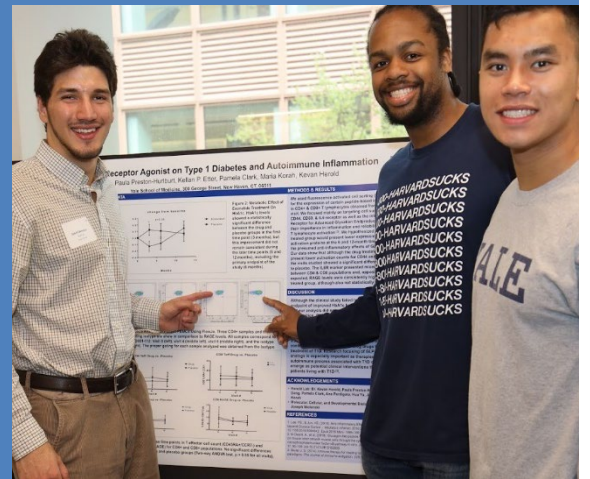
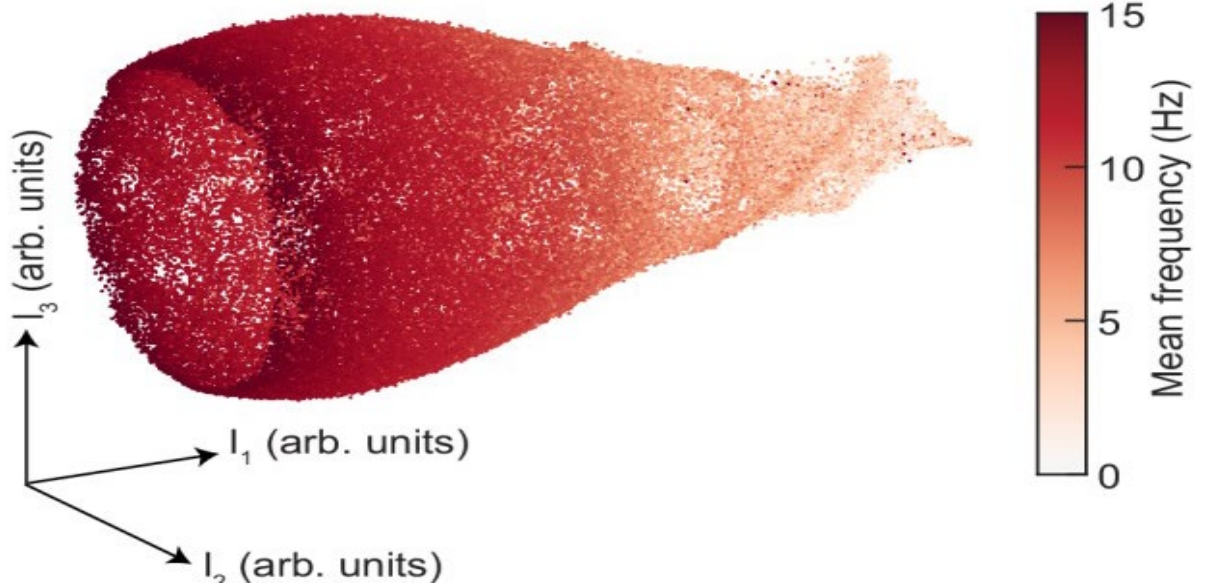


# Molecular, Cellular, Developmental Biology



2020-2021



This booklet is intended to supplement the Yale College Programs of Study for the Academic Year 2020- 2021. The latter contains brief descriptions of all Undergraduate MCDB Courses.

<http://catalog.yale.edu/ycps/subjects-of-instruction/molecular-cellular-developmental-biology/#coursestext>

The MCDB major is offered by the department of Molecular, Cellular, Developmental Biology. For further information contact:

Crystal Adamchek  
Undergraduate Registrar, YSB 235  
MCDB Department  
Yale Science Building, 260 Whitney Ave  
(203) 432-3839, Fax: (203) 432-6161  
Email: crystal.adamchek@yale.edu

Professor Douglas Kankel, YSB 111  
Director of Undergraduate Studies  
Molecular Cellular and Developmental Biology

### Table of Contents

Introduction .....	3
What can being a MCDB Major do for me? .....	3
Courses for Students Majoring in Other Subjects.....	4
MCDB Roadmap .....	5
Requirements by Major .....	6
Acceleration Credits .....	6
Placement Exam.....	6
Interdisciplinary Tracks .....	7
The Senior Requirement .....	7
The BA degree .....	8
The BS degree.....	8
The BS INT degree.....	8
The BS/MS degree.....	8
Research Opportunities .....	8
Research Courses .....	9
Summer Research .....	10
Where to Get Advice.....	11
The First Year.....	11
Upperclassmen.....	11
Peer Mentors .....	12
Advisors.....	13
MCDB Faculty.....	13
Recommendations for Premedical Students .....	19
Studies Abroad .....	19
The Combined BS/MS Degree Program .....	19
Facilities.....	20
Courses in MCDB.....	22
2018-2019 Undergraduate Research Projects.....	25
Undergraduate Prizes and Awards.....	29
Addendums: Worksheets for MCDB Majors	
Research Guidelines	

# The Major in Molecular, Cellular, Developmental Biology (MCDB) At Yale University

## Introduction

The science of biology is extremely broad, ranging across the domains of molecules, cells, tissues and organs, organisms, and ecosystems. Moreover, biology explores questions of evolutionary history and the processes of evolutionary change as well as the mechanisms by which cells, organisms, and ecosystems function. Students majoring in Molecular, Cellular, and Developmental Biology receive a thorough yet varied liberal education and preparation for professional careers in a diverse array of fields. Practical applications of topics studied in the major include the development of biologicals and pharmaceuticals, the practice of medicine, and a pursuit of the scientific bases for understanding the development and function of biological systems.

Molecular, Cellular, and Developmental Biology (MCDB) offers programs for students wishing to concentrate on molecular biology, cell biology, genetics, and their applications to problems in cell and developmental biology, neurobiology, and various aspects of computational and quantitative biology. Interdisciplinary opportunities are available within the major in the biotechnology, neurobiology and quantitative biology tracks.

The MCDB major offers many opportunities for independent laboratory research. With approval from the DUS, research can be conducted under the supervision of faculty members

The teaching and research facilities in biology are primarily distributed in the new Yale Science Building, Yale West Campus and the SCL teaching laboratory facilities. There are about 30 faculty members, 60 postdoctoral fellows, 70 graduate students and approximately 300 undergraduate students that work and study in these buildings. The quality and breadth of expertise in this biological community has made Yale a premier center for both students and scientists.

## What can being a MCDB Major do for me?

The major in MCDB contributes to a liberal education as well as providing excellent preparation for a wide range of professional careers in medicine, public health, the pharmaceutical and biotechnology industries, science writing, teaching, as well as biological research. MCDB undergraduates at Yale have a high rate of acceptance at medical and graduate schools. Today, with the use of genetic testing in court cases, the patenting of biological products, procedures for assessing environmental impact, and the general importance of biological issues in the public arena, this major can also be helpful in law, business, consulting and government careers.

Official Yale College program and course information is found in *Yale College Programs of Study*, available on line at <http://catalog.yale.edu/ycps/>.

## Courses for Students Majoring in Other Subjects

For students who do not intend to major in MCDB, there are a variety of courses that have no prerequisites. (*\*Note: All courses list the Primary instructor first*)

MCDB 040b	Science and Politics of Cancer	Robert Bazell	TTh 1.00-2.15
MCDB 050a	Immunology and Microbes	Paula Kavathas	TTh 1.00-2.15
MCDB 065a	Science & Politics of HIV/AIDS	Robert Bazell	TTh 2.30-3.45
MCDB 103a	Cancer	Alexia Belperron	MW 1:00-2:15PM
MCDB 105a or MCDB 105b	An Issues Approach to Biology	Fall: John Carlson Jennifer Marlon Ronit Kaufman  Spring: Don Engelman, Shirin Bahmanyar Yannick Jacob Candice Paulsen Ronit Kaufman	MW 11.35-12.25
MCDB 106b	Biology of Malaria, Lyme & Other Vector-Borne Diseases	Alexia Belperron	MW 1.00-2.15
MCDB 109b	Immunity and Contagion	Paula Kavathas	TTh 2.30-3.45
MCDB 175La	Exploring the Microbial World	Iain Dawson	Th 2.30-5.30

The programs in the MCDB major are designed to enhance a liberal education as well as offer excellent preparation for professional and graduate study in the biological sciences, and in medicine and other health-related fields. The following diagram provides an overview of the major; details are provided on the following pages. In addition to the standard major, MCDB offers three interdisciplinary programs of study in the biotechnology, neurobiology and quantitative biology tracks. As described below, the senior requirement differs for the BA, the BS, the BS Intensive major, and the combined BS/MS degrees.

Class of 2021 and beyond

**Molecular, Cellular, and Developmental Biology**

Degrees Offered

BA	BS	BS Intensive	BS/MS
----	----	--------------	-------

Prerequisites for entering the major

BIOL 101, 102, 103, and 104			
1 course in MATH 115 or higher or S&DS course at Yale			
3 terms in CHEM or PHYS	2 term lecture sequence in CHEM + 2 Labs		
	2 terms PHYS		
	1 term Organic CHEM + 1 Lab		

Requirements for each degree

5.5 Course Credits beyond prereqs	9 Course Credits beyond prereqs	11 Course Credits beyond prereqs	11 Course Credits beyond prereqs + 6 Grad Credits (consult DUS)
2 courses from MCDB 200, 202, 205, 210, 290, 300 (or MB&B 300)	3 courses from MCDB 200, 202, 205, 210, 290, 300 (or MB&B 300)		
1 Bioscience Lab	2 MCDB Labs		
2 General Electives from core courses or upper level MCDB courses (MCDB 250 and above)			
1 Special Elective from MCDB 350 or higher			

Senior Requirements

Senior Essay or 1 term MCDB 475	MCDB 485/486 or 2 terms MCDB 475	MCDB 495/496	MCDB 585 (jr. spring) MCDB 595/596 (sr. year)
---------------------------------	----------------------------------	--------------	---

Special Track Requirements

Biotechnology: MCDB 370; 1 elective from MCDB 350 or higher; 1 elective from MB&B 420, 443, BENG 351, 352, 410, 435, CENG 210, 411, CPSC 437, 445, 470, or 475.
Neurobiology: MCDB 320; 1 elective from MCDB 350 or higher; 1 elective from BENG 410, CPSC 475, 310, 315 415, 430, MCDB 361, PSYC 270, S&DS 101.
Quantitative Biology: MCDB 330; 1 elective from MCDB 350 or higher; 1 elective from MCDB 320, 361, 461, MB&B 302, 435, 452, 523, PHYS 402, MATH 246, or CPSC 475; 2 labs numbered MCDB 201L or above.

## Requirements by Major

Below are the requirements formally approved by the Yale College Faculty for the Classes of 2023 and beyond. Students in the Class of 2022 and previous classes may fulfill the requirements of the major that were in place when they entered the major in MCDB as described in previous editions of the bulletin. Alternatively, they may fulfill the requirements for the major as described below for the Class of 2023 and subsequent classes.

- **Major: Molecular, Cellular, Developmental Biology**
  - MCDB - Standard Track
  - MCDB - Neurobiology Track
  - MCDB - Biotechnology Track
  - MCDB - Quantitative Biology Track
- **Major: Molecular, Cellular, Developmental Biology - Intensive**
  - MCDB, Intensive - Standard Track
  - MCDB, Intensive - Neurobiology Track
  - MCDB, Intensive - Biotechnology Track
  - MCDB, Intensive - Quantitative Biology Track

Students interested in the biotechnology, neurobiology, or quantitative biology tracks should consult an advisor for the track.

### Biotechnology Track Advisors:

Ronald Breaker, 311 YSB (432-9389)  
Craig Crews, 250 YSB (432-9364)  
Farren Isaacs, ISTC 850WC 333 (737-3156)  
Kenneth Nelson, 137 YSB (432-5013)  
Joseph Wolenski, C112 YSB (432-6912)

### Neurobiology Track Advisors

Paul Forscher, 120 YSB (432-6344)  
Haig Keshishian, 228 YSB (432-3478)  
Robert Wyman, 139 YSB (432-3475)  
Weimin Zhong, 225 YSB (432-9233)

### Quantitative Biology Track Advisors:

Murat Acar, ISTC 850WC 122(737-3255)  
Damon Clark, C148 YSB (432-0750)  
Thierry Emonet, C169 YSB (432-3516)  
Douglas Kankel, 111 YSB (432-3532)

## Acceleration Credits

Acceleration credit awarded in chemistry, mathematics, and physics, or completion of advanced courses in those departments, is accepted instead of the relevant prerequisites for the MCDB major. Students who already have mathematics preparation equivalent to MATH 115a or b or higher are encouraged to take additional mathematics, such as MATH 120a or b, 222a or b, or 225a or b, ENAS 151a or b, 194a or b, or statistics (e.g. S&DS 105a or 100b or higher preferred).

Premedical students will likely need to take the laboratory with introductory physics, although it is not required for the major in MCDB. Premedical students should consider the advisability of taking the introductory MCDB laboratory MCDB S121La or 221La. Note that the premedical requirements and the prerequisites for both MCDB and MB&B majors are substantially the same, so students do not have to choose among these paths during their freshman year.

Official Yale College program and course information is found in *Yale College Programs of Study*, available on line at <http://catalog.yale.edu/ycps/majors-in-yale-college/>.

## Placement Exam

Students with a 5 on the AP Biology exam, a score of 7 on the IB Biology higher-level exam, a score of A on the GCE Biology A-level exam, or the equivalent on other national standardized exams are **eligible to take a placement examination** administered at Yale. Based on the results of the examination, a student may place out of one or more courses in the BIOL 101–104 sequence. One or more of these foundational Biology courses (or their equivalent placement) may be explicitly required as prerequisites for upper-level MCDB courses. More information on the Placement Exam can be found at this website: <http://catalog.yale.edu/first-year-student-handbook/academic-information/special-programs-placement-preregistration/biology/>.





## [Alternatives](#)

### The BA degree

The requirement can be met in either of two ways: by submitting a senior essay of 15-20 pages evaluating current research in a field of biology; or by successful completion of one credit of Senior Independent Research (MCDB 475a or b).

A senior choosing to fulfill the requirement with a senior essay must consult with a faculty advisor on the scope and literature for the topic and that advisor must submit their written approval to the office of the director of undergraduate studies at least one month before the paper is due in the student's last term at Yale. The senior essay may be related to the subject matter of a course, but the essay is a separate departmental requirement *in addition* to any work required for that course. It does not count toward the grade in any course. The senior essay must be completed and submitted via email to [mcdb.undergraduateregistrar@yale.edu](mailto:mcdb.undergraduateregistrar@yale.edu) at the office of the director of undergraduate studies by the last day of classes. Students electing this option should obtain an approval form from the office of the director of undergraduate studies.

### The BS degree

The BS differs from the BA in its greater emphasis on individual research. The senior requirement for the standard BS is two contiguous terms of Senior Research: MCDB 485a/486b. Although not preferred, students may take 2 contiguous terms of MCDB 475, at least one of which must be taken during the senior year. Ordinarily both terms of Research will be taken during the senior year, but it is possible for a student to begin work toward the senior requirement in the spring of the junior year by taking MCDB 475b, continue the research over the summer, and complete such research during the fall of the senior year by taking MCDB 475a –this latter path must be pre-approved by the DUS. Yale College does not grant academic credit for summer research unless the student is enrolled in an independent research course in Yale Summer Session.

### The BS INT degree

For the MCDB BS *Intensive major*, students fulfill the senior requirement by taking MCDB 495a/496b, Senior Research Intensive, for four credits during their senior year.

### The BS/MS degree

See the section entitled The Combined BS/MS Degree Program.

## Research Opportunities

There are many opportunities for students to carry out research in the laboratory of a faculty member. A broad spectrum of state-of-the-art research activities is performed at Yale in the MCDB department and in related departments, including those in the Yale Medical School. This research is carried out in the fields of molecular biology, biochemistry, genetics, cell biology, neurobiology, physiology, computational biology, plant sciences, and evolution, among many others. All interested students are encouraged to participate in independent research. Students may work in laboratories for academic credit and/or experience. Financial support may be available in some cases, but students being paid will not receive course credit.

The choice of a research laboratory should be made in consultation with faculty advisors and the director of undergraduate studies. Opportunities can be found on the following web sites: <https://mcdb.yale.edu/research>, <https://database.yuraresearch.org/>, and



<https://medicine.yale.edu/dfri/>. A mandatory meeting for Juniors and Seniors anticipating completing the Senior Requirement with Research will be held each term with the instructor of the Independent Research Courses. More information on that can be found on our website <https://mcdy.yale.edu/academics/undergraduate-program/undergraduate-events>.

## Research Courses

Degree	Course Number	Course Title
BA	MCDB 475	Independent Research (1 term during senior year, 1.0 Credit) 10 hours/week in the lab; 12-15 page Research Journal Report.
BS	MCDB 485/486	Senior Research (year-long research course, 1.0 Credit) 10 hours/week in the lab; Fall: 2-page Summary Proposal; 5-page Grant Proposal; Spring: Oral Presentation, Poster Symposium; 12-15-page Research Journal Report.
BS INT	MCDB 495/496	Senior Research Intensive (year-long intensive research course, 1.0 Credit each term) 20 hours/week in the lab; Fall: 2-page Summary Proposal, Oral Presentation; 5-10-page Grant Proposal; Spring: Poster Symposium; 15-20-page Research Journal Report.
BS/MS	MCDB 585, 595/596	Intensive Research in MCDB for BS/MS Candidates (begins in Spring of Junior year and continues through Senior year, 2.0 credit each term) 20 hours/week in the lab; Spring 585: 2-page Summary Proposal, 8-10 page Written Prospectus; Prospectus Presentation to Committee. Fall 595: Oral Presentation; Spring 596: Poster Symposium; Thesis Defense; Written Thesis 40-100 pages.

Independent Research course (MCDB 474) earns Yale College credit for Underclassmen, but is governed by the “P/F with report” policy. A student who passes this course will have the mark of “P” entered on the Yale College transcript once the course instructor submits an independent study report form that describes the nature of the course and provides a detailed evaluation of the student’s performance in it. Failures in the course will result in the recording of an “F”.

Independent Research (other than those taken during the senior year for the senior requirement) **DO NOT** contribute to satisfying any requirements for the MCDB major.

These courses are primarily for students who are culminating their undergraduate experience by doing independent research to fulfill the senior requirement. It is possible for students who wish to do research earlier in their course of study to take MCDB 474a or b before their senior year, but it does not substitute for any course requirements. MCDB 474 or 475 count toward the 36 credits required for the Yale College degree; but other than meeting the senior requirement, 475, and indeed all the research courses, **DO NOT** contribute to satisfying the requirements for the major. For research courses, hours are typically arranged at the mutual convenience of the student and the faculty advisor. Please note that taking MCDB 475 at any time **DOES NOT** satisfy the lab requirement, general elective or special elective requirement for a course from MCDB at 350 or above (**MCDB 474 satisfies no requirement for the major**).

Approval from the Yale College Committee on Honors and Academic Standing is required if certain limits are exceeded. A student must petition the committee for permission to enroll in more than one such course credit in any one term before the senior year or in more than two such course credits in any one term during the senior year. Permission is also required for a student to enroll in more than three such course credits in the first six terms of enrollment. In the petition the student must give sound academic reasons for exceeding these limits.

**Underclassmen:** During the academic year, students, with instructor approval, may take MCDB

474a or b. This course is the only option for underclassmen and will be graded Pass/Fail.

*MCDB 474a or b Independent Research:* Students are expected to spend at least ten hours per week in the laboratory of a faculty member. At the completion of the term, a paper must be submitted to the Instructor in Charge. This is the only course available for Underclassmen and non-majors for Independent Research.

**Upperclassmen:** Several options exist for students to fulfill the Senior Requirement for MCDB.

*MCDB 475a or b Senior Independent Research:* Students are expected to spend at least ten hours per week in the laboratory of a faculty member. At the completion of the term, a paper must be submitted to the Instructor in Charge.

*MCDB 485a, 486b Senior Research:* Is a year-long research course. Students are expected to spend a minimum of ten to twelve hours per week in the laboratory. Research should be conducted under the supervision of the same faculty member(s). At the end of each term a written report on the research accomplished must be submitted before a grade will be given. One grade is given at the end of the second semester.

*MCDB 495a, 496b: Senior Research Intensive:* Is a year-long course, two credits each term, in which students are expected to spend at least twenty hours per week in the laboratory. At the end of each term, students prepare a paper describing the research they completed. One grade is given at the end of the second semester.

*MCDB 585b Intensive Research in MCDB for BS/MS Candidates:* Is taken by juniors admitted to the BS/MS program, two credits; students are expected to spend at least twenty hours per week in the laboratory.

*MCDB 595ab Intensive Research for BS/MS Candidates:* Is a year-long course, two credits each term, in which students are expected to spend at least twenty hours per week in the laboratory. Students prepare a thesis describing the research they completed.

## Summer Research

Yale students can also perform research with a faculty member during the summer months, which allows students to devote full-time effort to a research project. Summer research enables students to continue research that was initiated during the previous academic year or to begin research that will be continued during the following academic year. Sometimes the faculty member has grant funds that can support students during the summer. Other possibilities for financial support can be found at <https://science.yalecollege.yale.edu/yale-science-engineering-research/fellowship-grants>. Interested students should consult a member of the Yale faculty or the director of undergraduate studies. Academic credit is not granted unless the student is registered in (and paying tuition to) the Yale summer school (IDRS S300).

Summer research at other institutions (including those outside the United States) is possible through several programs. More information can be found at: <http://yalecollege.yale.edu/student-services/funding-opportunities>, <http://science.yalecollege.yale.edu/yale-science-engineering-research/fellowship-grants> Yale does not award academic credit for research done at other institutions, even if done in the context of a course.

## Where to Get Advice

The advising system for students majoring in MCDB provides a source of clear and readily accessible information regarding programs of study throughout the students' four years at Yale. Each student will have three formal advisors to guide academic choices, but finding the right person for the problem sometimes requires student initiative.

### The First Year...

Upon entrance into Yale University, each student is assigned to one of the fourteen residential colleges on campus. With this initial assignment, the first-year student encounters a team of three important advisors who will be helpful in answering questions and directing the student's choice of classes.

Each entering student is assigned a freshman counselor from their residential college, who is a senior student living with the freshman class. The student counselor gives the freshmen a "student's eye view" of the curriculum, courses and instructors. Valuable as this is, it should not substitute for the advice of a faculty advisor. This is particularly important for freshmen that are considering a major in one of the sciences. A second advisor is also assigned and is usually a faculty fellow of that student's college, and is sometimes a member of the MCDB department. This faculty advisor is responsible for advising the student about fulfilling distributional requirements in the first year. The third person on the first-year advising team is, of course, the student's residential college dean. This dean has ultimate authority over the student's decisions for courses and programs of study. If the freshman faculty advisor is not a member of a science department in Yale College, and the student believes it likely that they will major in one of the sciences, the student is strongly advised to consult with the director of undergraduate studies in the field of the student's primary interest. There are also meetings for prospective science majors held in the fall before classes begin.

<https://orgsync.com/154223/calendar/?view=calendar>. MCDB holds an Advising session early in the Fall and Spring terms. More information can be found on <https://mcdb.yale.edu/academics/undergraduate-program/undergraduate-events>

An important issue for prospective MCDB majors is to seriously consider taking chemistry during the first year. This is because many courses, including some in MCDB, have prerequisites for 3 terms of chemistry followed by at least 1 term of biochemistry. An early start on this sequence can be important. If the student is going to take a second science course, it should be in the MCDB sequence. It is possible to postpone the laboratory for either biology or chemistry until the year after the course is taken, although this is not recommended. Math and physics can be taken in later years.

### Upperclassmen...

At the end of freshman year, the student has the option of continuing with the faculty fellow advisor assigned for the first year or of choosing a new faculty advisor for the sophomore year. MCDB majors should find an advisor in the program as soon as they decide on MCDB as a major. Students in the MCDB major should contact the MCDB Registrar, at [mcdb.undergraduateregistrar@yale.edu](mailto:mcdb.undergraduateregistrar@yale.edu) to be assigned an advisor or they can select any member of the MCDB faculty as an advisor, either a fellow of their residential college or an individual with common interests. A list of primary MCDB faculty fellows and their affiliated colleges is presented in this handbook. Students in the neurobiology, biotechnology or quantitative biology tracks should consult the advisors specified above with those tracks. The

sophomore year advisor often remains a student's advisor for the subsequent two years as well, but it is possible to switch an advisor if a student prefers another individual. Note: It is possible to switch areas of concentration, especially in the first two years. If a student changes areas, they should also change to an appropriate advisor for that area. Students might find it most convenient to consult with the MCDB Undergraduate Registrar to identify an appropriate primary faculty advisor. In whatever way a primary faculty advisor is identified, communicating that choice to the MCDB Undergraduate Registrar will ultimately be useful to both you and the Department. The MCDB faculty advisor's role is four-fold. First, the advisor ensures that the student selects and fulfills the requirements needed for graduation. Second, the advisor ensures that the major's distributional requirements are fulfilled. Third, the advisor gives guidance on the student's curriculum and future career plans. Finally, the faculty advisor may be asked to write letters of recommendation if the student should so desire.

The regular faculty advisor should handle most routine issues, including signing schedules. Certain matters require the attention of the director of undergraduate studies. The MCDB DUS can be reached by email or through the undergraduate registrar. See the inside front cover of this booklet for names, phone numbers, and email addresses.

## Peer Mentors

Recently, MCDB has implemented a system of Peer Mentors. These are usually upperclass majors in MCDB who are familiar both with the MCDB programs and with other requirements for a Yale degree. They have agreed to provide advice to other MCDB majors. Most commonly, there are two Peer Mentors for each residential college. (more information can be obtained about the Peer Mentors [here](#))

College	Last Name	First Name	Email	YC2R
Benjamin Franklin College	Collins	Alejandro	<a href="mailto:alejandro.collins@yale.edu">alejandro.collins@yale.edu</a>	YC20
Benjamin Franklin College	Lam	Stanley	<a href="mailto:stanley.lam@yale.edu">stanley.lam@yale.edu</a>	YC21
Berkeley College	Li	Alice	<a href="mailto:alice.li.al2248@yale.edu">alice.li.al2248@yale.edu</a>	YC21
Berkeley College	Walz	Lucas	<a href="mailto:lucas.walz@yale.edu">lucas.walz@yale.edu</a>	YC20
Branford College	Burton	Jackson	<a href="mailto:jackson.burton@yale.edu">jackson.burton@yale.edu</a>	YC20
Branford College	Xiong	Amy	<a href="mailto:amy.xiong@yale.edu">amy.xiong@yale.edu</a>	YC20
Davenport College	Mendez	Josefina	<a href="mailto:josefina.mendez@yale.edu">josefina.mendez@yale.edu</a>	YC20
Davenport College	Musoff	Charles	<a href="mailto:charles.musoff@yale.edu">charles.musoff@yale.edu</a>	YC20
Ezra Stiles College	Zhu	Gina	<a href="mailto:gina.zhu@yale.edu">gina.zhu@yale.edu</a>	YC20
Ezra Stiles College	Ruiz	Diana	<a href="mailto:diana.ruiz@yale.edu">diana.ruiz@yale.edu</a>	YC20
Grace Hopper College	Camp	Brandon	<a href="mailto:brandon.camp@yale.edu">brandon.camp@yale.edu</a>	YC20
Grace Hopper College	Young	Jordan	<a href="mailto:jordan.young.jcy27@yale.edu">jordan.young.jcy27@yale.edu</a>	YC21
Jonathan Edwards College	Li	Kevin	<a href="mailto:kevin.li@yale.edu">kevin.li@yale.edu</a>	YC21
Jonathan Edwards College	Sun	Anna	<a href="mailto:anna.sun@yale.edu">anna.sun@yale.edu</a>	YC21
Morse College	Sumida	Eyrica	<a href="mailto:eyrica.sumida@yale.edu">eyrica.sumida@yale.edu</a>	YC20
Morse College	Vitale	Tevis	<a href="mailto:tevis.vitale@yale.edu">tevis.vitale@yale.edu</a>	YC20

Pauli Murray College	Corey	Lukas	<a href="mailto:lukas.corey@yale.edu">lukas.corey@yale.edu</a>	YC21
Pauli Murray College	Lu	Nancy	<a href="mailto:nancy.lu@yale.edu">nancy.lu@yale.edu</a>	YC20
Pierson College	Qureshi	Omar	<a href="mailto:omar.qureshi@yale.edu">omar.qureshi@yale.edu</a>	YC20
Pierson College	Tai	Karen	<a href="mailto:karen.tai@yale.edu">karen.tai@yale.edu</a>	YC21
Saybrook College	Schilling	Mary	<a href="mailto:mary.serena-schilling@yale.edu">mary.serena-schilling@yale.edu</a>	YC20
Silliman College	Bae	Emily	<a href="mailto:emily.bae@yale.edu">emily.bae@yale.edu</a>	YC20
Silliman College	Enriquez	Kristen	<a href="mailto:kKristen.enriquez@yale.edu">kKristen.enriquez@yale.edu</a>	YC21
Timothy Dwight College	Tao	Alice	<a href="mailto:alice.tao@yale.edu">alice.tao@yale.edu</a>	YC20
Timothy Dwight College	Lin	Erica	<a href="mailto:erica.lin@yale.edu">erica.lin@yale.edu</a>	YC21
Trumbull College	Gillinov	Lauren	<a href="mailto:lauren.gillinov@yale.edu">lauren.gillinov@yale.edu</a>	YC21
Trumbull College	Walia	Anushka	<a href="mailto:aAnushka.walia@yale.edu">aAnushka.walia@yale.edu</a>	YC21

## Advisors

All primary faculty in the MCDB department are available as advisors. You are free to choose your advisor, and you can change advisor should you wish. Students might find it most convenient to consult with the MCDB Undergraduate Registrar to identify an appropriate faculty advisor. You are expected to consult your advisor at the start of each term and obtain their signature approving your selection of classes. Because of the size of the major, the DUS does not ordinarily sign schedules but is of course available to help you with any other academic issues. The list of all MCDB faculty (both primary and secondary) is listed in this booklet. Statutorily the DUS is the formal faculty advisor for all double major and BS/MS students.

## MCDB Faculty

Please note: # beside faculty name indicates secondary faculty and are **not** considered MCDB Faculty Advisors.

### Acar, Murat

*Asst. Prof. Mol Cell & Dev Biology & Physics*

ISTC 850WC, 122, West Haven

203-737-3255

[murat.acar@yale.edu](mailto:murat.acar@yale.edu)

Ezra Stiles Fellow

Research: Systems biology, synthetic biology, gene regulatory networks, noise in gene expression, aging, evolution of gene networks.

Contact via email for advising

### Bahmanyar, Shirin

*Asst. Prof. Mol Cell & Dev Biology*

YSB 116, 260 Whitney Ave

203-432-5561

[shirin.bahmanyar@yale.edu](mailto:shirin.bahmanyar@yale.edu)

Pauli Murray Fellow

Research: Organelle structure, lipid synthesis, nuclear envelope, lamins, high resolution microscopy, cellular dynamics, C elegans.

Contact via email for advising

### Bazell, Robert

*Adjunct Prof., Mol Cell & Dev Biology*

YSB 145, 260 Whitney Ave

203 432-5978

[robert.bazell@yale.edu](mailto:robert.bazell@yale.edu)

### Belperron, Alexia #

*Res. Sci., Med (Rheumatology) & Lect., Mol Cell & Dev Biology; Advisor, Ctr S&QR*

TAC S-520, 300 Cedar St

203-785-7665  
alexia.belperron@yale.edu

Research: Study of Immune Responses and Pathogenesis of Tick-Borne Diseases

---

### **Breaker, Ronald**

*Henry Ford II Prof Mol Cell & Dev Biology; Investigator in Howard Hughes Med Inst*

YSB 311, 260 Whitney Ave.  
203-432-9389  
ronald.breaker@yale.edu  
Jonathan Edwards Fellow

Research: Discovery and analysis of noncoding RNAs, riboswitches and ribozymes, engineering of novel RNA and DNA enzymes by directed evolution.  
Contact via email for advising

---

### **Breslow, David**

*Asst. Prof., Mol Cell & Dev Biology*

YSB 216, 260 Whitney Ave  
203-432-8280  
david.breslow@yale.edu  
Branford Fellow

Research: Investigating physiologic roles of primary cilia, cellular processes that support these functions, disease states that result from errors in processes; cilium serves as organizing center for select signaling pathways (e.g. Hedgehog signaling and dissecting interdependence between cell cycle progression and cilium assembly/disassembly.)  
Contact via email for advising

---

### **Carlson, John**

*Eugene Higgins Prof of Molecular, Cellular & Developmental Biology*

YSB 206, 260 Whitney Ave  
203-432-3541  
john.carlson@yale.edu  
Pierson College Fellow

Research: The molecular basis of olfaction, taste, and mate recognition in Drosophila and insects that transmit global disease.  
Contact via email for advising

---

### **Chandra, Sreenganga #**

*Assoc. Prof., Neurology/Neuroscience and Mol Cell & Dev Biology*

BCMM 154D, 295 Congress Ave  
203-785-6172  
sreenganga.chandra@yale.edu

Research: Presynaptic Biology; Synapse Maintenance; Parkinson's Disease; Lysosomal Storage Disease; Neurodegeneration.

---

### **Clark, Damon**

*Asst. Prof., Mol Cell & Dev Biology, Co-DUS, Neuroscience*

YSB C148, 260 Whitney Ave  
203-432-0750  
damon.clark@yale.edu  
Pauli Murray Fellow

Research: Drosophila visual behaviors and circuitry; computational and modeling approaches to neural computation.  
Contact via email for advising

---

### **Cooley, Lynn #**

*Dean, Graduate School, C.N.H. Long Prof., Genetics & Prof. Cell Biology and Mol Cell & Dev Biology*

SHM 1329b, 333 Cedar St  
203-432-2733  
lynn.cooley@yale.edu

Research: Molecular genetics of Drosophila oogenesis, control of oocyte growth, ring canals.

---

### **Crews, Craig**

*Lewis B. Cullman Prof., Mol Cell & Dev Biology, Prof., Pharm & Chemistry*

YSB 250, 260 Whitney Ave  
203-432-9364  
craig.crews@yale.edu  
Pauli Murray Fellow

Research: Exploration and control of signal transduction pathways using chemical probes.  
Contact via email for advising

---

### **Dawson, Iain**

*Lecturer, Mol Cell & Dev Biology*

YSB 145, 260 Whitney Ave

Research: Regulation of cell cycle in Drosophila melanogaster.



203-432-4539

iain.dawson@yale.edu

Branford Fellow

Contact via email for advising

---

### **Dellaporta, Stephen L.**

*Prof., Mol Cell & Dev Biology*

YSB 325, 260 Whitney Ave

203-432-3895

stephen.dellaporta@yale.edu

Davenport Fellow

Research: Sex determination and cell death in plants.

Contact via email for advising

---

### **Dimitrova, Nadya**

*Asst. Prof., Mol Cell & Dev Biology*

YSB 211, 260 Whitney Ave

203-432-3492

nadya.dimitrova@yale.edu

Pierson Fellow

Research: Focuses on long non-coding RNAs (lncRNAs) and their roles in the regulation of critical cellular pathways during tumor development.

Contact via email for advising

---

### **Emonet, Thierry**

*Assoc. Prof., Mol Cell & Dev Biology and Physics*

YSB C169, 260 Whitney Ave

203-432-3516

thierry.emonet@yale.edu

Branford Fellow

Research: We study how live cells and animals process information, interact, and make decisions using wet lab experiments and computational modeling.

Contact via email for advising

---

### **Forscher, Paul**

*Prof., Mol Cell & Dev Biology*

YSB 120, 260 Whitney Ave

203-432-6344

paul.forscher@yale.edu

Davenport Fellow

Research: Molecular mechanisms of axon guidance: cytoskeletal protein dynamics and related signal transduction. Biomechanics of cell movement and growth.

Contact via email for advising

---

### **Gendron, Joshua**

*Asst. Prof., Mol Cell & Dev Biology*

YSB 424, 260 Whitney Ave

203-432-7317

joshua.gendron@yale.edu

Pauli Murray Fellow

Research: Plants, circadian clock, protein degradation.

Contact sandra.pariseau@yale.edu for advising appointment

Will hold student meetings in Dining Hall by appointment

---

### **Hartmann, Amaleah**

*Lecturer, Mol Cell & Dev Biology*

YSB 147, 260 Whitney Ave

amaleah.hartman@yale.edu

Contact via email for advising

---

### **Hatzios, Stavroula**

*Asst. Prof., Mol Cell & Dev Biology*

840 West Campus Dr

2-3-737-8121

Stavroula.Hatzios@yale.edu

Branford Fellow

Research: Explore functional proteome of bacterial infections; bacterial and host proteins active during infection, how they impact molecular interactions between pathogen and host, how infection-associated environmental cues influence protein function at the host-microbe interface, using *Helicobacter pylori* and *Vibrio cholera* to uncover biochemical pathways shape severe gastrointestinal diseases (gastric cancer and cholera.)

Contact via email for advising

---

**Hochstrasser, Mark W #**

*Eugene Higgins Prof., MB&B and Prof. Mol Cell & Dev Biology*

BASS 224, 266 Whitney Ave  
203 432-5101  
mark.hochstrasser@yale.edu

Research: Crossroads of biochemistry and genetics and take advantage of the many tools offered by budding yeast as a model eukaryote. Dynamics of protein modification by ubiquitin and ubiquitin-related proteins and degradation by the proteasome.

---

**Holley, Scott**

*Prof. Mol Cell & Dev Biology*

YSB 106, 260 Whitney Ave  
203-432-3230  
scott.holley@yale.edu  
Timothy Dwight Fellow

Research: The systems developmental biology and biomechanics of spinal column development.

Contact via email for advising

---

**Horsley, Valerie**

*Assoc. Prof., Mol Cell & Dev Biology*

YSB 121, 260 Whitney Ave  
203-436-9126  
valerie.horsley@yale.edu  
Pierson Fellow

Research: Study of the cellular and molecular mechanisms that control stem cell activity and function within epithelial tissues.

Contact via email for advising

---

**Irish, Vivian**

*Chair and Prof., Mol Cell & Dev Bio, Prof Ecology & Evolutionary Bio*

YSB 425, 260 Whitney Ave  
203-432-5572  
vivian.irish@yale.edu  
Berkeley Fellow

Research: Developmental genetics of flowering in Arabidopsis; evolution of plant development.

Contact via email for advising

---

**Isaacs, Farren**

*Assoc. Prof., Mol Cell & Dev Biology, Dir. Grad Studies Mol Cell & Dev Biology*

ISTC 850WC, 333, West Haven  
203-737-3156  
farren.isaacs@yale.edu  
Jonathan Edwards Fellow

Research: Developing foundational cellular and biomolecular engineering technologies to understand and engineer biological systems.

Contact via email for advising

---

**Iwasaki, Akiko #**

*Waldemar von Zedtwitz Prof., Immuno and Mol Cell & Dev Biology, Investigator, Howard Hughes Med Inst*

TAC S-655b, 300 Cedar St  
203-785-2919  
akiko.iwasaki@yale.edu

Research: Immune responses to viruses and vaccine design.

---

**Jacob, Yannick**

*Asst. Prof., Mol Cell & Dev Biology*

YSB 416, 260 Whitney Ave  
203-432-8908  
yannick.jacob@yale.edu

Research: Epigenetics using plants as model systems to understand how epigenome contributes to basic cellular mechanisms like DNA replication, gene silencing, complex processes like developmental transitions, trans-generational inheritance and aging.

Trumbull Fellow

Contact via email for advising

---

**Kankel, Douglas**

*Prof. & Dir. Undergrad Studies, Mol Cell & Dev Biology*

YSB 111, 260 Whitney Ave  
203-432-3839  
douglas.kankel@yale.edu  
Benjamin Franklin Fellow

Research: Nervous system development and function in *Drosophila melanogaster*.

Contact via email for advising

---

**Kavathas, Paula #**

*Prof., Lab Med, Immunobiology and Mol Cell & Dev Biology*

TAC S-641a, 300 Cedar St  
203-785-6223

paula.kavathas@yale.edu

Research: Study of immune response in lung cancer patients undergoing immunotherapy.

---

**Keshishian, Haig**

*Prof., Mol Cell & Dev Biology*

YSB 228, 260 Whitney Ave  
203-432-3478

haig.keshishian@yale.edu

Morse Fellow

Research: Factors governing the formation of synaptic connections during development.

Contact via email for advising

---

**Lin, Samantha**

*Lecturer, Mol Cell & Dev Biology*

YSB 147, 260 Whitney Ave

samantha.lin@yale.edu

Contact via email for advising

---

**Miller-Jensen, Kathryn #**

*Asst. Prof., Bio Eng & Mol Cell Dev Biology*

MEC 311, 55 Prospect St  
203-432-4265

kathryn.miller-jensen@yale.edu

Research: We use quantitative systems biology approaches to study signaling in innate immunity and viral infection.

---

**Mooseker, Mark**

*Ross Granville Harrison Prof., Mol Cell & Dev Biology*

YSB 240, 260 Whitney Ave  
203-432-3468

mark.mooseker@yale.edu

Grace Hopper Fellow

Research: Functional characterization of the myosin family of actin filament based molecular motors.

Contact via email for advising

---

**Moreno, Maria**

*Res. Sci & Lect. Mol Cell & Dev Biology, Academic Dir. Science, Technology & Res Scholars (STARS) Program*

YSB 149, 260 Whitney Ave  
203-436-4161

maria.moreno@yale.edu

Trumbull Fellow

Research: Research interests focus on technologies for population genomics to enhance food security.

Contact via email for advising

---

**Nachtergaele, Sigrid**

*Asst. Prof. Mol Cell & Dev Biology*

YSB 320, 260 Whitney Ave

Research: Regulation of how mRNA is methylated, how these alterations affect gene expression, cell signaling, cell growth, and how the processes become dysregulated in disease states.

---

**Nelson, F. Kenneth**

*Assoc. Rsrch. Scientist & Lect. Mol Cell & Dev Biology*

YSB 137, 260 Whitney Ave  
203-432-5013

kenneth.nelson@yale.edu

Morse Fellow

Research: Flow cytometry analysis and sorting.

Will hold appointments in Morse Dining Hall by appointment

Contact via email for advising

---

**Pollard, Thomas**

*Sterling Prof., Mol Cell & Dev Biology, Prof. MB&B*

YSB 125, 260 Whitney Ave  
203-432-3565

thomas.pollard@yale.edu

Morse Fellow

Research: Molecular mechanisms of actin-based cellular movements.

Contact via email for advising

---

**Pyle, Anna**

*William Edward Gilbert Prof., Mol Cell & Dev Bio; Investigator Howard Hughes Med Inst; Prof. Chemistry*  
YSB 306, 260 Whitney Ave  
203-432-5633  
anna.pyle@yale.edu

Research: Biological function and molecular structures of noncoding RNAs, viral RNA genomes and the nanomechanical proteins that act on RNA, such as RNA helicases and innate immune receptors (RIG-I and Mda-5).  
Contact via email for advising

---

**Rodeheffer, Matthew #**

*Asst. Prof., Comparative Med and Mol Cell & Dev Biology*  
BML 329d, 310 Cedar St  
203-737-3370  
matthew.rodeheffer@yale.edu

Research: Obesity, excessive increase in white adipose tissue (fat) mass, is the leading public health concern of modern society. Despite the importance of fat in human disease our understanding of the regulation of fat mass is limited. Elucidating cellular and molecular mechanisms that regulate fat mass and contribute to the development of obesity and obesity associated pathologies.

---

**Rosenbaum, Joel**

*Prof., Mol Cell & Dev Biology*  
YSB 239, 260 Whitney Ave  
203-432-3472  
joel.rosenbaum@yale.edu  
Silliman Fellow

Research: The assembly of cilia and its dependence on Intraflagellar Transport (IFT); the role of IFT proteins in ciliopathies; cilia as secretory organelles in cell and organismal communication.  
Contact via email for advising

---

**van Wolfswinkel, Josien**

*Asst. Prof., Mol Cell & Dev Biology*  
YSB 207, 260 Whitney Ave  
203-432-3520  
Josien.van.Wolfswinkel@yale.edu  
Branford Fellow

Research: Study of RNA biology and genome regulation of pluripotent stem cells using the regenerating flatworm *Schmidtea mediterranea*.  
Contact via email for advising

---

**Wolenski, Joseph**

*Research Scientist & Lecturer Mol Cell & Dev Biology, Dir. Light Microscopy Imaging Facility*  
YSB 207, 260 Whitney Ave  
203-432-6912  
joseph.wolenski@yale.edu  
Berkeley Fellow

Research: Fluorescence microscopy imaging.  
Contact via email for advising

---

**Wyman, Robert**

*Prof., Mol Cell & Dev Biology*  
YSB 139, 260 Whitney Ave  
203-432-3475  
robert.wyman@yale.edu  
Grace Hopper Fellow

Research: Molecular biology and neurophysiology of gap junctions; genetic control of neural circuit development.  
Contact via email for advising

---

**Yan, Jing**

*Asst. Prof., Mol Cell & Dev Biology*  
YSB C144, 260 Whitney Ave  
203-432-8363  
jing.yan@yale.edu

Research: Biophysical, genetic and molecular tools to understand how bacteria switch from free-living lifestyle into a biofilm.  
Contact via email for advising

---

**Zhong, Weimin**

*Assoc. Prof., Mol Cell & Dev Biology*  
YSB 225, 260 Whitney Ave  
203-432-9233  
weimin.zhong@yale.edu  
Davenport Fellow

Research: Regulation of stem cells and development of the mammalian neocortex.  
Contact via email for advising

---

# Recommendations for Premedical Students

The Yale Pre-Med Office (Office of Career Strategy) <http://ocs.yale.edu/yale-college/health-professions> is a useful source of information for those interested in applying for postgraduate education in the health sciences. Additional information can also be found at the links below recommended by the Office of Career Strategy Health Professions: <http://ocs.yale.edu/yale-college/academic-preparation>

## **Required Courses for MCAT Preparation**

Each medical school has its own individual set of pre-requisite requirements. School websites have the most current information for these requirements, but another comprehensive resource is the online version of the AAMC Medical School Admission Requirements: <https://students-residents.aamc.org/applying-medical-school/applying-medical-school-process/deciding-where-apply/medical-school-admission-requirements/>

Students who expect to apply to medical school should consult the Health Professions Advisory Board (HPAB) at Undergraduate Career Services (UCS) located at 55 Whitney Avenue (phone: 432-0818), preferably during the first term of enrollment at Yale.

Some state-supported medical schools and a few private medical schools have additional course requirements in the humanities and social sciences. All premedical students should check the requirements of their state-supported medical schools, since over 70% of applicants matriculate in one of these schools.

The HPAB publishes an informational bulletin that contains general information, *Preparing to Become a Health Care Professional*, and a second bulletin with specific information for those about to apply for admission to medical school (primarily juniors and seniors), *Applying to Medical School*. Students who are interested in applying as MD/PhD applicants can view the online AAMC publication <https://students-residents.aamc.org/choosing-medical-career/careers-medical-research/md-phd-dual-degree-training/>

## Studies Abroad

It is possible for MCDB majors to participate in programs that include study abroad. More detailed information can be found at: <https://cipe.yale.edu/>.

## The Combined BS/MS Degree Program

The combined BS/MS degrees program in MCDB is designed to allow exceptional students with a strong interest in biological and biomedical research to accelerate their professional education. This program is to be completed in eight terms of enrollment. The requirements are as follows:

1. Candidates must satisfy the Yale College requirements for the BS degree. In addition to the three core requirements specified, the four electives must be relevant graduate-level courses designated "G." One of these is a graduate seminar selected with the approval of the director of undergraduate studies. Students must earn a grade of A or A- in two graduate-level courses and a grade of B- or higher in the rest.
2. Six term courses outside the major must be taken in the last two years, and at least two undergraduate courses in the last two terms.
3. In addition to the courses specified above, students must complete two graduate research courses for six course credits:
  - a) MCDB 585b, a two-credit course taken in the second term of the junior year. At the start of the course, each

student forms a committee comprised of their thesis advisor and two faculty members that meet to discuss the research project. Two of the members of this committee must be members of MCDB faculty, as appropriate to the thesis topic. At the end of the course, the student completes a detailed prospectus describing the thesis project and the work completed to date. The committee evaluates an oral and written presentation of the prospectus and decides whether the student may continue in the combined program.

b) MCDB 595/596, a four-credit, year-long course (two credits each term) and is taken during the senior year. During the course, the student gives an oral presentation describing the work. At the end of the course, the student is expected to present their work to the department in the form of a poster presentation. In addition, the student is expected to give an oral thesis defense, followed by a comprehensive examination of the thesis conducted by the thesis committee. Upon successful completion of this examination, as well as all other requirements, the student is awarded the combined BS/MS degree.

Students must also satisfy the requirements of Yale College for the simultaneous award of the bachelor's and master's degrees, including the following:

- Students must apply in writing to the director of undergraduate studies and obtain departmental approval no later than the beginning of the second term of their Junior year. Students must have the approval of both the director of undergraduate studies and the director of graduate studies to receive graduate credit for the graduate courses they select.
- At the time of the application, only those students with two-thirds A or A- grades in all their courses and with two-thirds A or A- grades in MCDB courses, including prerequisites, will be admitted to the program.
- Students must have this program approved by the undergraduate affairs committee of the major and the relevant departmental faculty by the end of the first term of their junior year. Because faculty meetings are held irregularly, the director of undergraduate studies should receive proposed programs by **November 1**.

## Facilities

The offices and laboratories of primary faculty members are now located in two buildings on Science hill; Yale Science Building (YSB) and Osborn Memorial Laboratories (OML) and in facilities on West Campus (WC). Joint appointees are housed in their home departments. In addition to the state-of-the-art laboratories in these buildings, listed below are additional facilities accessible to students for research and study at Yale.

The New **Yale Science Building** (YSB) During the end of the Summer and the Fall term, MCDB faculty will be moving from their lab and office spaces in OML and KBT to the new Yale Science Building (YSB). This new building has state-of-the-art laboratory facilities for faculty research, and a number of core laboratories for a variety of special functions. It also houses a new modern 500-seat auditorium the OC Marsh Lecture Hall.

**Libraries:** The several science libraries collectively constitute one of the great collections of biological literature in the world. The Center for Science and Social Science Information (CSSSI), Peabody Museum (ornithology and entomology), Kline Geology Library (paleobiology), School of Forestry & Environmental Studies (forest and environmental biology), Engineering Library and Medical Library (biomedical sciences) together represent a total collection of approximately one million volumes.

The CSSSI <http://csssi.yale.edu/> is located in the concourse level of the Kline Tower and has substantial functionality in computing with their state-of-the-art StatLab. Additional workshop courses can be found on the YUL Instruction Calendar including using R, MATLAB, Qualtrics, SPSS, Stata and more. <http://statlab.stat.yale.edu/workshops/>.



<http://schedule.yale.edu/calendar/instruction/?cid=4960&t=d&d=0000-00-00&cal=4960>

**Peabody Museum of Natural History:** <http://peabody.yale.edu/> With collections dating to 1825 and now numbering over 2,000,000 units, Yale's Peabody Museum is a major resource for research and teaching in the biological sciences. Research and work-study opportunities with any of the scientific staff members of the Museum are accessible to students.

**Genomics and Molecular Biology Facilities:** University services for all aspects of molecular biological investigations are available in various Yale facilities. These include oligonucleotide synthesis, DNA sequencing, monoclonal and polyclonal antibody preparation, peptide synthesis, cell sorting, and amino acid analysis. In addition, facilities are available for mass spectrometry and X-ray crystallography. Equipment to generate and analyze DNA chips and protein microarrays are located both at the Yale Medical School and in the MCDB Department. Cell sorting and analysis are available in the MCDB Department on BD FACS Aria and BD FACS Calibur flow cytometers. In addition, the laboratories for teaching and for faculty research are well equipped with state-of-the-art instrumentation and equipment for specific projects.

<https://medicine.yale.edu/keck/ycga/index.aspx> <https://research.yale.edu/core-research>

**Imaging Facilities:** <https://mcdb.yale.edu/imaging-facility-science-hill> The MCDB Department operates a state-of-the-art light microscope imaging facility directed by Dr. Joseph Wolenski in the new Yale Science Building. The Light Microscopy Imaging Core consists of five Zeiss stand-alone operating stations, including: 1) A LSM 880 confocal with laser lines at 405, 458, 488, 514, 561 and 633 nm. 2) A LSM 880 Airyscan confocal with identical laser lines as well as NLO 2P NIR lines and FCS and FLIM capabilities. 3) A Lightsheet Z.1 dual illumination microscope for large transparent samples with laser lines at 405, 445, 488, 515, 561 and 638nm. 4) A LSM 510 LSM META with spectral separation capabilities, and 5) A LSM 510 with visible excitation wavelengths. Both LSM 880 confocal microscopes have stage heater/incubation chambers for live cell time-lapse imaging. These microscopes are available to the Yale scientific community at competitive hourly rates.

**DNA Analysis Facility on Science Hill (DAFSH):** A non-profit academic Core Facility for DNA Sequencing and Fragment Analysis. This service facility is located on the first floor of the ESC Room 150 within the YIBS-MSCG Center. Training and job opportunities for Yale students are available during both academic and summer months. <http://dna-analysis.yale.edu/>.

**Plant and Animal Husbandry:** Numerous controlled environment growth chambers, constant temperature rooms, green houses and plant tissue culture facilities are available for environmentally controlled growth of plant materials located in YSB. The major animal care facility for small mammals for the Arts and Sciences campus is also located in YSB. There is also a new insectary located in YSB.

**Marsh Botanical Garden:** The University's botanic garden and arboretum is located north of OML on the grounds of Marsh Hall at Prospect Street and Hillside Terrace. The garden features a diverse collection of native and exotic trees, shrubs, and perennials highlighting plant communities and environmental change. The greenhouses feature plants from tropical regions and arid climates as well as economically important crops. <https://marshbotanicalgarden.yale.edu/>

**Yale's West Campus:** There are also a series of Core Facilities established on Yale's West Campus these currently include: Yale Center for Molecular Discovery, Yale Center for Genome Analysis, High Performance Computing Center, West Campus Analytical Chemistry Core, West Campus Imaging Core, and West Campus Materials Characterization Core. The Krios cryo-electron microscope, a technology that is enabling scientists to visualize the molecules of biological life in atomic detail, was unveiled at Yale in 2017. Please visit their web site for more information: <http://westcampus.yale.edu/research/scientific-core-facilities>

## Courses in MCDB

For students who do not intend to major in MCDB, there are a variety of courses that have no prerequisites.

(\*Note: URL for complete course listing in YCPS <http://catalog.yale.edu/ycps/subjects-of-instruction/molecular-cellular-developmental-biology/#coursestext>) Note: The most current information including course descriptions can always be found on [YCS](#); [YCPS](#); and on the departmental website ([mcdb.yale.edu](http://mcdb.yale.edu)).

Courses for Students Majoring in Other Subjects					
Course	Title	Instructor (In Charge)	Term	Day	Time
MCDB 040	Science and Politics of Cancer	Robert Bazell	S21	TTh	1:00-2:15PM
MCDB 070	Human Biology	William Segraves	S21	TTh	11:35-12:50PM
MCDB 103	Cancer	Alexia Belperron	S21	MW	1:00-2:15PM
MCDB 105	Biology, the World and Us	John Carlson	F20	MW	11:35-12:25PM
MCDB 105	Biology, the World and Us	Donald Engelman	S21	MW	11:35-12:25PM
MCDB 109	Immunity & Contagion	Paula Kavathas	S21	TTh	2:30-3:20PM
MCDB 175L	Exploring the Microbial World (Bracketed for F20)	Iain Dawson		M	2:30-5:30PM

Foundation Courses					
Course	Title	Instructor (In Charge)	Term	Day	Time
BIOL 101	Biochemistry and Biophysics	Michael Koelle	F20	MW	11:35-12:50
BIOL 101	Biochemistry and Biophysics	Anthony Koleske	S21	MW	11:35-12:50
BIOL 102	Principles of Cell Biology	Valerie Horsley	F20	MW	11:35-12:50
BIOL 102	Principles of Cell Biology	Mark Mooseker	S21	MW	11:35-12:50
BIOL 103	Genetics and Development	Vivian Irish	F20	MW	11:35-12:50
BIOL 103	Genetics and Development	Weimin Zhong	S21	MW	11:35-12:50
BIOL 104	Principles of Ecology and Evolutionary Biology	Richard Prum	F20	MW	11:35-12:50
BIOL 104	Principles of Ecology and Evolutionary Biology	Thomas Near	S21	MW	11:35-12:50

MCDB Core Courses					
Course	Title	Instructor (In Charge)	Term	Day	Time
MCDB 200	Molecular Biology	Farren Isaacs	S21	MW	9:00-10:15AM
MCDB 202	Genetics	Stephen Dellaporta	F20	TTh	11:35-12:50PM
MCDB 205	Cell Biology	Thomas Pollard	S21	TTh	9:00-10:15AM
MCDB 210	Developmental Biology	Scott Holley	F20	TTh	1:00-2:15PM
MCDB 290	Microbiology	John Wertz	S21	TTh	1:00-2:15PM
MCDB 300	Biochemistry	Ronald Breaker	F20	MWF	9:25-10:15AM
MB&B 300	Principles of Biochemistry I	Michael Koelle	F20	TTh	11:35-12:50AM

MCDB Laboratory Courses					
Course	Title	Instructor (In Charge)	Term	Day	Time
MCDB 201L	Molecular Biology Laboratory	Maria Moreno	S21	M or W	1:30-5:30PM
MCDB 203L	Laboratory for Genetics	Iain Dawson	F20	T or W	1:45-5:00PM
MCDB 221L	Model Organisms in Biological Research	Maria Moreno	F20	TWThF	1:30-5:30PM
MCDB 251L	Laboratory for Biology of Reproduction & Development	Seth Guller	S21	T or W	1:30-5:00PM
MCDB 291L	Laboratory for Microbiology	Iain Dawson	S21	T,W or Th	2:30-5:30PM
MCDB 301L	Laboratory for Biochemistry	Aruna Pawashe	S21	TTh	1:30-5:30PM
MCDB 301L	Laboratory for Biochemistry	Aruna Pawashe	F20	TTh	1:30-5:30PM
MCDB 303L	Advanced Molecular Biology Laboratory	Maria Moreno	S21	T	2:30-4:30PM
MCDB 321L	Laboratory for Neurobiology	Haig Keshishian	F20	TW	1:30-5:30PM
MCDB 342L	Laboratory in Nucleic Acids I	Kenneth Nelson	F20	TTh	1:30-4:30PM
MCDB 343L	Laboratory in Nucleic Acids II	Kenneth Nelson	F20	TTh	1:30-4:30PM
MCDB 344L	Experimental Techniques in Cellular Biology	Joseph Wolenski	S21	MW	1:30-6:30PM
MCDB 345L	Experimental Strategies in Cellular Biology	Joseph Wolenski	S21	MW	1:30-6:30PM

MCDB General Elective Courses					
Course	Title	Instructor (In Charge)	Term	Day	Time
MCDB 250	Biology of Reproduction	Hugh Taylor	S21	MWF	10:30-11:20AM
MCDB 315	Pathobiology	David Hudnall	S21	TTh	11:35-12:50PM
MCDB 310	Physiological Systems	Mark Saltzman	F20	MWF	9:25-10:15AM
MCDB 320	Neurobiology	Haig Keshishian	F20	MWF	11:35-12:25PM
MCDB 325	Molecular Hallmarks of Cancer	Nadya Dimitrova	F20	TTh	10:30-11:20AM
MCDB 330	Modeling Biological Systems I	Damon Clark	F20	TTh	2:30-3:45PM

MCDB Special Elective Courses					
Course	Title	Instructor (In Charge)	Term	Day	Time
MCDB 361	Modeling Biological Systems II	Thierry Emonet	S21	TTh	2:30-3:45PM
MCDB 350	Epigenetics	Yannick Jacob	F20	WF	11:35-12:50
MCDB 355	The Cytoskeleton, Associated Proteins, & Disease	Surjit Chandhoke	F20	W	9:25-11:15AM
MCDB 361	Modeling Biological Systems	Jonathan Howard	S21	TTh	2:30-3:45PM
MCDB 370	Biotechnology	Craig Crews	S21	MW	11:35-12:50PM
MCDB 380	Advances in Plant Molecular Biology (biennial)	Vivian Irish	F20	F	9:25-11:15AM
MCDB 387	Eukaryotic Cell Cycle	Iain Dawson	S21	T	7:00-8:50PM
MCDB 415	Cellular & Molecular Physiology	Emile Boulpaep	S21	MWF	9:25-10:15AM
MCDB 425	Basic Concepts of Genetic Analysis	Jun Lu	F20	MW	11:35-12:50PM
MCDB 430	Biology of the Immune System	Eric Meffre	F20	MWF	9:25-10:15AM
MCDB 435	Landmark Papers in Cell Biology (Bracketed for F20)	Joel Rosenbaum	F20	T	7:00-8:50PM
MCDB 450	The Human Genome	Stephen Dellaporta	S21	M	3:30-5:20PM
MCDB 452	Biomedical Data Science Mining & Modeling	Mark Gerstein	S21	MW	1:00-2:15PM
MCDB 461	Concepts & Applications in Systems Biology (Bracketed for S21)	Murat Acar		F	3:30-5:20PM
MCDB 482	Adv Sem in Cell Bio: Intracellular Signal Transduction (Bracketed for F20)	Craig Crews		M	3:30-5:20PM

<b>MCDB Independent Research</b>					
<b>Course</b>	<b>Title</b>	<b>Instructor (In Charge)</b>	<b>Term</b>	<b>Day</b>	<b>Time</b>
MCDB 474	Independent Research	Joseph Wolenski	F20		HTBA
MCDB 474	Independent Research	Joseph Wolenski	S21		HTBA
MCDB 475	Senior Independent Research	Joseph Wolenski	F20		HTBA
MCDB 475	Senior Independent Research	Joseph Wolenski	S21		HTBA
MCDB 485	Senior Research	Joseph Wolenski	F20		HTBA
MCDB 486	Senior Research	Joseph Wolenski	S21		HTBA
MCDB 495	Senior Research Intensive	Joseph Wolenski	F20		HTBA
MCDB 496	Senior Research Intensive	Joseph Wolenski	S21		HTBA

<b>MCDB BS/MS Courses</b>					
<b>Course</b>	<b>Title</b>	<b>Instructor (In Charge)</b>	<b>Term</b>	<b>Day</b>	<b>Time</b>
MCDB 585	Research in MCDB for BS/MS Candidates	Douglas Kankel	S21		HTBA
MCDB 595	Intensive Research for BS/MS Candidates	Douglas Kankel	F20		HTBA
MCDB 596	Intensive Research for BS/MS Candidates	Douglas Kankel	S21		HTBA

<b>MCDB Graduate Courses</b>					
<b>Course</b>	<b>Title</b>	<b>Instructor (In Charge)</b>	<b>Term</b>	<b>Day</b>	<b>Time</b>
MCDB 500	Biochemistry	Ronald Breaker	F20	MWF	9:25-10:15AM
MCDB 530	Biology of the Immune System	Eric Meffre	F20	MWF	9:25-10:15AM
MCDB 550	Physiological Systems	Mark Saltzman	F20	MWF	9:25-10:15AM
MCDB 560	Cellular & Molecular Physiology: Molecular Machines in Human Disease	Emile Boulpaep	S21	MWF	9:25-10:15AM
MCDB 562	Modeling Biological Systems II	Damon Clark	S21	TTh	2:30-3:45PM
MCDB 599	Concepts & Applications in Systems Biology	Murat Acar	S21	F	3:30-5:20PM
MCDB 602	Molecular Cell Biology	Thomas Melia	F20		HTBA
MCDB 603	Seminar in Molecular Cell Biology	Thomas Pollard	F20		HTBA
MCDB 625	Basic Concepts of Genetic Analysis	Jun Lu	F20	MWF	11:35-12:50PM
MCDB 630	Biochemical & Biophysical Approaches in Molecular & Cellular Biology	Thomas Pollard	S21	TTh	2:30-3:45PM
MCDB 650	Epigenetics	Yannick Jacob	F20	WF	11:35-12:50PM
MCDB 670	Advanced Seminar in Biochemistry & Genetics	Ronald Breaker	S21	MW	1:30-3:20PM
MCDB 677	Mechanisms of Development	Zhaoxia Sun	S21	W	1:30-3:20PM
MCDB 680	Advances in Plant Molecular Biology	Vivian Irish	F20	F	9:25-11:15AM
MCDB 720	Neurobiology	Haig Keshishian	F20	MWF	11:35-12:25PM
MCDB 743	Advanced Eukaryotic Molecular Biology	Mark Hochstrasser	S21	TTh	11:30-12:50
MCDB 752	Biomedical Data Science: Mining & Modeling	Mark Gerstein	S21	MWF	1:00-2:15PM

## 2018-2019 Undergraduate Research Projects

Ameen, Nadia ( <i>Gastroenterology</i> )	Understanding the Pathogenesis of Meconium Ileus in Cystic Fibrosis
Anderson, Karen ( <i>Pharmacology</i> )	Understanding the Mechanism and Catalysis of the Human PrimPol Replicative Enzyme Containing Clinically Relevant Mutations
Bahmanyar, Shirin ( <i>MCDB</i> )	Analysis of Nuclear Envelope Associated Proteins in Growth and Maintenance of the Nuclear Permeability Barrier in early <i>C. elegans</i> Embryos
Ben Mamoun, Choukri ( <i>Infectious Diseases</i> )	Determining the Biological Activity and Mode of Action of Quinolines in Babesia Microti and Babesia Duncanii
	Therapy and Diagnosis of Babesia Duncanii
Bender, Jeffrey ( <i>Immunobiology</i> )	Effects of Androgen on Vascular Endothelial Function
Bindra, Ranjit ( <i>Therapeutic Radiology</i> )	Characterization & Exploitation of the role of ATRX in DNA Repair in Gliomas
Blumenfeld, Hal ( <i>Neurology</i> )	Mechanisms of Impaired Consciousness in Absence Seizures
Bogan, Jonathan ( <i>Endocrinology</i> )	Mechanistically Linking Diabetes and Obesity Through Transcriptional Regulation by TUG
	Regulation of the Tug C-terminus by the N-end Rule
	Studying the Role of ISGylation in TUG Processing
	The Role of TUG, PGC1-alpha, and PPAR-gamma in Sarcolipin
Bordey, Angelique ( <i>Neuroscience</i> )	Reducing Filamin A Levels Prevents Cortical Malformations and Decreases Seizure Activity in Tuberous Sclerosis Complex
Brash, Douglas ( <i>Therapeutic Radiology</i> )	Measuring the Frequency of UV-Induced CPDs at Ultrasensitive Genomic Regions in Melanocytes
Breaker, Ronald ( <i>MCDB</i> )	Determining the Regulatory Function of an UTR Motif Upstream of purF
	Identifying Protein Binding Partners of OLE RNA in Bacillus halodurans to Provide Insight into its Function
	In Vitro and Characterization of Glucose-Binding RNA Aptamers using Isothermal Amplification
	Investigating TnpA and TnpB Endonucleolytic Activity on the HEARO Transposable Element
	Magnesium Transport Functions in the OLE RNA System
	Verifying a Consensus Sequence for OapB-OLE RNA Binding
Breslow, David ( <i>MCDB</i> )	Factors that Influence Cilium Disassembly and Progression Through the Cell Cycle
Brueckner, Martina ( <i>Cardiology</i> )	Celia and Lef-Right Development: an In Situ Hybridization and Whole-Mount Immunofluorescence Study
	Localization of the RNF20 Complex in the Developing Heart
Caccone, Adalgisa ( <i>E&amp;EB</i> )	Adaptive Variation in the Odorant Receptor Protein Obp59a in Two Teste Fly Species, the Obligate Vectors of African Trypanosomiasis
	Analysis of the Natural Genetic Variation of the Obp59a in Ae. Aegypti
Cafferty, William ( <i>Neurology</i> )	Overexpression of Spr Ia in Intact Neurons Increases Axon Plasticity after Spinal Cord Injury
Cantley, Lloyd ( <i>Nephrology</i> )	Cast Clearance by Epithelial Cells in Acute Kidney Injury

	Failed Tubular Repair following Ischemia/Reperfusion Injury Promotes Macrophage Recruitment in the AKI-to-CKD Transition
Caplan, Michael ( <i>C&amp;M Physiology</i> )	Development of GSK3 $\beta$ Fluorescence Kinase Assay and Lentiviral Vector-Mediated DNTF PC1
Chen, Lieping ( <i>Immunobiology</i> )	Generating a Human PD-1H Agonistic Monoclonal Antibody
	Searching for the Counter Receptor of Immune Modulating Molecule PD-1H
Chen, Sidi ( <i>Genetics</i> )	Assessing the Role of Ornithine Decarboxylase 1 in T-cells
Cheng, Yung-Chi ( <i>Pharmacology</i> )	Exploration of a Commonly used Chinese Herb for the treatment of Androgen and Estrogen Dependent Diseases
Colon-Ramos, Daniel ( <i>Cell Biology</i> )	Localization and Synaptic Vesicle Functionality of Glycolytic Enzymes Under Energy Stress
Dardik, Alan ( <i>C&amp;M Physiology</i> )	Rapamycin Downstream Inhibition of Akt Signaling on AVF Maturation in Mice
Dela Cruz, Charles ( <i>Microb. Patho.</i> )	Role of Mitochondrial Reactive Oxygen Species in Influenza Infection
Demb, Jonathan ( <i>Ophthalmology</i> )	Anatomical and Molecular Characterization of a Neuropeptide Receptor-Expressing Cell Population in the Mouse Retina
Dimitrova, Nadya ( <i>MCDB</i> )	Investigating the Tumorigenic Effects of Mutations in Cancer-Associated Long lncRNAs
Eisenbarth, Stephanie ( <i>Immunobiology</i> )	The Role of Deducator of Cytokines 8 and TLR-4 in Hyper0Ige Production and Allergic Response
Emonet, Thierry ( <i>MCDB</i> )	Differential Cell Leakage from Bacterial Chemotactic Waves in Soft Agar
Fikrig, Erol ( <i>Infectious Disease</i> )	Exploration of NeSt1 Protein's Impact on the Pathogenicity of Zika Virus
	Investigation and Characterization of Aedes Aegypti Salivary Protein NeSt1 Vector Relationships with Zika Virus and the Murine Host Immune System
	The Characterization of SG27 as a Chemoattractant for Borrelia burgdorferi
Flavell, Richard ( <i>Immunobiology</i> )	Discovering Non-Canonical Open Reading Frames (ORFs) that Control Mucosal Immunity
Gendron, Joshua ( <i>MCDB</i> )	Characterization of Protecin Complexes Involved in Plant Energy Homeostasis
	Discovering Transcriptional Regulators of PAL2: The Phenylpropanoid Pathway of Arabidopsis thaliana
Gilbert, Wendy ( <i>MB&amp;B</i> )	Investigation of PUS7L Binding Sites and its Post-Transcriptional Modification of Human RNA
Gracheva, Elena ( <i>C&amp;M Physiology</i> )	Effects of Changing Osmolality Under Torpor States in a Mammalian Hibernator
Grutzendler, Jaime ( <i>Neurology</i> )	Investigating the Cellular Mechanisms of Axonal Dystrophies in Alzheimer's Disease
Guo, Shangqin ( <i>Cell Biology</i> )	Reprogramming Hematopoietic Progenitors into Insulin-Producing Pancreatic Beta Cells
Halene, Stephanie ( <i>Hematology</i> )	Determining the Role of m <sup>6</sup> A Modification of mRNA in Hematopoiesis and Leukemia
Herold, Kevan ( <i>Immunobiology</i> )	Bridging the Gap Between Cancer and type 1 Diabetes: An Analysis of How Cancer Immunotherapy can Lead to Autoimmunity
Ho, Ya-Chi ( <i>Infectious Diseases</i> )	Immortalization of CD4 <sup>+</sup> T Cells to Advance Research of HIV-1 Latent Reservoir



Hochstrasser, Mark ( <i>MB&amp;B</i> )	Understanding the Role of NST1 in Proteasome Regulation
Hoffman, Ellen ( <i>CSC</i> )	Using Behavioral, Pharmacological, Cellular and Brain Activity Mapping Tools to Study ASK-Risk Genes in a Zebrafish Model
Horsley, Valerie ( <i>MCDB</i> )	Altered Wound Healing Process in a Diabetic State due to Differences in Adipose Tissue and Lipolysis
	Myotibroblast Heterogeneity Influences Diabetic Wound Healing
	Overexpression of spr1a in Intact Neurons Increases Axon Plasticity after Spinal Cord Injury
	The Effect of Dermal Adipocyte Lipolysis on Cathelicidin Production in Infected Skin Wounds
Humphrey, Jay ( <i>Biomed. Engineering</i> )	Investigating the Effects of Drug Delivery on Hutchinson-Gilford Progeria Syndrome Mouse Model Arterial Mechanics
	Investigating the role of Transforming Growth Factor-B Signaling Disruption in the formation and Rupture of Aortic Aneurysms
Hwa, John ( <i>Cardiology</i> )	Mitochondrial Biogenesis in the Anucleate Platelet: A Pilot Study
Isaacs, Farren ( <i>MCDB</i> )	Design and Construction of Strains for the Evolution of Orthogonal Aminoacyl-tRNA Synthetases-tRNA Pair in Escherichia coli for the Genetic Encoding of Nonstandard Amino Acids
	Implementing Multiplex Automated Genome Engineering (MAGE) in S. Meliloti
Jacob, Yannick ( <i>MCDB</i> )	Characterizing SDG24 Function and Expression in Arabidopsis Thaliana
Jensen, Ryan ( <i>Therapeutic Radiology</i> )	Functional Analysis of BRCA2 Variants of Uncertain Significance in the BRC Repeats Domain
Jonas, Elizabeth ( <i>Endocrinology</i> )	Actin Architecture and Dynamics in the Presynaptic Terminal
Katz, Samuel ( <i>Pathology</i> )	Epitope Tagging of BCL-Z Ovarian Killer (BoK) Using CRISPR Cas 9 System Allows Protein Localization in Steady State and ER Stress Conditions
Keshishian, Haig ( <i>MCDB</i> )	Analysis of Synaptic Connections in Drosophila
King, Megan ( <i>Cell Biology</i> )	Epigenetic Mediators of Homolog Directed Repair Defects by the Oncometabolite s-Hydroxyglutamate in Schizosaccharomyces Pombe
Kliman, Harvey ( <i>OBGYN</i> )	Identification of the Nuclear Binding Partners of Serotonin in Human Placental Trophoblast Cells
	Placental Trophoblast Inclusions as a Marker of Developmental Disorders
Koleske, Anthony ( <i>MB&amp;B</i> )	Mechanistic Study of Integrin-Mediated Activation of Ab12/Arg Activity
Krause, Diane ( <i>Cell Biology</i> )	A New Cell Line in Acute Megakaryocytic Leukemia: The Molecular Characterization of Leukemogenesis
	Role of MKL1 in Fetal Megakaryopoiesis
Kwan, Alex ( <i>Psychiatry</i> )	The Role of the Rodent Secondary Motor Cortex (M2) on Valve-Based Decision Making
Lee, Francis ( <i>Orthopedics</i> )	Mechanisms to Inhibit Breast Cancer -Related Bone Destruction
Lin, Haifan ( <i>Cell Biology</i> )	Purification of Miwi2 and its Interactors for Structural Analysis
	Systematic Dissection of Piwi Function in Different types of Somatic Cells during Drosophila Oogenesis
MacMicking, John ( <i>Immunobiology</i> )	CRISPR/Cas9 Interrogation of IFN-Mediated Defense Networks Against Bacterial Infection

Mak, Michael ( <i>Biomedical Engineering</i> )	Modeling the Effects of E-cadherin Downregulation in Basal-Like Breast Cancer Metastasis
Medzhitov, Ruslan ( <i>Immunobiology</i> )	Role of Enteroendocrine Cells in Nutrient Sensing in the Gastrointestinal Tract
Meffre, Eric ( <i>Immunobiology</i> )	Role of toll-like Receptors (TLRs) in Regulating the Removal of Developing Autoreactive B Cells During Establishment of Human Central B Cell Tolerance
Melia, Thomas ( <i>Cell Biology</i> )	Significance of an H262Y ATG3 Point-Mutation on Autophagy Lipidation
Miranker, Andrew ( <i>MB&amp;B</i> )	Designing Amyloid-Disrupting Peptides to Target p53 and Paralogs in Ovarian Cancer
Moeckel, Gilbert ( <i>Pathology</i> )	Role of MIF-2/D-DT in Tubular Cell Regeneration
Nicoli, Stefania ( <i>Cardiology</i> )	Investigating a Role of MiR-223 Modulation of N-Glycosylation in Zebrafish Hematopoietic Stem Cell Formation
Niklason, Laura ( <i>Biomedical Engineering</i> )	Creation and Characterization of an Extracellular Matrix (ECM) Hydrogel from Pancreatic ECM
O'Connor, Kevin ( <i>Neurology</i> )	Mechanism of Pathogenicity of Anti-MuSK Monoclonal Antibodies in Myasthenia Gravis
Palm, Noah ( <i>Immunobiology</i> )	Directing IgA to Enteric Bacteria for Hybrid Antibody Mediated Resolution of Dysbiosis (DIEHARD)
Pereira, Joao ( <i>Immunobiology</i> )	Molecular Regulation of Emergency Myelopoiesis
Perry, Rachel ( <i>Endocrinology</i> )	Tumor Immunometabolism
Pollard, Thomas ( <i>MCDB</i> )	Investigating the Relationship Between Bgs1-D277N and Wee1-50 in Regulating the Cytokinetic Timeline
	Structural Basics for Labeling Actin Filaments within the Seventeen-Residue Peptide Lifeact
Pyle, Anna ( <i>MCDB</i> )	Building a Computational Pipeline for SHAPE Probing of RNA Secondary Structures
	Characterization of Marathon RT DNA Polymerase Activity
	Creation of Mutant Fluorescent RIG-I Receptors
	Mechanisms of MDA5 Mutants and their Role in Autoimmune Disease
	The Creation of Mutant, Fluorescent RIG-I Receptors and a Constitutively Closed, Active RIG-I Construct
Rimm, David ( <i>Pathology</i> )	Determining the Prognostic Significance of Tumor Associated Macrophages in Head and Neck Cancer
Roy, Craig ( <i>Microbial Pathogenesis</i> )	Assessing in vivo Functions of Secreted Coxiella burnetii Effector Proteins Cig2, CvpF, and YebC in Galleria mellonella Model System
Rutherford, Helena ( <i>CSC</i> )	Frontal EEG Asymmetry and Maternal Behavior
Saltzman, Mark ( <i>Biomedical Engineering</i> )	Tailored Vascular Targeting to Direct the final Accumulation Region of Nanoparticle-based Drug Delivery
Schalper, Kurt ( <i>Pathology</i> )	Role of the HLA Antigen Presenting Machinery (APM) in Resistance to PD-1 Axis Blockade in Non-Small Cell Lung Cancer
Sklar, Jeffrey ( <i>Pathology</i> )	Identifying Clonal Mutations in Normal Human Tissues with Next Generation Sequencing
Strittmatter, Stephen ( <i>Neurology</i> )	Colocalization of Complement Protein Complex with Synapses in SAM Compound Treated Mice Models of Alzheimer's Disease
	Colocalization of Complement Protein Complex with Synapses in Treated Mice Models of Alzheimer's Disease

	Investigating Risk Factor Pyk2 in Relation to Tauopathy in Alzheimer's Disease Pathogenesis
	TMM Lo6B Modulation of Neurodegeneration
Su, Xiaolei ( <i>Cell Biology</i> )	Mechanisms of Action of Common ATL Associated PLCy1 Point Mutations in the Production of T-Cell Hyperactive Signaling and Hyperproliferation
Sweasy, Joan ( <i>Therapeutic Radiology</i> )	Investigating DNA Polymerase Beta Variant H285D's Mechanism for Mismatch Extension
Taylor, Hugh ( <i>OBGYN</i> )	Endometriosis Leads to Atherosclerosis in Mouse Model
	Mechanistic Effects of Endometriosis on the Brain
Tommasini, Steven ( <i>Orthopedics</i> )	Development of Improved Sub Trochanteric Femoral Fracture Fixation Devices
Vaccarino, Flora ( <i>CSC</i> )	Examining Early Neurodevelopment in Normocephalic Autism Using Telencephalic Organoids
Wajapeyee, Narendra ( <i>Pathology</i> )	Drug Inhibition of Melanoma Cell Metastasis
Yan, Qin ( <i>Microbial Patho</i> )	Characterization of the Role of KDM5 Family Members in Repressing Immune Response Using Mouse Breast Cancer Model
Yang, Xiaoyong ( <i>Comp Medicine</i> )	Identifying Metabolic Vulnerabilities Associated with Hyperactive O-GlcNacylation by CRISPR Screen

## Undergraduate Prizes and Awards

The department gives awards to graduating seniors for the following categories:

Excellence in Research: MCDB Edgar J. Boell Prize (*Boell*)

Excellence in Academic Performance: MCDB William R. Belknap Prize (*Belknap*)

For the past academic year, 6 students were awarded the Boell and 3 students were awarded the Belknap.

# Standard Track Worksheet

MCDB	MCDB INT	BA	BS
------	-------------	----	----

SID \_\_\_\_\_

Research Lab Mentor: \_\_\_\_\_

Student Name: \_\_\_\_\_

MCDB Faculty Advisor: \_\_\_\_\_

BIOL Prerequisite:	Course #	Semester	Grade
BIOL 101 Biochemistry and Biophysics			
BIOL 102 Prin of Cell Biology			
BIOL 103 Genetics and Development			
BIOL 104 Prin of Ecology & Evolutionary Biology			
GEN CHEM Prerequisite:	Course #	Semester	Grade
General Chemistry (2 terms -161/165; or 163/167; or its equivalent)			
General Chemistry Labs (2 terms - 134L/136L)			
(BS/BS INT only) (BA: For students satisfying one or more prerequisites with AP scores, requirement is still to take any 3 terms of CHEM & PHYS courses at Yale with at least 1 from each department)			NA for BA
			NA for BA
ORG CHEM Prerequisite: (BS & BS/INT only)	Course #	Semester	Grade
Organic Chemistry (1 term - 174a; or 175b; or 220a)			NA for BA
Organic Chemistry Lab (1 term - 222L; or 223L; or 226L)			NA for BA
(BS/BS INT only: Completion of the Freshman Organic Chemistry sequence 174/175 and 222L/223L satisfies all of the Chemistry prerequisites for the MCDB major) (BA - Not Applicable)			
PHYSICS Prerequisite:	Course #	Semester	Grade
Physics (170/171; or 180/181; or 200/201; or 260/261)			
BA: 1 term; BS & BS INT: 2 terms			NA for BA
MATH Prerequisite:	Course #	Semester	Grade
Math 115 or higher or S&DS course (BA/BS/BS INT) 1 term - not including Math 190)			
CORE COURSES: BA-Choose any 2; BS & BS INT -Choose any 3	Course #	Semester	Grade
MCDB 200 Molecular Biology			
MCDB 202 Genetics			
MCDB 205 Cell Biology			NA for BA
MCDB 210 Developmental Biology			
<b>EITHER:</b> MCDB 300 Biochemistry <b>OR:</b> MB&B 300 Principles of Biochemistry I			
GENERAL ELECTIVES: (2 Total)	Course #	Semester	Grade
BS & BS/INT: Choose 2 from MCDB 250 or above (or from the Core list)			BA-must be MCDB
(2nd term Orgo Chem and Statistics acceptable for BS & BS INT only)			BA-must be MCDB
Additional Courses: (used to report Major GPA & Distinction in the Major)			
BA: Choose 2 from MCDB 250 or above (or from the Core list)			
SPECIAL ELECTIVES:	Course #	Semester	Grade
BA, BS & BS INT: Choose 1 from MCDB 350 or above			
LABS:	Course #	Semester	Grade
BA: Choose 1 lab (from Biological Sciences: MCDB/EEB/MBB/ANTHRO Labs)			
BS: Choose 2 labs (required: labs must be from MCDB)			NA for BA
SENIOR REQUIREMENT:	Course #	Semester	Grade
<b>BA: (Senior Essay or 1 term of Research)</b>			
<b>BS: (Need 2 terms of Research)</b>			
MCDB 475 a or b	Independent Research MCDB		
MCDB 485/486	Senior Requirement MCDB BS Major		
	*MCDB 485/486 is preferred - but 2 terms of MCDB 475 (+ summer) will satisfy this req		
<b>BS INT: (Need 2 terms of Research)</b>			
MCDB 495/496	Senior Requirement MCDB BS INT Major		

# Biotechnology Track Worksheet

MCDB	INT	BA	BS
------	-----	----	----

SID \_\_\_\_\_

Research Lab Mentor: \_\_\_\_\_

Student Name: \_\_\_\_\_

MCDB Faculty Advisor: \_\_\_\_\_

BIOL Prerequisite:	Course #	Semester	Grade	
BIOL 101 Biochemistry and Biophysics	BIOL 101			
BIOL 102 Prin of Cell Biology	BIOL 102			
BIOL 103 Genetics and Development	BIOL 103			
BIOL 104 Prin of Ecology & Evolutionary Biology	BIOL 104			
GEN CHEM Prerequisite:	Course #	Semester	Grade	
General Chemistry (2 terms -161/165; or 163/167; or its equivalent)				
General Chemistry Labs (2 terms - 134L/136L)				
(BS/BS INT only) (BA: For students satisfying one or more prerequisites with AP scores, requirement is still to take any 3 terms of CHEM & PHYS courses at Yale with at least 1 from each department)				NA for BA
				NA for BA
ORG CHEM Prerequisite: (BS & BS/INT only)	Course #	Semester	Grade	
Organic Chemistry (1 term - 174a; or 175b; or 220a)				NA for BA
Organic Chemistry Lab (1 term - 222L; or 223L; or 226L)				NA for BA
(BS/BS INT only: Completion of the Freshman Organic Chemistry sequence 174/175 and 222L/223L satisfies all of the Chemistry prerequisites for the MCDB major) (BA - Not Applicable)				
PHYSICS Prerequisite:	Course #	Semester	Grade	
Physics (170/171; or180/181; or 200/201; or 260/261)				
BA: 1 term; BS & BS INT: 2 terms				NA for BA
MATH Prerequisite:	Course #	Semester	Grade	
Math 115 or higher or S&DS course (BA/BS/BS INT) 1 term - not including Math 190)				
CORE COURSES: BA-Choose any 2; BS & BS INT -Choose any 3	Course #	Semester	Grade	
MCDB 200 Molecular Biology				
MCDB 202 Genetics				
MCDB 205 Cell Biology				NA for BA
MCDB 210 Developmental Biology				
<b>EITHER:</b> MCDB 300 Biochemistry <b>OR:</b> MB&B 300 Principles of Biochemistry I				
GENERAL ELECTIVES: (2 Total)	Course #	Semester	Grade	
<b>Required Track Course: MCDB 370b Biotechnology</b>	MCDB 370			
<b>AND Choose 1 additional elective below (or from the Core list)</b>				
BENG 351a Biomedical Engineering I				
BENG 352b Biomedical Engineering II				
BENG 410a Basis of Bioimaging & Biosensing				
BENG 435b Biomaterial - Tissue Interactions				
BENG 457b Biomechanics				
BENG 464b Tissue Engineering				
CENG 210a Chem Eng & Process Modeling				
CENG 411a Separation & Purification Processes				
CENG 412b Chemical Engineering Laboratory				
CPSC 437a Introduction to Databases				
CPSC 445b Introduction to Data Mining				
CPSC 470a Artificial Intelligence				
CPSC 475b Comp. Vision & Bio Perception				
MB&B 420a Macromolecular Structure				
MB&B 421b Macromolecular dynamics				
MB&B 443b Eukaryotic Molecular Biology				
SPECIAL ELECTIVE:	Course #	Semester	Grade	
BA, BS & BS INT: Choose 1 from MCDB 350 or above				
LABS:	Course #	Semester	Grade	
BA: Choose 1 lab (from Biological Sciences: MCDB/EEB/MBB/ANTHRO Labs)				
BS: Choose 2 labs (required: labs must be from MCDB)				NA for BA
SENIOR REQUIREMENT:	Course #	Semester	Grade	
<b>BA: (Senior Essay or 1 term of Research)</b>				
<b>BS: (Need 2 terms of Research)</b>				
MCDB 475 a or b	Independent Research MCDB			
MCDB 485/486	Senior Requirement MCDB BS Major			
	*MCDB 485/486 is preferred - but 2 terms of MCDB 475 (+ summer) will satisfy this req			
<b>BS INT: (Need 2 terms of Research)</b>				
MCDB 495/496	Senior Requirement MCDB BS INT Major			

# Neurobiology Track Worksheet

MCDB	MCDB INT	BA	BS
------	-------------	----	----

SID \_\_\_\_\_

Research Lab Mentor: \_\_\_\_\_

Student: \_\_\_\_\_

MCDB Faculty Advisor: \_\_\_\_\_

BIOL Prerequisite:	Course #	Semester	Grade	
BIOL 101a or b Biochemistry and Biophysics	BIOL 101			
BIOL 102a or b Prin of Cell Biology	BIOL 102			
BIOL 103a or b Genetics and Development	BIOL 103			
BIOL 104a or b Prin of Ecology & Evolutionary Biology	BIOL 104			
GEN CHEM Prerequisite:	Course #	Semester	Grade	
General Chemistry (2 terms -161/165; or 163/167; or its equivalent)				
General Chemistry Labs (2 terms - 134L/136L)				
(BS/BS INT only) (BA: For students satisfying one or more prerequisites with AP scores, requirement is still to take any 3 terms of CHEM & PHYS courses at Yale with at least 1 from each department)				NA for BA
				NA for BA
ORG CHEM Prerequisite: (BS & BS/INT only)	Course #	Semester	Grade	
Organic Chemistry (1 term - 174a; or 175b; or 220a)				NA for BA
Organic Chemistry Lab (1 term - 222L; or 223L; or 226L)				NA for BA
(BS/BS INT only: Completion of the Freshman Organic Chemistry sequence 174/175 and 222L/223L satisfies all of the Chemistry prerequisites for the MCDB major)				
PHYSICS Prerequisite:	Course #	Semester	Grade	
Physics (170/171; or 180/181; or 200/201; or 260/261)				
BS & BS INT: 2 terms				NA for BA
MATH Prerequisite:	Course #	Semester	Grade	
Math 115 or higher (or Statistics course at Yale)				
CORE COURSES: BA-Choose any 2; BS & BS INT -Choose any 3	Course #	Semester	Grade	
MCDB 200 Molecular Biology				
MCDB 202 Genetics				
MCDB 205 Cell Biology				NA for BA
MCDB 210 Developmental Biology				
<b>EITHER:</b> MCDB 300 Biochemistry <b>OR:</b> MB&B 300 Principles of Biochemistry I				
GENERAL ELECTIVES: (2 Total)	Course #	Semester	Grade	
<b>Required Track Course: MCDB 320a Neurobiology</b>	MCDB 320			
<b>AND Choose 1 additional elective below (or from the Core list)</b>				
BENG 410a Basis of Bioimaging & Biosensing	MCDB 361b Modeling Biological Systems II			
CPSC 475b Comp Vision & Biol Perception	MCDB 430a Biology of the Immune System			
MCDB 250b Biololgy of Reproduction	PSYC 270a Research Methods Behavioral Neuro			
MCDB 315b Pathobiology	PSYC 320a Cognitive Neuroscience			
MCDB 415b Cellular & Molecular Physiology	PSYC 376a Basics of Learning and Memory			
MCDB 425a Basic Concepts Genetic Analysis				
SPECIAL ELECTIVE:	Course #	Semester	Grade	
BS & BS INT: Choose 1 from MCDB 350 or above				
LABS:	Course #	Semester	Grade	
BA: Choose 1 lab (from Biological Sciences: MCDB/EEB/MBB/ANTHRO Labs)				
BS: Choose 2 labs (required: labs must be from MCDB)				NA for BA
Senior Requirement:	Course #	Semester	Grade	
<b>BA: (Senior Essay or 1 term of Research)</b>				
<b>BS: (Need 2 terms of Research)</b>				
MCDB 475 a or b	Independent Research MCDB			
MCDB 485/486	Senior Requirement MCDB BS Major *MCDB 485/486 is preferred - but 2 terms of MCDB 475 (+ summer) will satisfy this req			
BS INT: (Need 2 terms of Research)	Course #	Semester	Grade	
MCDB 495/496	Senior Requirement MCDB BS INT Major			



# Quantitative Biology Track Worksheet

MCDB	MCDB INT	BA	BS
------	-------------	----	----

SID \_\_\_\_\_ Research Lab Mentor: \_\_\_\_\_

Student Name: \_\_\_\_\_ MCDB Faculty Advisor: \_\_\_\_\_

BIOL Prerequisite:	Course #	Semester	Grade	
BIOL 101a or b Biochemistry and Biophysics	BIOL 101			
BIOL 102a or b Prin of Cell Biology	BIOL 102			
BIOL 103a or b Genetics and Development	BIOL 103			
BIOL 104a or b Prin of Ecology & Evolutionary Biology	BIOL 104			
GEN CHEM Prerequisites:	Course #	Semester	Grade	
General Chemistry (2 terms -161/165; or 163/167; or its equivalent)				
General Chemistry Labs (2 terms - 134L/136L)				
(BS/BS INT only) (BA: For students satisfying one or more prerequisites with AP scores, requirement is still to take any 3 terms of CHEM & PHYS courses at Yale with at least 1 from each department)				NA for BA
				NA for BA
ORG CHEM Prerequisite: (BS & BS/INT only)	Course #	Semester	Grade	
Organic Chemistry (1 term - 174a; or 175b; or 220a)				NA for BA
Organic Chemistry Lab (1 term - 222L; or 223L; or 226L)				NA for BA
(BS/BS INT only: Completion of the Freshman Organic Chemistry sequence 174/175 and 222L/223L satisfies all of the Chemistry prerequisites for the MCDB major) (BA - Not Applicable)				
PHYSICS Prerequisite:	Course #	Semester	Grade	
Physics (170/171; or 180/181; or 200/201; or 260/261)				
BA: 1 term; BS & BS INT: 2 terms				NA for BA
MATH Prerequisite:	Course #	Semester	Grade	
Math 115 or higher or S&DS course (BA/BS/BS INT) 1 term - not including Math 190)				
CORE COURSES: BA-Choose any 2; BS & BS INT -Choose any 3	Course #	Semester	Grade	
MCDB 200 Molecular Biology				
MCDB 202 Genetics				
MCDB 205 Cell Biology				NA for BA
MCDB 210 Developmental Biology				
<b>EITHER:</b> MCDB 300 Biochemistry <b>OR:</b> MB&B 300 Principles of Biochemistry I				
GENERAL ELECTIVES: (2 Total)	Course #	Semester	Grade	
<b>Required Track Course: MCDB 330 Modeling Biological Systems I</b>	MCDB 330			
<b>AND Choose 1 additional elective</b>				
MCDB 320a Neurobiology	MATH 251b			
MCDB 361b* Modeling Biological Systems II	MB&B 302b			
*Pref. elective				
BENG 467b Systems Biology of Signaling	MB&B 435a			
CENG 320a Immunoengineering	MB&B 452b			
CPSC 440b Numerical Computation	MB&B 523a			
CPSC 475a Comp Vision & Bio Perc.	PHYS 402b			
MATH 246b Ordinary Differential Equations				
SPECIAL ELECTIVES:	Course #	Semester	Grade	
BA, BS & BS INT: Choose 1 from MCDB 350 or above				
LABS:	Course #	Semester	Grade	
BA: Choose 1 lab (from Biological Sciences: MCDB/EEB/MBB/ANTHRO Labs)				
BS: Choose 2 labs (required: labs must be from MCDB)				NA for BA
SENIOR REQUIREMENT:	Course #	Semester	Grade	
<b>BA: (Senior Essay or 1 term of Research)</b>				
<b>BS: (Need 2 terms of Research)</b>				
MCDB 475 a or b	Independent Research MCDB			
MCDB 485/486	Senior Requirement MCDB BS Major *MCDB 485/486 is preferred - but 2 terms of MCDB 475 (+ summer) will satisfy this req			
BS INT: (Need 2 terms of Research)	Course #	Semester	Grade	
MCDB 495/496	Senior Requirement MCDB BS INT Major			



## MCDB SENIOR ESSAY

Graduation from Yale College requires the passing of a departmental examination or the equivalent. The MCDB requirement is met by having each student do an individual research course (usually MCDB 475, 485, or 495) or submit a senior essay. *The senior essay is graded, but it carries no course credit.* The **deadline** for seniors finishing in the fall term is **first week of December**. For those finishing in the spring term the deadline is the **first week of April**.

The senior essay should be a critical evaluation of some aspect of the current and pertinent, primary biological literature. The topic may be anything within the realm of biology or it may explore the relationships of biology to other fields. Each student must obtain approval of the paper topic from the MCDB DUS to assure that the subject is promising. The Senior Essay form must be returned to the office of the DUS via electronic submission to [mcdb.undergraduateregistrar@yale.edu](mailto:mcdb.undergraduateregistrar@yale.edu) **at least one month before the paper is due**. Students should attach a thesis paragraph describing the chosen topic. Papers are due at 4:00pm on the last day of classes.

The paper is to be 15-20 double-spaced pages, including bibliography. It is the student's obligation to procure a faculty advisor to read and grade each paper. If a student needs assistance in this area, the office of the DUS is available for guidance. Papers are to be submitted to the office of DUS. Electronic submission is acceptable and preferred to: [mcdb.undergraduateregistrar@yale.edu](mailto:mcdb.undergraduateregistrar@yale.edu). Normally, a grade of "Satisfactory" is reported to the registrar by the DUS. However, honor candidates must achieve a grade of A, which is of course reported. If the essay is "Unsatisfactory", the student may make arrangements with the DUS to submit another paper. Papers received late may not be processed before Commencement.

**Submission and Formatting Instructions for All Written Work:** Papers should be sent electronically to [mcdb.undergraduateregistrar@yale.edu](mailto:mcdb.undergraduateregistrar@yale.edu) by the deadlines stated. ***Additionally, please follow these formatting instructions:*** Students should follow the American Psychological Association Guidelines for formatting instructions. You can use the following URLs for more information:

- [www.apastyle.org](http://www.apastyle.org)
- [https://owl.purdue.edu/owl/research\\_and\\_citation/apa\\_style/apa\\_formatting\\_and\\_style\\_guide/general\\_format.html](https://owl.purdue.edu/owl/research_and_citation/apa_style/apa_formatting_and_style_guide/general_format.html) (which is referenced by the Center for Teaching and Learning at this URL:
  - <https://ctl.yale.edu/FacultyResources/English>
- <https://ctl.yale.edu/sites/default/files/files/Formatted%20Writing%20an%20APA%20Style%20Empirical%20Paper%20KVCulin.pdf>

Be sure to include a title page with the following information: (a) Title of Paper, (b) Student Name and Class Year, (c) PI Name, (e) Senior Essay for MCDB BA degree. Make sure to include a header on pages 2 through the end of the document with (a) Student Name, (b) Senior Essay and (c) Page Number. Save papers as a pdf using the following nomenclature: *StudentLastName\_FirstName\_SrEssay\_Year.pdf*. ***Please send a copy to your PI***

In choosing a faculty member to advise on your senior essay, first decide on the general area in biological science you would like to explore. Then determine which faculty member might have interest or expertise in that area. The best source is the MCDB Department handbook, available on the MCDB Website. Second, if a faculty member discussed the topic in a course, they would be a good choice or source for suggestions. Otherwise, the Yale College Program of Study provides a list of faculty member and courses that may include your prospective topic.

Approach the faculty member identified above. If they are not the best person to advise you on your topic, the faculty member should know who would be more knowledgeable in your area. Your senior essay advisor will often not be the same advisor that signs your course schedule.

In discussion with the essay advisor, narrow your area of interest to a focused topic on which you can write in depth; a superficial review of a broad field is not appropriate. The advisor may also suggest a few references to start off your reading in the field.

## MCDB 474 – Independent Research FOR Underclassmen & Non-Majors taken as PASS / FAIL

### Course Overview:

The main purpose of this course is to enable you to obtain hands-on experience with basic research as part of your education at Yale. The course entails one semester of experimental work (the minimum time expectation is 10-12 hr/week in the lab) aimed at generating data using experimental strategies designed to address a specific research problem. The course also requires a final written paper in the format of a **Research Article**.

### Course Requirements:

**Student and Research Mentor Contracts:** Due dates: Fall: **Monday, September 9, 2019 @ 12:00 noon**; Spring: **Monday, January 27, 2020 @ 12:00 noon**. These should be uploaded to the Assignments section of Canvas. Contracts are available on Canvas and the MCDB Website.

**Research Proposal:** Due dates: Fall: **Monday, September 9, 2019 @ 12:00 noon**; Spring: **Monday, January 27, 2020 @ 12:00 noon**. A 1-2 page double-spaced summary of your research (written in collaboration with your research mentor) should include ~ 1 page overview/background of the project (documented with a short bibliography) and a section describing the general objectives, hypothesis to be tested and most importantly, the specific aims of your project. For guidance, ask your mentor to see a Specific Aims section of one of their NIH or NSF grants.

Inappropriate Proposals include simply analyzing data gathered by someone else, for example entering previously obtained data into a computer and running a statistical analysis program. An unsuitable proposal at the other extreme would be gathering data for another person to analyze, for example taking medical histories or clinical measurements that will be passed on to someone else for study. Projects involving allelic screening of patient populations for SNPs associated with a given disease are also not acceptable unless there is substantive experimental design/content. ***If you are considering a project that may fall into one of the categories above, please discuss this with the instructor in charge prior to committing to that laboratory or project (there may be suitable alternative projects in the same lab).***

### Time Commitment:

We are particularly concerned that each student fulfills the minimum 10-12 hr/week research commitment in the lab; part of the Mentor's Contract is to verify that level of participation by mid-semester. ***If for any reason you are unable to fulfill your commitment to the course and laboratory, you will be asked to withdraw from the course.***

**Final Report – Research Journal:** Due dates: Fall: **Friday, December 6, 2019 @ 4:00pm**; Spring: **Friday, April 24, 2020 @ 4:00pm**. A 12-15 page double-spaced report in the form of a typical **Research Journal** uploaded to the Assignment section in Canvas by the above dates. Well in advance of this deadline, you should meet with your research mentor to plan a general outline for your paper and engage them in continued discussions throughout the writing process. You should conform to any other specifics that your mentor might expect in your write-up. The research mentor should grade the final version of the report and return it to us with comments electronically along with a recommendation for an overall course grade. Your research mentor will be contacted directly with grading information near the end of the term. The report should be written in a style similar to that of a paper in a typical **Research Journal** and should include the following sections:

- **Abstract:** This is a brief summary of the project and the results obtained.
- **Introduction:** What is the biological problem, why is it important, and what's known about it already?
- **Experimental Procedures** (Material and Methods).
- **Results:** Describe what you have done. Include bar graphs, sketches, diagrams, tables, photographs etc. – whatever is needed to represent your data.
- **Discussion:** If your project was successful, describe the significance of the results. If your project did not work, describe what you think went wrong, and what your expectations were. Regardless of the outcome, describe what you would try next if you were to continue the project.
- **References:** References to previous work discussed as well as methods used should be cited as in any other research paper.

**Grading:** All students taking this course will receive Pass/Fail. Independent study courses earn Yale College credit for Underclassmen, but are governed by the new "P/F with report" policy.

A student who passes this course will have the mark of "P" entered on the Yale College transcript once the course instructor submits an independent study report form that describes the nature of the course and provides a detailed evaluation of the student's performance in it. Failures in the course will result in the recording of an "F".

## MCDB 475 – Senior Independent Research

### Course Overview:

MCDB 475 is an independent research course designed to promote hands-on biological and biomedical investigation in the laboratory of a faculty member at Yale. The workload expectation is for students to be present and involved in laboratory research for 10-12 hours per week. Due to the inherent nature of independent laboratory research, students often spend considerably more than 12 hours per week in the lab to generate useful data. This course also requires a final written paper in the form of a Research Journal.

### Course Requirements:

**Student and Research Mentor Contracts:** Due dates: Fall: **Monday, September 9, 2019 @ 12:00 noon**; Spring: **Monday, January 27, 2020 @ 12:00 noon**. These should be uploaded to the Assignments section of Canvas. Contracts and complete guidelines are available on Canvas and the MCDB Website.

**Research Proposal:** Due dates: Fall: **Monday, September 9, 2019 @ 4:00pm**; Spring: **Monday, January 27, 2020 @ 4:00pm** A 1-2 page double-spaced summary of your research (written in collaboration with your research mentor) is due at the beginning of the term. This should include ~ 1 page overview/background of the project (documented with a short bibliography) and a section describing the general objectives, hypothesis to be tested and most importantly, the specific aims of your project. For guidance, ask your mentor to see a Specific Aims section of one of their NIH or NSF grants.

Inappropriate Proposals include simply analyzing data gathered by someone else, for example entering previously obtained data into a computer and running a statistical analysis program. An unsuitable proposal at the other extreme would be gathering data for another person to analyze, for example taking medical histories or clinical measurements that will be passed on to someone else for study. Projects involving allelic screening of patient populations for SNPs associated with a given disease are also not acceptable unless there is substantive experimental design/content. ***If you are considering a project that may fall into one of the categories above, please discuss this with the instructor in charge prior to committing to that laboratory or project (there may be suitable alternative projects in the same lab).***

**Time Commitment:** We are particularly concerned that each student fulfills the minimum 10-12 hr/week research commitment in the lab; part of the Mentor's Contract is to verify that level of participation by mid-semester. ***If for any reason you are unable to fulfill your commitment to the course and laboratory, you will be asked to withdraw from the course.*** Note, if you are a senior planning on attending multiple interviews for medical school in the Fall, you are expected to make up for lost time.

**Final Report – Research Journal:** Due Date: Fall: **December 6, 2019 @ 4:00pm**; Spring: **April 24, 2020 @ 4:00pm** A 12-15 page double-spaced report in the form of a typical **Research Journal** uploaded to the Assignment section in Canvas by the above dates. Well in advance of this deadline, you should meet with your research mentor to plan a general outline for your paper and engage them in continued discussions throughout the writing process. You should conform to any other specifics that your mentor might expect in your write-up. The research mentor should grade the final version of the report and return it to us with comments electronically along with a recommendation for an overall course grade. Your research mentor will be contacted directly with grading information near the end of the term.

The report should be written in a style similar to that of a paper in a typical **Research Journal** and should include the following sections:

- **Abstract:** This is a brief summary of the project and the results obtained.
- **Introduction:** What is the biological problem, why is it important, and what's known about it already?
- **Experimental Procedures** (Material and Methods).
- **Results:** Describe what you have done. Include bar graphs, sketches, diagrams, tables, photographs etc. – whatever is needed to represent your data.
- **Discussion:** If your project was successful, describe the significance of the results. If your project did not work, describe what you think went wrong, and what your expectations were. Regardless of the outcome, describe what you would try next if you were to continue the project.
- **References:** References to previous work discussed as well as methods used should be cited as in any other research paper.

**Grading:** All students taking this course for Senior Requirement will receive a letter grade and 1.0 Yale College credits.

## MCDB 485 – Senior Research

### Course Overview:

MCDB 485 is an independent research course designed to promote hands-on biological and biomedical investigation in the laboratory of a faculty member at Yale. The expectation is that students in MCDB 485 are fully committed to a full year of research and will continue their project in the same laboratory for one additional term in MCDB 486. While the minimum workload expectation is for students to be active in the laboratory for 10-12 hours per week, many students discover that data acquisition and fruitful results require more time at the lab bench. This course also requires a final written report in the form of a Research Journal.

### Course Requirements:

**Student and Research Mentor Contracts:** Due date: **Monday, September 9, 2019 @ 12:00 noon.**

These should be uploaded to the Canvas Assignment section. Contracts and complete guidelines are available on Canvas and the MCDB Website.

**Research Proposal:** Due date: **Monday, September 9, 2019 @ 12:00 noon.**

A 1-2 page double-spaced summary of your research (written in collaboration with your research mentor) is due at the beginning of the term. This should include ~ 1 page overview/background of the project (documented with a short bibliography) and a section describing the general objectives and most importantly, the specific aims of your project. For guidance, ask your mentor to see a Specific Aims section of one of their NIH or NSF grants.

Inappropriate Proposals include simply analyzing data gathered by someone else, for example entering previously obtained data into a computer and running a statistical analysis program. An unsuitable proposal at the other extreme would be gathering data for another person to analyze, for example taking medical histories or clinical measurements that will be passed on to someone else for study. Projects involving allelic screening of patient populations for SNPs associated with a given disease are also not acceptable unless there is substantive experimental design/content. ***If you are considering a project that may fall into one of the categories above, please discuss this with the instructor in charge prior to committing to that laboratory or project (there may be suitable alternative projects in the same lab).***

### Time Commitment:

We are particularly concerned that each student fulfills the minimum 10-12 hr/week in the lab research commitment; part of the Mentor's Contract is to verify that level of participation by mid-semester. ***If for any reason you are unable to fulfill your commitment to the course and laboratory, you will be asked to withdraw from the course.*** Note, if you are planning on attending multiple interviews for medical school in the Fall, you are expected to make up for lost time.

**Fall Report – Grant Proposal:** Due date: **Friday, December 6, 2019 @ 4:00pm**

A 5 page (double spaced) **Grant Proposal** should include the following sections, which are patterned after the format of an NIH or NSF Grant:

*General Objectives (very brief statement)*

*Specific Aims*

*Background and Significance*

*Preliminary Results*

*Research Plan*

*Bibliography*

*Figure legends must have captions that describe the contents of each figure*

**Oral Presentations – SPRING only for MCDB 485/486 students (April 17-24, 2020 in YSB 352 – check Canvas for dates/times).** Upload your PowerPoint presentation to the Canvas Assignment section at least 2 days before the scheduled presentation. Don't forget to include your 2-3 questions for the group.

Each student is required to give a formal seminar (PowerPoint slides) on their research progress at the end of the Spring term (always held in multiple sessions spread out over the last week of classes). Each student seminar is capped at 15 minutes, with the slide presentation limited to 10-12 minutes, followed by 3-5 minutes for questions from peers and course instructors. Students should also prepare a final slide that includes 2-3 questions for the audience to discuss. All students are required to attend two full seminar sessions. This includes attending the session in which you are a presenter, and also attending a second full seminar session on a different day in which you are not presenting, but are an active member of the seminar audience. Students are expected to arrive promptly and to remain for the duration of each of their two required seminar sessions. Most sessions consist of 5-8 student seminar speakers. The actual time of each session varies from 1.5 – 2.5 hours depending on the number of speakers and the extent of questions from the



audience. You will not be required to attend any sessions in the Fall term. A digital projector will be available; however, you should plan on bringing your own laptop to plug into the system.

**Spring Poster Symposium:** Due Date: **Friday, April 24, 2020 2:00-4:00pm in YSB Lobby**

The Poster Symposium is a **mandatory session** that will be held **Friday, April 24, 2020 from 2-4pm – YSB Lobby**. The purpose of the symposium is to share information and more specifically to highlight undergraduate research at Yale. Refreshments will be provided courtesy of the MCDB Dept. The symposium will be open to anyone wishing to attend, so please encourage friends, colleagues, family and other students to come. Your research mentor is strongly urged to attend.

**Each student must prepare a poster.** Posters can be as large as 3' X 5', but may be smaller. We will have poster boards and easels available to put your poster on. Posters may be printed professionally (**please note that there is no funding available for this expense from MCDB**), or the student may print them on a color printer and assemble individual sheets onto the poster board at the poster session. **DO NOT WAIT** until the 11<sup>th</sup> hour to print your poster as the poster-printing service is always backlogged.

Posters should have a title, and the authors (including you and your research mentor) should be listed as well, usually in large letters at the top. Indicate which research course you are in (MCDB 485). The poster should include three sections: Introduction, Results, and Conclusions. The Introduction explains the purpose of your project; the Results section contains figures and/or tables showing your data, with legends or commentary; the Conclusion summarizes what you learned. Feel free also to include what you would do next were you to continue working on the project.

**Spring Report – Research Journal:** Due date: **April 24, 2020 @ 4:00pm**

A 12-15 page double-spaced paper uploaded to the Canvas Assignment section, and a copy to your research mentor. The report should be written in a style similar to that of a paper in a typical **Research Journal** and should include the following sections:

- *Title Page:* Including title, the name and department of the faculty member in whose laboratory the project was performed, the name of the student, course number and date.
- *Abstract:* This is a brief summary of the project and the results obtained.
- *Introduction:* What is the biological problem, why is it important, and what's known about it already
- *Experimental Procedures* (Material and Methods).
- *Results:* Describe what you have done. Include bar graphs, sketches, diagrams, tables, photographs etc. -- whatever is needed to represent your data.
- *Discussion:* If your project was successful, describe the significance of the results. If your project did not work, describe what you think went wrong, and what your expectations were. Regardless of outcome, describe what you would try next if you were to continue the project.
- *References:* References to previous work mentioned in your paper, as well as methods used, should be cited as in any other research paper. Each reference must be listed in the order of its appearance in the text and include title, authors, journal name, volume, year and page numbers.
- *Figure Legends:* Captions that describe the contents of each figure.

**Grading:**

The final grade will be based primarily on the recommendations from your research mentor on the level and quality of effort in the laboratory, and the quality of the final research reports.

## MCDB 495 – Senior Requirement MCDB BS INT Major

### Course Overview:

MCDB 495 is an intensive 2 credit independent research course designed to promote hands-on biological and biomedical investigation in the laboratory of a faculty member at Yale. The expectation is that students in MCDB 495 are fully committed to a full year of vigorous independent research and will continue their project in the same laboratory for one additional term in MCDB 496. Students should be prepared to be in the laboratory engaged in benchwork for a minimum of 20 hours per week. To be productive in MCDB 495, most students spend large blocks of time in the lab on weekends and evenings, and it is not uncommon for students who are fully captivated by scientific problems to work >30 hours each week on average. If you have never worked full time (e.g., during a summer internship in a research laboratory, MCDB 495 may not be in your best interest. Accordingly, if you are planning on leaving town for multiple job interviews or graduate school/medical school visits, you will have difficulty meeting the 20 hour/week minimum lab requirement for MCDB 495 and should consider enrolling in MCDB 485 (10-12 hour per week minimum) instead. Only MCDB seniors may take this course, and only to fulfill the Senior Requirement for the MCDB BS Intensive degree.

### Course Requirements:

**Student and Research Mentor Contracts:** Due date: **Monday, September 9, 2019 @ 12:00 noon.**

These should be uploaded to the Canvas Assignment section. Contracts and complete guidelines are available on Canvas and the MCDB Website.

**Research Proposal** Due date: **Monday, September 9, 2019 @ 12:00 noon.**

A 1-2 page double-spaced summary of your research (written in collaboration with your research mentor) is due at the beginning of the term. This should include ~ 1 page overview/background of the project (documented with a short bibliography) and a section describing the general objectives and most importantly, the specific aims of your project. For guidance, ask your mentor to see a Specific Aims section of one of their NIH or NSF grants.

Inappropriate proposals include simply analyzing data gathered by someone else, for example entering previously obtained data into a computer and running a statistical analysis program. An unsuitable proposal at the other extreme would be gathering data for another person to analyze, for example taking medical histories or clinical measurements that will be passed on to someone else for study. Projects involving allelic screening of patient populations for SNPs associated with a given disease are also not acceptable unless there is substantive experimental design/content. ***If you are considering a project that may fall into one of the categories above, please discuss this with the instructor in charge prior to committing to that laboratory or project (there may be suitable alternative projects in the same lab).***

### Time Commitment:

We are particularly concerned that each student fulfills the minimum 20+ hr/week in the lab research commitment; part of the Mentor's Contract is to verify that level of participation by mid-semester. ***If for any reason you are unable to fulfill your commitment to the course and laboratory, your course affiliation and credit will be converted to 485 (or 475 if you decide not to continue in the Spring term).*** If you fail to meet the course commitment for 475 or 485 (10-12 hr/week), you will be asked to withdraw from the course. Note, if you are planning on attending multiple interviews for medical school in the Fall, you are expected to make up for lost time.

**Fall Report – Grant Proposal:** Due date: **Friday, December 6, 2019 @ 4:00 pm.**

A 5-10 page (double spaced) **Grant Proposal** is due **Friday, December 6, 2019.** Make sure you have the following sections, which are patterned after the format of an NIH or NSF Grant:

- *General Objectives (very brief statement)*
- *Specific Aims*
- *Background and Significance*
- *Preliminary Results*
- *Research Plan*
- *Bibliography*
- *Figure legends must have captions that describe the contents of each figure*

**MCDB Oral Presentations - FALL only for MCDB 495 students (December 2-6, 2019 in YSB 352. Check Canvas for dates/times.)** These should be uploaded to the Canvas Assignment section at least 2 days before the scheduled presentation. Don't forget to include your 2-3 questions for the group.

Each student is required to give a formal seminar (PowerPoint slides) on their research progress at the end of the spring term (always held in multiple sessions spread out over the last week of classes). Each student seminar is capped at 15 minutes, with the slide presentation limited to 10-12 minutes, followed by 3-5 minutes for questions from peers and course instructors. Students should also prepare a final slide that includes 2-3 questions for the audience to discuss. All

students are required to attend two full seminar sessions. This includes attending the session in which you are a presenter, and also attending a second full seminar session on a different day in which you are not presenting, but are an active member of the seminar audience. Students are expected to arrive promptly and to remain for the duration of each of their two required seminar sessions. Most sessions consist of 5-8 student seminar speakers. The actual time of each session varies from 1.5 – 2.5 hours depending on the number of speakers and the extent of questions from the audience. You will not be required to attend any sessions in the Fall term. A digital projector will be available; however, you should plan on bringing your own laptop to plug into the system.

**Spring Poster Symposium:** Due Date: **Friday, April 24, 2020 @ 2:00-4:00 pm YSB Lobby**

The Poster Symposium is a **mandatory session** that will be held **Friday, April 24, 2020 from 2-4pm – YSB Lobby**. The purpose of the symposium is to share information and more specifically to highlight undergraduate research at Yale. Refreshments will be provided courtesy of the MCDB Dept. The symposium will be open to anyone wishing to attend, so please encourage friends, colleagues, family and other students to come. Your research mentor is strongly urged to attend.

**Each student must prepare a poster.** Posters can be as large as 3' X 5', but may be smaller. We will have poster boards and easels available to put your poster on. Posters may be printed professionally (**please note that there is no funding available for this expense from MCDB**), or the student may print them on a color printer and assemble individual sheets onto the poster board at the poster session. **DO NOT WAIT** until the 11<sup>th</sup> hour to print your poster as the poster-printing service is always backlogged.

Posters should have a title, and the authors (including you and your research mentor) should be listed as well, usually in large letters at the top. Indicate which research course you are in (MCDB 495). The poster should include three sections: Introduction, Results, and Conclusions. The Introduction explains the purpose of your project; the Results section contains figures and/or tables showing your data, with legends or commentary; the Conclusion summarizes what you learned. Feel free also to include what you would do next were you to continue working on the project.

**Spring Report – Research Journal:** Due date: **Friday, April 24, 2020 @ 4:00 pm.**

A 15-20 page double-spaced paper is due on **Friday, April 24, 2020** uploaded to the Canvas Assignment section, and a copy to your research mentor. Well in advance of this deadline, you should meet with your research mentor to plan a general outline for your paper. You and your mentor should engage in continued discussions throughout the writing process. The research mentor should grade the final version of the report and return it to us with comments electronically, along with a recommendation for an overall course grade. Your research mentor will be contacted directly with a form for grading near the end of the term. Consult your research mentor with any further questions that you might have. You should conform to any other specifics that your research mentor might expect in your write-up.

The report should be written in a style similar to that of a paper in a typical **Research Journal** and should include the following sections:

- *Title Page:* Including title, the name and department of the faculty member in whose laboratory the project was performed, the name of the student, course number and date.
- *Abstract:* This is a brief summary of the project and the results obtained.
- *Introduction:* What is the biological problem, why is it important, and what's known about it already
- *Experimental Procedures* (Material and Methods).
- *Results:* Describe what you have done. Include bar graphs, sketches, diagrams, tables, photographs etc. -- whatever is needed to represent your data.
- *Discussion:* If your project was successful, describe the significance of the results. If your project did not work, describe what you think went wrong, and what your expectations were. Regardless of outcome, describe what you would try next if you were to continue the project.
- *References:* References to previous work mentioned in your paper, as well as methods used, should be cited as in any other research paper. Each reference must be listed in the order of its appearance in the text and include title, authors, journal name, volume, year and page numbers.
- *Figure Legends:* Captions that describe the contents of each figure.

**Grading:**

The final grade will be based primarily on the recommendations from your research mentor on the level and quality of effort in the laboratory, and the quality of the final research reports.

## Guidelines for MCDB 585

Interested students should contact the instructor prior to their second semester junior year.

### For 585 (Juniors-Spring Semester):

- 1) **Research:** Students choose a research mentor. It is expected that the same research mentor will be used for 585 and 595. Assistance in selection of a research mentor can be arranged through the student's regular academic advisor. Students are expected to devote at least 20 hrs/week to their research. It is not uncommon for students who are fully captivated by scientific problems to work >30 hours/week on average.
- 2) **Committee:** Students need to form an advisory committee comprised of three faculty members. One is the research mentor and **at least two faculty members must come from the Department of MCDB**. The members of the committee should be arranged in consultation with the student's research mentor. **The committee should meet once within the first two weeks of the semester to discuss and approve of the research project.** Students should set up individual meetings with each member of the committee and present your work mid-semester. \*A Committee Meeting Form should be completed for all committee meetings and returned to the office of the DUS to [mcdb.undergraduate@yale.edu](mailto:mcdb.undergraduate@yale.edu).
- 3) **Proposal:** Students should prepare a one-page proposal stating the hypothesis and aims of your project and a short paragraph describing the approach. This proposal should be distributed to your committee and uploaded to Canvas **one week before this first committee meeting**.
- 4) **Written Prospectus:** At the end of the course, students will prepare a written prospectus that will review their field, discuss their research accomplished and their research plan for 595. The paper should be approximately 8-10 pages double spaced, not including references uploaded to Canvas by **Friday, April 24, 2020 @ 4:00 pm**.
- 5) **Prospectus Presentation:** Students will present their prospectus to their advisory committee before the end of the Spring semester. Students must notify the office of the DUS of the date of the scheduled presentation. The committee will question the student about their knowledge of both their field and research project. The committee will decide on a grade for the student.
- 6) **Oral Presentations:** 585 Students are also **invited to attend any of the MCDB Oral Presentations sessions** (Check Canvas for dates/times). Spring 585 students are *not* expected to give an oral presentation during these sessions.
- 7) **Poster:** Students are invited to attend the MCDB Poster Session on **Friday, April 24, 2020 @ 2:00-4:00pm in YSB Lobby**, and may (*but are not required to*) present a poster.

## Guidelines for MCDB 595

**Research:** Students are expected to devote 20+ hrs/week to their research.

MCDB Oral Presentations - **FALL only for MCDB 595 students** Oral Presentations will be held on **December 2-6, 2019, at various times in YSB 352. (Check Canvas for dates/times.)** These should be uploaded to the Canvas Assignment section at least 2 days before the scheduled presentation. Don't forget to include your 2-3 questions for the group.

Each student is required to give a formal seminar (PowerPoint slides) on their research progress at the end of the spring term (always held in multiple sessions spread out over the last week of classes). Each student seminar is capped at 15 minutes, with the slide presentation limited to 10-12 minutes, followed by 3-5 minutes for questions from peers and course instructors. Students should also prepare a final slide that includes 2-3 questions for the audience to discuss. All students are required to attend two full seminar sessions. This includes attending the session in which you are a presenter, and also attending a second full seminar session on a different day in which you are not presenting, but are an active member of the seminar audience. Students are expected to arrive promptly and to remain for the duration of each of their two required seminar sessions. Most sessions consist of 5-8 student seminar speakers. The actual time of each session varies from 1.5 – 2.5 hours depending on the number of speakers and the extent of questions from the audience. You will not be required to attend any sessions in the Fall term. A digital projector will be available; however, you should plan on bringing your own laptop to plug into the system.

After each talk, the audience will be allowed to ask questions, and then the speaker will be expected to ask 2 or 3 questions of the audience. A portion of your course grade will be based in part on participation in these sessions. Individual slides should be simple and not overloaded with text. Many skilled presenters find it effective to present only one key idea on each slide, as a general rule, and to provide a title on each slide. Your talk should include an introduction of the overarching biological question that you addressed, an explanation of the approach you took to tackle this question, your results, and the conclusions. Your objective should be to make your presentation clear and interesting to individuals who do not share your research background. It is extremely important to define any technical terms and to avoid acronyms. You should assume that the audience does not know the terminology or background of your field.

Practice your talk. Give a practice talk to the lab you are working in before you give it to the class. As noted in the Research Mentor's contract, their attendance at the session at which you are presenting is expected; if they cannot attend, you should arrange for someone else from your lab to attend. Mentor participation is a critical aspect of the course. Consequently, consult your research mentor at the beginning of the term to select a date that fits with their schedule.

**Poster:** Students should present a poster for the research symposium held on **Friday, April 24, 2020 @ 2-4pm in the YSB Lobby.**

**Each student must prepare a poster.** Posters can be as large as 3' X 5', but may be smaller. We will have poster boards and easels available to put your poster on. Posters may be printed professionally (**please note that there is no funding available for this expense from MCDB**), or the student may print them on a color printer and assemble individual sheets onto the poster board at the poster session. **DO NOT WAIT** until the 11<sup>th</sup> hour to print your poster as the poster-printing service is always backlogged.

Posters should have a title, and the authors (including you and your research mentor) should be listed as well, usually in large letters at the top. Indicate which research course you are in (MCDB 595). The poster should include three sections: Introduction, Results, and Conclusions. The Introduction explains the purpose of your project; the Results section contains figures and/or tables showing your data, with legends or commentary; the Conclusion summarizes what you learned. Feel free also to include what you would do next were you to continue working on the project.

**Committee Meetings:** Students are to schedule committee meetings in each of the two academic terms to discuss their thesis and research. The format of the meeting can be arranged by the research mentor. Students should notify the office of the DUS as to the date of the committee meetings. The student should complete the top portion of the attached Committee Meeting Form (on Canvas) and provide to the Research Mentor for completion. The Research Mentor is expected to provide the completed form to the office of the DUS [mcdb.undergraduateregistrar@yale.edu](mailto:mcdb.undergraduateregistrar@yale.edu).

**Thesis Defense:** The student is expected to give an oral thesis defense to the committee, followed by a comprehensive examination of the thesis conducted by the thesis committee. Students should notify the office of the DUS [mcdb.undergraduater registrar@yale.edu](mailto:mcdb.undergraduater registrar@yale.edu) as to the date of the thesis defense – and provide the form from Canvas to their research mentor before the defense. The Research Mentor is expected to provide the completed form to the office of the DUS [mcdb.undergraduater registrar@yale.edu](mailto:mcdb.undergraduater registrar@yale.edu).

**Written Thesis:** Due Date: **One week prior to committee meeting/Thesis Presentation**

- One chapter should be Introduction/Review of the field. Subsequent chapter(s) will discuss the student's research and a thorough discussion of it.
- The length of the thesis should be 40-100 pages double spaced.
- Each committee member should receive a copy of the thesis at least one week prior to meeting with the committee.
- Additional guidelines for thesis should to be arranged in consultation with the student's research mentor.
- There will be letter grades for each semester. The grade will be determined by the student's faculty committee.



## Cover Legend

Top Left: The *Drosophila* central nervous system and a pheromone-sensitive neural circuit. Nerve fibers were labeled in blue, a subset of pheromone-sensitive taste neurons was labeled in green, while the putative post-synaptic partners (i.e. 2nd order neurons) of these pheromone-sensitive neurons were labeled in red. (Photo credit: Yichen Luo, PI: John Carlson)

Top Right: A 10.5 day old mouse embryo expressing a gene marking cells (dark blue) that give rise to the neocortex, the brain region responsible for the most sophisticated perceptual and cognitive functions. (Photo credit: PI: Weimin Zhong)

Mid Right: 2019 Undergraduate Poster Symposium: Gabriel Betancur – Analysis of the Effects of a GLP-1 Receptor Agonist on Type 1 Diabetes and Autoimmune Inflammation (Photo credit: Joseph Wolenski)

Bottom: Visualization of the structure of how limbs are coordinated during walking in the fruit fly *Drosophila*. Each point represents a single time point, and hotter colors represent faster forward motion. UMAP embedding of limb coordinate time series colored by the mean frequency of forward walking. Frequency (correlated with forward walking velocity) maps to the height along the vase-shaped manifold. (Photo credit: Brian D. DeAngelis, PI: Damon Clark)

# Molecular, Cellular & Developmental Biology

## The Senior Requirement

In addition to the course work described on previous pages, all majors in Yale College must satisfy a senior requirement. In MCDB, this can be accomplished in any of several ways, depending on whether the student is a candidate for a BA, BS, BS INT, or BS/MS degree. *The senior requirement must be done during the senior year.*

### **The BA Degree [0 (senior essay) or 1 (MCDB 475) credit]**

The requirement can be met in either of two ways: by submitting a senior essay of 15-20 pages evaluating current research in a field of biology; or by successful completion of one credit of Senior Independent Research (MCDB 475a or b).

A senior choosing to fulfill the requirement with a senior essay must consult with a faculty advisor on the scope and literature of the topic and submit their written approval to the office of the director of undergraduate studies at least one month before the paper is due in the student's last term. The senior essay may be related to the subject matter of a course, but the essay is a separate departmental requirement in addition to any work done in a course. It does not count toward the grade in any course. The senior essay must be completed and submitted via email to [crystal.adamchek@yale.edu](mailto:crystal.adamchek@yale.edu) at the office of the director of undergraduate studies by the last day of classes. Students electing this option should obtain an approval form from the office of the director of undergraduate studies.

### **The BS Degree [2 (MCDB 485 & 486) or 2 (MCDB 475 & 475) credits]**

The BS differs from the BA in its greater emphasis on individual research. The senior requirement for the standard BS is two contiguous terms of Senior Research: MCDB 485a/486b. However, students may take 2 contiguous terms of MCDB 475, at least one of which must be taken during the senior year. Ordinarily both terms of Research will be taken during the senior year, but it is possible for a student to begin work toward the senior requirement in the spring of the junior year by taking MCDB 475b, continue the research over the summer, and complete it during the fall of the senior year by taking MCDB 475a – which must be pre-approved by the DUS. Yale College does not grant academic credit for summer research unless the student is enrolled in an independent research course in Yale Summer Session.

### **The BS INT Degree [4 (MCDB 495 & 496) credits]**

For the MCDB BS Intensive major, students fulfill the senior requirement by taking MCDB 495a/496b, Senior Research Intensive, for four credits during their senior year.

## The Combined BS/MS Degree Program

Because of the additional and substantial requirements associated with thesis work in the third and fourth years, there is no Senior Requirement *per se*.

=====

## The Senior Requirement – Some Special Options During Covid-19 Pandemic

We hope that seniors will be able to complete their senior research as originally outlined above. For instance, it may be possible to work in lab during the fall of 2020, or some research projects involving data analysis or computation may be pursued remotely. However, should it not be possible to complete the research requirements, we are making the following substitutions possible to count towards senior requirements.

In addition, if it becomes necessary to move away from in-person research during fall 2020 or spring 2021 semesters, those enrolled in senior research courses will be transitioned to MCDB 470/471-style tutorials or other arrangements made with their lab with permission of the DUS, while remaining enrolled in the original course number.

### **The BA Degree [0 (senior essay) or 1 (MCDB 475) credit or 1 (MCDB 350+) credit or 1 (MCDB 470) credit or 1 (MCDB 471) credit]**

- A) A course MCDB 350 or higher may be substituted for MCDB 475. This is in addition to the regular requirement for an MCDB 350+.
- B) MCDB 470 or MCDB 471 may be substituted for MCDB 475.
- C) The senior essay option remains an option instead of either of these.

### **The BS Degree [2 (MCDB 485 & 486) or 2 (MCDB 475 & 475) ) or 2 (MCDB 350+/MCDB 470) credits]**

- A) During the pandemic, the two independent research courses MCDB 485/486 or MCDB 475 can be replaced by MCDB courses numbered at or above 350. These are in addition to the regular major requirement of one MCDB 350+ course.
- B) The research courses may also be replaced by the new MCDB 470 or MCDB 471 courses. These can replace one or both terms.

**The BS INT Degree [4 (MCDB 495 & 496) credits or 4 credits from MCDB350+/470/471]**

Given the research-intensive nature of this degree, the best option is to fulfill the Senior Requirement with 4 credits of independent research. We will, however, allow the substitution of any combination of 4 MCDB courses numbered at or above 350 or the new MCDB 470 or 471 courses. *Any of the options other than the 4 credits of independent research will require the permission of the DUS.*

The MCDB 350+ courses in this option are in addition to the regular major requirement of one MCDB 350+ course.

=====

**MCDB 470 – Tutorial in MCDB**

Offered fall 2020 and likely spring 2021. Individual or small-group study for qualified students who wish to investigate an area of experimental biology not presently covered by regular courses. A student must secure the sponsorship of a Yale faculty member, who sets the specific requirements. The course will include one or more written works and is expected to meet at least once per week. *It will require the submission of a brief course description, a syllabus and a reading list to and permission from the DUS at the beginning of the term.*

This course may be taken only by seniors and can be used only to satisfy the Senior Requirement in MCDB.

-----

**MCDB 471 – Senior Seminar in Biology**

Offered fall 2020 and spring 2021. Small Group study where students meet weekly with instructor to discuss a range of specific topics in the biological sciences and to develop effective writing and speaking skills required for preparation of scientific manuscripts, presentations and general communication in the scientific world. Students will be required to prepare and present oral presentations and to submit a literature review and written grant proposal by the end of the semester.

This course may be taken only by seniors and can be used only to satisfy the Senior Requirement in MCDB.