 332 (viz., trying to explain basic concepts and to demonstrate from where the venerable tenants/equations of thermodynamics actually originate), the primary difference between these two courses resides in the focus of applications (with Chem 328 obviously being more oriented towards biochemical applications).

d: MATH 115 and 116 are essentially equivalent in terms of calculus level. MATH 116 is a more intimate class, with readings grounded in biology and more use of differential equations to solve problems. Even if you place out of MATH 115, you may consider MATH 116 because of the unique topics presented. Please consult the instructors (e.g. John Hall) if you wish to discuss this further.

e: Several courses that fulfill this requirement and fit nicely with the interests of MB&B majors are as follows: MB&B strongly encourages all majors to strengthen their skills in statistics and data analysis. In particular, S&DS 110 (Introduction to R) and S&DS 220 (Intensive Intro Stats) include instruction in the R package for statistical computing, which is useful for all biologists. Some MB&B majors may be interested in S&DS 105 or 230, CPSC 100, 112, 201 or above. For those interested in computational or structural biology, multivariable calculus is advantageous (MATH 120 or ENAS 151). Linear algebra (Math 222 or 225) is highly recommended for computational biologists. Others with permission from academic advisor or DUS. AP credit cannot be applied toward the quantitative reasoning elective.

f: MB&B 251L is cross listed as MCDB 301L. This means that students could sign up for the class as “MB&B 251” if they need an additional chemistry lab for premed purposes. On the other hand, students who have already take at least three chemistry labs could instead register for “MCDB 301L” and thus complete both their MB&B biochemistry lab course requirement AND a premed “biology lab” course requirement at the same time.

g: The MB&B senior requirement for both B.S. and B.A. degrees is fulfilled by participation in MB&B 490b during the second semester of the senior year. This course will confer course credit for completion of the senior project in the department. Students prepare a written report and make an oral presentation on recent advances in research on a topic of their choice within biochemistry and biophysics. Students will meet with the faculty during the first two weeks of the spring term to agree upon a topic and approach.

Written presentation: The paper is expected to be 15–25 pages in length, and should critically review the literature on a scientific topic within biochemistry and biophysics. A first draft of the paper is due two weeks prior to the date of the oral presentation. It is inappropriate for students to resubmit a paper prepared for another course in fulfillment of the senior requirement. The literature project must be original new work approved by the faculty member overseeing the senior project. It is recommended that students who took research for credit earlier in their training write a new 15–25-page literature review on the topic of their research and append to it the research report they previously completed for the research course. Faculty in charge of the program will provide suggestions for the paper and return it to the student. A final draft of the paper is due the first day of the reading period of the student’s final term.

Oral presentation: Students will make a 15-minute oral presentation during the last three weeks of the student’s final term in a general scientific format open to the public. Other students in the senior project course are expected to attend the presentations.

NOTE: MB&B 470/471 are independent research courses for MB&B majors only that may be taken during the sophomore, junior, or senior years. Students receive letter grades. MB&B B.A. degree majors may take up to two credits of these courses and count one of them as the “MB&B elective” toward their MB&B B.A. degree requirements. Students may take additional independent research for credit by registering for MB&B 472/473, which have identical requirements but are graded Pass/Fail. These additional credits do not count towards the MB&B degree requirements. Ideally students will take MB&B 251L to receive a grounding in practical laboratory skills prior to taking an independent research course.

Possible Course Programs for B.A. MB&B Majors Entering Yale Without Any Advanced Placement

This B.A. program provides the minimal number of science and non-science courses required of all MB&B majors. It earns a total of 36.5 course credits and assumes no AP credit. (Credits are indicated in parentheses). Students having AP in science are urged to replace introductory science courses by more advanced ones in their freshman year.

Freshman	Sophomore	Junior	Senior
BIOL 101-104 (2)	CHEM 220 and 221 (2)	MB&B 300a (1)	CHEM 328a (1)
	CHEM 222 and 223 (1)	MB&B 301b (1)	MB&B elective (1)
CHEM 161, 165 (2)	MATH 116 a or b (1)	MB&B 251L (0.5)	MB&B 302b (1) Biophysics
CHEM 134L, 136L (1)	Quantitative Reasoning (1)	PHYS 180a and PHYS 181b (2)	MB&B 490b (1) Senior Seminar
MATH 112a or b (1)	Non-science (4)	Non-science (5)	Non-science (5)
Non-science (3)			

MB&B requirements/Total

6/9

5/9

4.5/9.5

4/9

TOTAL 19.5/36.5

Notes:

1. Majors who must begin their study of a foreign language after entering Yale are urged to do so in their freshman year. The foreign language requirement should be completed by the end of the junior year.
2. Half-credit courses such as BIOL 101-104 and MB&B 251L earn no course credit per se; one credit is awarded only after two such courses are completed. Additional half-credit courses include one-day-per-week lab courses offered by MCDB, Chemistry, Computer Science, Psychology, or Physics.

MB&B Coursework Planning Sheet for the B.A. Degree

REQUIREMENT

COURSE NAME

TERM TAKEN

Introductory Courses	(When alternative courses are listed on one line, circle the name of the one taken)	TERM TAKEN			
		Proposed	Enrolled	Completed	Grade
Introductory Biology	BIOL 101				
Introductory Biology	BIOL 102				
Introductory Biology	BIOL 103				
Introductory Biology	BIOL 104				
General Chem 1	CHEM 161 or 163 <small>(previously offered versions of general chem. and labs</small>				
General Chem Lab 1	CHEM 134L				
General Chem 2	CHEM 165 or 167				
General Chem Lab 2	CHEM 136L				
Calculus 1	MATH 112a/b				
Calculus 2	MATH 116a/b or 115a/b				
Quantitative Reasoning	Specify course:				
Mid-level Courses					
Physics 1	PHYS 170a or 180a or 200a				
Physics 2	PHYS 171b or 181b or 201b				
Organic Chem 1	CHEM 174a or 220a/b				
Organic Chem Lab 1	CHEM 222La/b				
Organic Chem 2	CHEM 175b or 221a/b				
Organic Chem Lab 2	CHEM 223La/b				
Biochemistry 1	MB&B 300a				
Biochemistry 2	MB&B 301b				
Biochemistry Lab BS	MB&B 251La				
Upper-level Courses					
Physical Chem 1	CHEM 328a or 332a				
Biophysics	MB&B 302b or CHEM 333b				
MB&B Elective*					
Senior Seminar	MB&B 490				
Other courses					
Other courses					
Other courses					

*MB&B elective is MB&B 107 or any 200-level or above MB&B course, including any lecture, seminar, lab or research for credit course.

The Bachelor of Science Degree

The B.S. program is designed especially for students with a strong commitment to research. B.S. program majors have an opportunity to carry out research in faculty laboratories after they have completed their required MB&B laboratory course. This program is readily adapted to permit qualified majors to enter the combined B.S./M.S. program that leads to the simultaneous award of the two degrees at the end of four years in Yale College.

In the absence of AP in any of the natural sciences or mathematics, and depending on the specific courses taken, completion of 21.5 credits of science courses are required for the completion of the B.S. degree.

Requirements for the B.S. Program in the MB&B Major

The table shows the MB&B requirements in the Basic Sciences (Part A) and in the Advanced Sciences (Part B) for the B.S. degree. Courses prefixed with a star (*) may be waived by receiving scores on AP tests sufficient to earn acceleration credits in the particular subjects, even if the student does not choose to accelerate. Note that you can find a complete list of MB&B courses, including electives, at the end of this handbook. Letters after the number of credits indicate footnotes. *Courses in italics indicate those areas in which the B.S. degree differs from the B.A. degree.*

Part A. Basic Sciences Credits

Introductory Biology:

*BIOL 101, 102, 103, and 104 2

Chemistry:

*General: CHEM 161, 165, or 163, 167; and 134L, 136L 3a

Organic: CHEM 174, 175, or 220, 221, and 222L, 223L 3b

Physical: CHEM 328 1c

Physics:

*General: PHYS 170, 171, or 180, 181, or 200, 201 2

Mathematics:

*Calculus: MATH 112 and either MATH 115 or 116 2d

Total Course Credits in Basic Science (Maximum) 13

Part B. Advanced Sciences and Senior Requirement

Biochemistry: MB&B 300a, 301b and 251 (.05) 2.5f

Biophysics: MB&B 302b (may substitute CHEM 333b) 1

MB&B Electives: *Two* additional MB&B courses 2g

Additional science elective 1h

MB&B 490b Senior Project 1i

Quantitative reasoning (QR) elective 1e

Total Course Credits in Advanced Science 8.5

Total Credits Required for B.S. Degree 21.5

a: (For class of 2018 and earlier, the previously offered general chem. courses will be accepted: 112, 113, or 114, 115, & 116L, 117L; or 118 & 119L)

b: Only students having AP for CHEM 113 are eligible for CHEM 174. By taking freshman organic chemistry (CHEM 174, 175) in the fall followed by organic chemistry (CHEM 221b) in the spring of the freshman year, a student is able to take MB&B 300a/301b in the sophomore rather than the junior year.

c: CHEM 328a is the standard one-term physical chemistry course that should be taken by most MB&B majors. A small number of students with especial interest in physical chemistry may want to take CHEM 332a instead of CHEM 328a. Taking CHEM 332a gives students the option to take a second term of physical chemistry, CHEM 333b, as a substitute for the biophysics course MB&B 302b. Aside from the more fundamental treatment given in Chem 332 (viz., trying to explain basic concepts and to demonstrate from where the venerable tenants/equations of thermodynamics actually originate), the primary difference between these two courses resides in the focus of applications (with Chem 328 obviously being more oriented towards biochemical applications).

d: MATH 115 and 116 are essentially equivalent in terms of calculus level. MATH 116 is a more intimate class, with readings grounded in biology and more use of differential equations to solve problems. Even if you place out of MATH 115, you may consider MATH 116 because of the unique topics presented. Please consult the instructors (e.g. John Hall) if you wish to discuss this further.

e: Several courses that fulfill this requirement and fit nicely with the interests of MB&B majors are as follows: MB&B strongly encourages all majors to strengthen their skills in statistics and data analysis. In particular, S&DS 110 (Introduction to R) and S&DS 220 (Intensive Intro Stats) include instruction in the R package for statistical computing, which is useful for all biologists. Some MB&B majors may be interested in S&DS 105 or 230, CPSC 100, 112, 201 or above. For those interested in computational or structural biology, multivariable calculus is advantageous (MATH 120 or ENAS 151). Linear algebra (Math 222 or 225) is highly recommended for computational biologists. Others with permission from academic advisor or DUS. AP credit cannot be applied toward the quantitative reasoning elective.

f: MB&B 251L is cross-listed as MCDB 301L. This means that students could sign up for the class as “MB&B 251” if they need an additional chemistry lab for premed purposes. On the other hand, students who have already take at least three chemistry labs could instead register for “MCDB 301L” and thus complete both their MB&B biochemistry lab course requirement AND a premed “biology lab” course requirement at the same time.

g: One of the two must be an MB&B lecture or seminar course. The other can be another MB&B lecture course, research for credit, or the upper level lab course MB&B 460L. **Only two course credits of MB&B 470, 471 and 478, 479 may count towards the B.S. degree requirements – one as an “MB&B elective” and the other as the “additional science elective”.**

h: This elective is chosen, with the approval of the major’s MB&B Faculty Advisor, from among courses with the Sc designation. Students may also use graduate courses offered by MB&B and other science departments, including Cell Biology, Human Genetics, Neuroanatomy, Pharmacology and Physiology. Courses must be at a higher level than those already required for the major. This elective can be an introductory course if no other course in that field is required.

i: The MB&B senior requirement for both B.S. and B.A. degrees is fulfilled by participation in MB&B 490b during the second semester of the senior year. This course will confer course credit for completion of the senior project in the department. Students prepare a written report and make an oral presentation on recent advances in research on a topic of their choice within biochemistry and biophysics. Students will meet with the faculty during the first two weeks of the spring term to agree upon a topic and approach.

Written presentation: The paper is expected to be 15–25 pages in length, and should critically review the literature on a scientific topic within biochemistry and biophysics. A first draft of the paper is due two weeks prior to the date of the oral presentation. It is inappropriate for students to resubmit a paper prepared for another course in fulfillment of the senior requirement. The literature project must be original new work approved by the faculty member overseeing the senior project. It is recommended that students who took research for credit earlier in their training write a new 15–25 page literature review on the topic of their research, and append to it the research report they previously completed for the research course. Faculty in charge of the program will provide suggestions for the paper and return it to the student. A final draft of the paper is due the first day of the reading period of the student’s final term.

Oral presentation: Students will make a 15-minute oral presentation during the last three weeks of the student’s final term in a general scientific format open to the public. Other students in the senior project course are expected to attend the presentations.

NOTE: MB&B 470/471 are independent research courses for MB&B majors only that may be taken during the sophomore, junior, or senior years. Students receive letter grades. MB&B majors may take up to two credits of these courses and count them as electives toward the MB&B B.S. degree requirements. Students may take additional independent research for credit by registering for MB&B 472/473, which have identical requirements but are graded Pass/Fail. These additional credits do not count towards the MB&B degree requirements. Ideally students will take MB&B 251L to receive a grounding in practical laboratory skills prior to taking an independent research course.

Possible Course of Study for the MB&B B.S. Major

Examples of course selections are provided below for the MB&B B.S. major, depending on the placement status of the incoming freshman. Note: you can major with a B.S. in MB&B even if you do not place out of any classes. In that case, please consult the example given on page 8 and note that some of the “non-science” credits would then be allocated to the additional MB&B requirements (2 credits). Note that taking MB&B 300/301 in the sophomore year frees up the junior year to finish other requirements and MB&B electives in the junior and senior years. Nevertheless, it is still possible to complete the requirements for a BS major in MB&B, taking 300/301 in the junior year, as shown on page 8.

The following example assumes that the student has acceleration credit for two semesters of math based on performance on the math AP exam.

AP	Freshman	Sophomore	Junior	Senior
Math (2)	BIOL 101-104 (2)	CHEM 220, 221 (2)	PHYS 180a PHYS 181b (2)	CHEM 328a (1)
	CHEM 161, 165 (2)	CHEM 222La/223Lb (1)	MB&B elective (1)	MB&B 302b (1)
	CHEM 134L, 136L (1)	MB&B 300a/301b (2)	Science elective (1)	MB&B elective (1)
	Non-science (4)	MB&B 251La (.5)	QR elective (1)	MB&B 490b Senior Seminar (1)
		Non-science (3)	Non-science (4)	Science or non-science (4)

MB&B requirements/Total

2/2

5/9

5.5/8.5

5/9

4/8

Total 21.5/36.5

MB&B Coursework Planning Sheet for the B.S. Degree

REQUIREMENT	COURSE NAME	TERM TAKEN			
Introductory Courses	(When alternative courses are listed on one line, circle the name of the one taken)	Proposed	Enrolled	Completed	Grade
Introductory Biology	BIOL 101				
Introductory Biology	BIOL 102				
Introductory Biology	BIOL 103				
Introductory Biology	BIOL 104				
General Chem 1	CHEM 161 or 163 (previously offered versions of general chem. and labs will be accepted for the classes of 2018 and earlier)				
General Chem Lab 1	CHEM 134L				
General Chem 2	CHEM 165 or 167				
General Chem Lab 2	CHEM 136L				
Calculus 1	MATH 112a/b				
Calculus 2	MATH 116a/b or 115a/b				
Quantitative Reasoning	Specify course:				
Mid-level Courses					
Physics 1	PHYS 170a or 180a or 200a				
Physics 2	PHYS 171b or 181b or 201b				
Organic Chem 1	CHEM 174a or 220a/b				
Organic Chem Lab 1	CHEM 222La/b or 226La				
Organic Chem 2	CHEM 175b or 221a/b				
Organic Chem Lab 2	CHEM 223La/b or 226Lb				
Biochemistry 1	MB&B 300a				
Biochemistry 2	MB&B 301b				
Biochemistry Lab BS	MB&B 251La				
Upper-level Courses					
Physical Chem 1	CHEM 328a or 332a				
Biophysics	MB&B 302b (or CHEM 333b)				
MB&B Lecture Elective#					
MB&B Elective*					
Senior Seminar	MB&B 490				
Science Elective					
Other courses					
Other courses					
Other courses					

*MB&B elective is MB&B 107 or any 200-level or above MB&B course, including any lecture, seminar, lab or research for credit course.

MB&B Lecture elective is MB&B 107 or any 200-level or above MB&B course EXCEPT a lab or research for credit course

Bachelor of Science/Master of Science Degree

To provide exceptionally able undergraduates an opportunity to accelerate their professional education, the MB&B department offers a combined B.S. and M.S. program usually requiring eight terms to complete.

1. The candidate must satisfy the requirements of Yale College for Yale's combined bachelor's and master's degree program. These rules are outlined in the Yale College Programs of Study, and are incorporated into the requirements described here.

2. The candidate normally must complete the core requirements of the B.S. degree during his/her first three years in Yale College. Specifically, he/she must:

- (a) Enter Yale College as a freshman with AP (or have received acceleration credit) equivalent to at least one *year* of college-level courses in biology, chemistry, mathematics, or physics;
- (b) Complete all of the following (or their equivalents) by the end of his/her fourth term in Yale College: Introductory Biology, CHEM 221/223L, the required Quantitative Reasoning course, PHYS 180a, and 181b;
- (c) Complete the following by the end of his/her sixth term in Yale College: MB&B 300a/600a, 301b/601b, and 360Lb/660Lb (or its equivalent), CHEM 328a, and either MB&B 302b or CHEM 333b; and
- (d) Complete one semester of Research in Biochemistry and Biophysics (MB&B 470a or 471b) or equivalent in the laboratory where the M.S. thesis project will be carried out.

3. The candidate must apply in writing to the Director of the B.S./M.S. Program for admission no later than December 1 of their junior year, and have achieved at that time grades of A or A- in at least two-thirds of all courses as well as in courses directly related to the MB&B major. It is not required that the student maintains these grade standards after he/she joins the B.S./M.S. program in order to successfully complete the degrees, although most students do maintain such grades.

4. In lieu of the electives required of B.S. majors, B.S./M.S. candidates must complete the graduate-level work described below. Courses qualify as graduate level if they have course numbers of 500 or higher. Some 400-level undergraduate courses are cross-listed as graduate-level courses and do qualify as counting toward the M.S. elective requirements.

- (a) During the senior year, two semesters of Intensive Research in Biochemistry and Biophysics (MB&B 570a and 571b).
- (b) Two graduate-level MB&B lecture electives. Among the possibilities are the following:

Fall term: MB&B 420a/720a *Macromolecular Structure and Biophysical Analysis*, MB&B 449a/749a *Medical Impact of Basic Science*, MB&B 452b/752bu *Bioinformatics: Practical Application of Simulation and Data Mining*, MB&B 602a *Molecular Cell Biology*, MB&B 750a2 *Biological Membranes*. **Note:** MB&B 730a *Methods and Logic in Molecular Biology* is not open to B.S./M.S. students.

Spring term: [MB&B 421b/721b *Macromolecular Interactions & Dynamic Properties*], MB&B 443b/743b *Advanced Eukaryotic Molecular Biology*, MB&B 630b *Biochemical & Biophysical Approaches in Molecular and Cellular Biology*, MB&B 710b4 *Electron Cryo-Microscopy for*

Protein Structure Determination, MB&B 760b3 Advanced X-ray Crystallography, MB&B 761b4 X-ray Crystallography Workshop, MB&B 465b/765b Enzyme Mechanisms.

(c) Four graduate-level electives in MB&B or in other biological or physical sciences.

5. Students must complete the graduate courses listed above under item 4 with grades of Honors (A or A-) in at least two courses and with and at least a High Pass (B) average in the remaining courses.

6. At least one of the graduate-level elective lecture courses taken to fulfill requirements 4b and 4c above should be oriented toward biology (as opposed to biophysics or other physical sciences). Suitable courses include MB&B 625a *Basic Concepts of Genetic Analysis*, MB&B 449a/749a *Medical Impact of Basic Science*, MB&B 602a *Molecular Cell Biology*, MCDB 430a/530a *Biology of the Immune System*, MCDB 310a/BENG 350a/MCDB 550a *Physiological Systems*, MCDB 415b/560b *Cellular and Molecular Physiology*, MCDB 677b *Mechanisms of Development*, MCDB 685b *Evolutionary Developmental Biology*, MCDB 720a *Neurobiology*, NBIO 501a *Principles of Neuroscience*, BIO 642a *Roles of Microorganisms in the Living World*, MBIO 685b *Molecular Mechanisms of Microbial Pathogenesis*.

7. Students in the program must take at least six term courses outside the major during their last four terms at Yale, and must take at least two of those six courses during their last two terms. Two of these six courses can be CR/D/F. At least two undergraduate courses must be taken during the last two terms.

8. SENIOR REQUIREMENT. The candidate must submit a master's thesis, based on the MB&B 570a, 571b research project, by the last day of the reading period in the spring term. The thesis should be 50–60 double-spaced pages (approximately 12,000 words) and in a format specified by instructions available from the DUS Registrar's office. Copies of the thesis must be submitted to the Research Supervisor and DUS Registrar's office. Students are encouraged to submit their thesis to their advisor in advance of the deadline so they can receive critical review of the work prior to final submission to the Registrar's office. At the end of the spring term the candidate must also present a 20-minute talk on the thesis research to the DUS, their research supervisor, and the other BS/MS students.

9. A 20-minute oral thesis presentation is required. This presentation will be open to all MB&B faculty, postdoctoral fellows, and students. The presentation will be scheduled toward the end of the spring term and typically takes place during reading week.

NOTE: MB&B 470/471 are independent research courses for MB&B majors only that may be taken during the sophomore, junior, or senior years. Students receive letter grades. MB&B majors may take up to two credits of these courses and count them as electives toward the MB&B B.S. degree requirements. Students may take additional independent research for credit by registering for MB&B 472/473, which have identical requirements but are graded Pass/Fail. These additional credits do not count towards the MB&B degree requirements. Ideally students will take MB&B 251L to receive a grounding in practical laboratory skills prior to taking an independent research course.

Possible Course of Study for the MB&B BS/MS Major

A course schedule satisfying the course credit requirements in the combined BS/MS program is shown below. This schedule assumes that the student has AP credit in math and biology, and enrolls in freshman organic chemistry based upon his/her AP chemistry score and the Chemistry department placement examination. It also assumes that the student is awarded a waiver for the MB&B 251L requirement based on gaining equivalent research training in the research courses (MB&B 470a or 471b, 570a, and 571b) and/or summer research internships. Eight graduate-level elective courses are required. The six credits outside the major in the final four semesters are identified with double daggers (‡).

AP	Freshman	Sophomore	Junior	Senior
Math (2)	CHEM 175 (2)	MB&B 300a (1)	CHEM 328a (1)	MB&B 570a (2)
Chem (3)	CHEM 126L (1)	MB&B 301b (1)	MCDB 302b (1)	MB&B 571b (2)
Biology (2)	Quantitative (1) Reasoning	PHYS 180a (1)	MB&B Grad (2) Electives	Grad Science (3)
		PHYS 181b (1)	Grad science (1) Elective	
			MB&B 470a (1) or 471b	
	Non-science (5)	Non-science (5)	Non-science (3)‡	Non-science (3)‡

Science/Total

7/7

4/9

4/9

6/9

7/10

Notes:

1. Students who want to participate in the BS/MS program are strongly encouraged to take freshman organic chemistry with lab and to complete the MB&B 300/301 series during their sophomore year.
2. It is also possible for students with fewer AP credits to complete the BS/MS degree, but particular effort must be made to complete the prerequisite courses during the freshman and sophomore years.

MB&B Coursework Planning for the B.S./M.S. Degree – classes of 2016 and later

Courses Used toward the Degrees

REQUIREMENT

COURSE NAME

TERM TAKEN

(or write “AP” under “completed” if you
received AP credit)

Courses to be completed in the first four terms	When alternatives are listed, circle the one taken. If a different course is used, specify.	Proposed	Enrolled	Completed	Grade
Introductory Biology	BIOL 101-104				
General Chem 1	CHEM 161 or 163 <small>(previously offered versions of general chem. and labs</small>				
General Chem Lab 1	CHEM 134L				
General Chem 2	CHEM 165 or 167				
General Chem Lab 2	CHEM 136L				
Organic Chem 1	CHEM 174a or 220a/b				
Organic Chem Lab 1	CHEM 222La/b or 126La				
Organic Chem 2	CHEM 175b or 221a/b				
Organic Chem Lab 2	CHEM 223La/b or 126Lb				
Calculus 1	MATH 112a/b				
Calculus 2	MATH 116 a/b or 115a/b				
Quantitative Reasoning	Specify course:				
Physics 1	PHYS 180a or 200a				
Physics 2	PHYS 181b or 201b				
Courses to be completed by the end of the 6th term					
Biochemistry 1	MB&B 300a				
Biochemistry 2	MB&B 301b				
Biochemistry Lab BS	MB&B 251L				
Physical Chem 1	CHEM 328a or 332a				
Biophysics	MB&B 302b (or CHEM 333b)				
Research for Credit	MB&B 470a or 471b				
Graduate-level courses					
MB&B grad elective					
MB&B grad elective					
Science grad elective					
Science grad elective					
Science grad elective					
Science grad elective					
Research: MB&B 570a					
Research: MB&B 571b					

Premed Curriculum

Advice for MB&B Majors with Advanced Placement Credit

The MB&B department allows AP credit to substitute for the introductory courses we normally require of our students. However, many medical schools do not. Premed students majoring in MB&B must be aware of how medical schools will treat their AP credit. Policies vary at different medical schools. Students are urged to contact the Yale Premedical Advisory Program (55 Whitney Avenue, 3rd Floor 203-432-0818) for information regarding specific schools. Also, see their Web site at <http://ocs.yale.edu/content/premedical-studies-yale-college>. Some general trends in medical school admissions requirements are described below. **Note that premedical requirements are changing and students should consult the premedical advisory program for the most up-to-date information.**

1. Biology. Most medical schools require students to take two semesters of biology, with lab, in college. AP credit cannot be used to substitute for this requirement. However, students with AP credit may usually take more advanced biology electives (with lab) instead of introductory biology. This fits nicely with MB&B's B.S. requirements, which ask students to take at least one advanced biology elective anyway (although MB&B does not require labs with advanced courses). Appropriate biology electives would include courses in areas such as genetics, microbiology or cell biology.

2. Chemistry. Most medical schools require two terms of general chemistry, with lab, and two terms of organic chemistry, with lab. However, students with AP credit for introductory chemistry will satisfy most medical school admissions requirements by taking one year of organic chemistry, with lab, followed by one term of biochemistry, with lab. MB&B asks students with AP credit for introductory chemistry to take a year of organic chemistry, with lab, followed by two semesters of biochemistry. The half credit lab MB&B 251L is the only MB&B lab requirement for the major.

3. Physics. This is the most difficult area for MB&B students with AP credit to negotiate. The MB&B department allows students to substitute AP credit for introductory physics. Some medical schools also allow this. Many do not. Also, medical schools require physics lab, while the MB&B major does not require any physics lab. The safest bet for a premedical MB&B student with AP physics credit is to take two semesters of introductory physics at Yale, with labs, or to take two semesters of more advanced physics courses, with labs.

4. Math. The Yale Premedical Advising Office finds that medical schools will accept students who use AP credit to skip MATH 112 and MATH 115/116 to satisfy their calculus requirement. A course in statistics is recommended, and there are many excellent options in S&DS (e.g. 105, 110, 220, etc) to consider. Some schools strictly require two semesters of college math, which can be satisfied by taking courses in computer science, statistics, or other quantitative disciplines

Frequently Asked Questions

What courses should I take as a freshman to best enable me to complete the MB&B major?

Freshman should take the highest-level chemistry courses for which they are eligible. Depending on their previous preparation in chemistry, freshmen should complete: 1) general chemistry (CHEM 161 and 165 or 163 and 167, along with the associated labs); or 2) organic chemistry (CHEM 174, 175, and the associated labs). The sooner students can complete at least one term of organic chemistry, the sooner they can take the biochemistry core course (MB&B 300a/301b) at the heart of the MB&B major. This course, in turn, is required for many upper-level MB&B electives. The other course should try to complete (or place out of) as a freshman is BIOL 101, Biochemistry and Biophysics, which is also a prerequisite for MB&B 300a/301b. Beyond this, the other introductory biology modules (BIOL 102-104) and calculus (MATH 112a or b and MATH 115a or b) are also good choices for freshmen.

I've taken some AP classes in math and science during high school. How does that affect the courses I will need to take to fulfill requirements for the major?

Students who scored 5 on the AP biology exam can take the placement exams for BIOL 101-104 and potentially place out of certain of these half-semester introductory biology courses. Acceleration credit in math and physics is accepted for fulfillment of the introductory courses in their respective departments. AP in chemistry is arranged by the Chemistry department and includes AP test scores as well as a departmental placement exam given at the beginning of the freshman year. **Note:** Most medical schools have requirements in each of the basic sciences and mathematics. AP credit does not satisfy these since most schools require the applicant to take a course (either introductory or advanced) in each of these areas while enrolled in college. Contact the Career Service Office (Premedical Advisory Program, 203-432-0818) for further information.

I have received full acceleration credit for biology, chemistry, or physics. Does this include the laboratory course requirements in these sciences?

The AP credit applies to both the lecture course and the laboratory. However, pre-medical students are advised that medical school regulations call for two chemistry, one biology, and one physics laboratory taken in college. The MB&B 251L lab usually is counted as a chemistry laboratory. Therefore, it is recommended that the student take an advanced biology elective that has a laboratory associated with it.

Can I use credits for courses taken at other universities toward the science or math requirements of the MB&B major?

Courses in math, biology, chemistry, or physics at other universities may be substituted for the prerequisite courses in these subjects required of MB&B majors at Yale, provided the courses taken are equivalent to the Yale courses for which they will be substituted. We are unlikely to allow courses at other universities to substitute for MB&B 300a, 301b, 302b, or the required MB&B electives. Official course credits should be transferred to Yale, but in rare cases students will be exempted from a course required for the MB&B major even if Yale College does not grant transfer credit for the course. In these cases, students may be asked to complete a higher-level course at Yale College as a substitute. To obtain a waiver, students should obtain a waiver form from the MB&B DUS office or the MB&B undergraduate Web site. This form must be signed by the MB&B faculty advisor and the MB&B DUS. To allow the advisor and DUS to evaluate the courses taken, the student should provide a copy of the course syllabus and contact information for the course instructor.

What is the Senior Project requirement for the major?

- B.A. and B.S. requirement: Participation in MB&B 490b, which includes a written paper and oral presentation

- B.S./M.S. requirement: BS/MS Thesis

My Research Report/Senior Requirement Report is due the last day of the reading period. What can I do if I need an extension of time to complete my report?

You need permission from your College Dean and have him/her call the DUS Registrar's office to indicate his/her permission. However, remember that your grade will be reported incomplete and you cannot graduate until the report has been completed.

What math courses should I take as an MB&B major?

All MB&B majors are required to complete basic calculus (MATH 112 and 115 or 116). We recommend MATH 116, which is tailored to students interested in biology. They must also take one additional quantitative reasoning course, which can be an upper-level math course, or could also be a lower-level course in a discipline such as statistics or computer science. One additional semester of upper-level math can be counted toward the MB&B BS degree requirements as the "additional science elective". The MB&B faculty strongly recommend that students interested in a research career take as much upper-level mathematics as possible, including studies of differential equations, linear algebra, and other applied math topics. This mathematical training will strongly enhance students' ability to perform well in the physical chemistry and biophysics courses that are required for the MB&B major, and will provide training that will be beneficial for the rest of their scientific careers.

Many MB&B students take MATH 120, which is a pure math course, and thus only indirectly relevant to the applied math used by scientists. However, MATH 120 is a prerequisite for the applied math courses offered at Yale that are of greatest benefit to MB&B students. The applied math courses we recommend include ENAS 151a, ENAS 194a or b, PHYS 301a, MATH 222 a or b, and MATH 225b. In certain years MB&B offers a math course—MB&B 435a1 "Mathematical Methods in Biophysics & Biochemistry". This half-credit course is for students who have completed both MB&B 300a and MATH 120, and is designed to expose MB&B students to just the applied math concepts most needed by biophysicists.

ENAS 151a is designed for engineering students, and covers some of the same topics as MATH 120, but is oriented toward applied math and includes some additional applied math topics. Enrollment in ENAS 151a will be limited to a small number of MB&B students, at the discretion of the Bioinformatics instructor.

I am interested in doing research for credit. How do I find a research advisor and select a research project?

Turn the page!

Getting your hands wet: finding a research lab at Yale

Doing research in a lab is the ultimate way to experience the excitement of discovery, deepen your understanding of the scientific method, use the biophysical and biochemical tools you have been learning about, and appreciate the beauty of life's molecules in action. All MB&B majors are encouraged to work in a research lab during the semester and/or over the summer. During the semester, you have several options for getting involved in a research project: you can simply volunteer for the number of hours you think is reasonable for you, you can take research for credit (e.g. MB&B 470/471) that anticipates a minimum of 10hrs/week in the lab, or you can organize/respond to an ad for student employment in a lab. Summer research can be supported by a fellowship:

<http://science.yalecollege.yale.edu/yale-science-engineering-research/fellowship-grants>) Arrange summer research early in the spring term, to give you time to apply!

When you do research in the lab, you'll be asking a question that has never been answered before. Getting the right or wrong result is not the point of research. Taking MB&B 251L is an opportunity to find out the kinds of research you might enjoy and gain real skills you can use in any research lab. But there are so many fascinating unanswered questions, you may not know which interests you the most before getting started.

In choosing a lab, there are three main considerations:

1. Pick a lab that studies something that really interests you! It could be a broad goal (how do cells move?), a more focused goal (how do proteins bind RNA?), or a technical interest (how does X-ray crystallography or RNA-Seq work?).
2. You will have the chance to get to know the professor (PI) of the lab really well. Although the PI may not supervise your every move, he/she will want to get to know you, discuss your experiments with you and help you set new goals in and out of the lab. Consider working in the lab of a professor who has inspired you in the classroom. Or, meet with a professor you have never heard of and decide if you have a good rapport.
3. The lab is also a social and learning environment. You will have the chance to get to know other undergrads, graduate students, technicians, and postdoctoral fellows. When you talk to the professor, peek into the lab and even chat with some of the lab members if possible. Does the lab environment feel exciting and welcoming to you?

MB&B encourages students to take advantage of all ~350 biomedical research labs at Yale. Keep in mind that most biological research is medically relevant. Although you need not restrict yourself to MB&B, reading the blurbs the ~50 MB&B faculty members have written about their research on our web site is a good place to start.

MB&B faculty from A-to-Z: <http://medicine.yale.edu/mbb/faculty/facultyaz.aspx>

MB&B faculty by research area: <http://medicine.yale.edu/mbb/faculty/research/>

For all 350 labs, see Biological and Biomedical Sciences Faculty: <http://bbs.yale.edu/people/>

Another resource is your MB&B advisor; he or she will be full of tips.

To approach a professor about working in their lab, just write an email. He or she will love to hear from you! Here is the sort of information you can write in your email to introduce yourself and your goals:

- a. Say who you are (Yale college undergrad, what year, what major, what science courses you have completed, what you long term career goals are). Tell them if you have taken MB&B 251L!
- b. Explain why you are specifically interested in that professor's research. For example, you are interested in the research topic, you read a paper by the professor, your academic advisor suggested the professor, etc.
- c. Explain that you want to do an independent research project. State when you would like to work in the lab (e.g. this semester, next semester, next summer).

Distinction in the Major

As described in the Yale College Programs of Study, graduation with distinction in the major requires that students earn an A or A- in 3/4 of the credits taken for the major. Students must also receive an A or A- in the senior project course, MB&B 490b. Finally, the MB&B department requires students receive A or A- in at least 2/3 of the MB&B core courses: MB&B 300a, 301b, and 302b. To calculate if you have earned an A or A- in 3/4 of the credits taken for the major, we count up how many A/A- credits you received in courses taken for the major (numerator), divide by the total number of credits you took for the major (denominator), and look for a ratio of ≥ 0.75 . Half credit courses count half as much as full credit courses both in the numerator and denominator for this calculation. "Courses taken for the major" means all courses required for the major, including prerequisites in math, physics, chemistry, biology, not just courses from the MB&B department. Grades of F are included as non-A grades. Courses for which acceleration credits are received are not included in the calculation. No courses used toward MB&B degrees may be taken using the Credit/D/Fail option.

Sigler Prize for Undergraduates



Paul Sigler, 1934-2000

Founded in 2001, by a friend and colleague, in memory of Paul Sigler, who was a distinguished member of the faculty in the Department of Molecular Biophysics and Biochemistry. Paul Sigler was one of the world's leading structural biologists on the mechanisms by which gene expression is controlled, transmembrane signaling is accomplished, and correct folding of proteins is assisted by chaperonins. The Sigler Prize is awarded to a graduating Molecular Biophysics and Biochemistry major who has demonstrated excellence in scholarship and research.

The recipients are:

2021 Dana Joseph and Guna Mandava
2020 Anna-Sophia Boguraev and Kimberly Wei
2019 Benjamin Koleske
2018 James Diao and Charlotte Herber
2017 Paul Chung and Laura Goetz
2016 Charlie Kinzig
2015 Maria Christina Passarelli
2014 Connie Zhao
2013 Max Valenstein and Jonathan Liang
2012 Durga Thakral
2011 Eugene Serebryany and Julia Rogers
2010 Susan Scanlon
2009 Valerie Gordon
2008 Bennett Harrison Lane and Aaron Michael Ring
2007 David Weinberg and Rebecca Voorhees
2006 Eleanor Marshall
2005 Sara Koenig
2004 Srinivas Viswanathan
2003 Ruey Ho and Michael Gong
2002 Stanley Lo
2001 Yoomi Lee

Course Listing 2021-2022

The most up to date list of courses can be found at: <https://courses.yale.edu/?keyword=MB&srcdb=202103>