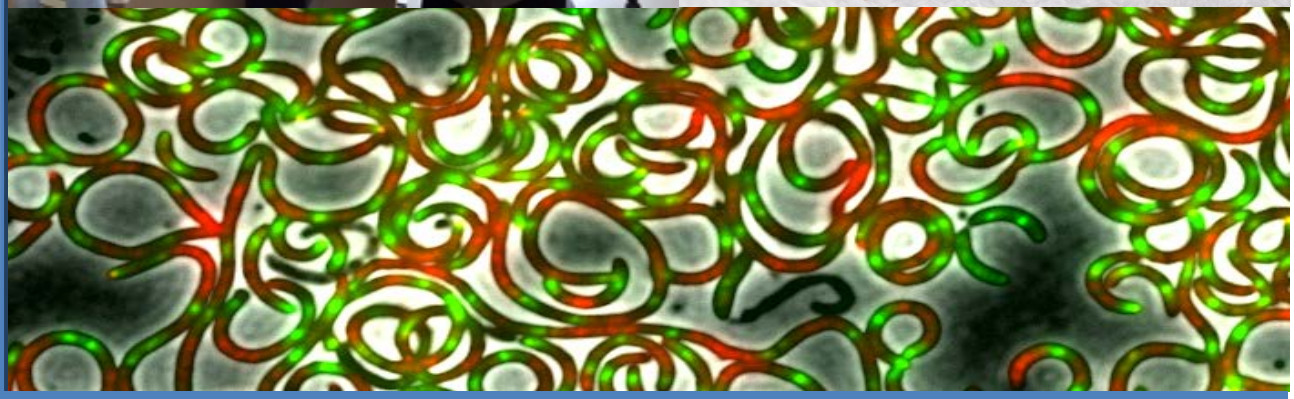
Molecular, Cellular, Developmental Biology



2017-2018

This booklet is intended to supplement the Yale College Programs of Study for the Academic Year 2017-2018. The latter contains brief descriptions of all Undergraduate MCDB Courses.

The MCDB major is offered by the department of Molecular, Cellular, Developmental Biology.

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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 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 in any Yale department.

The teaching and research facilities in biology are distributed in three buildings, Osborn Memorial Laboratories, Kline Biology Tower, and the Environmental Science Facility. There are about 50 faculty members, 60 postdoctoral fellows, and 45 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 industry, 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://yalecollege.yale.edu/content/yale-college-programs-study.

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
MCDB 050a	Immunology and Microbes
MCDB 103a	Cancer
MCDB 105a or b	An Issues Approach to Biology
MCDB 106b	Biology of Malaria, Lyme & Other Vector-Borne Diseases
MCDB 109b	Immunity and Contagion

MCDB 040b, **Science and Politics of Cancer**. Robert Bazell
TTh 1.00-2.15
Fundamentals of cell biology, Darwinian evolution, immunology, and genetics that underlie cancer; the history of cancer science and treatment; historical and current policy issues. *Prerequisite: Completion of the Advanced Placement test in Biology or equivalent. Enrollment limited to freshmen; preregistration required.*

MCDB 050a, **Immunology and Microbes**. Paula Kavathas
TTh 2.30-3.45
Introduction to the immune system and its interaction with specific microbes. Attention both to microbes that cause illness, such as influenza, HIV, and HPV, and to microbes that live in harmony with humans, collectively called the microbiome. Readings include novels and historical works on diseases such as polio and AIDS. Enrollment limited to freshmen. Preregistration required; see under Freshman Seminar Program.

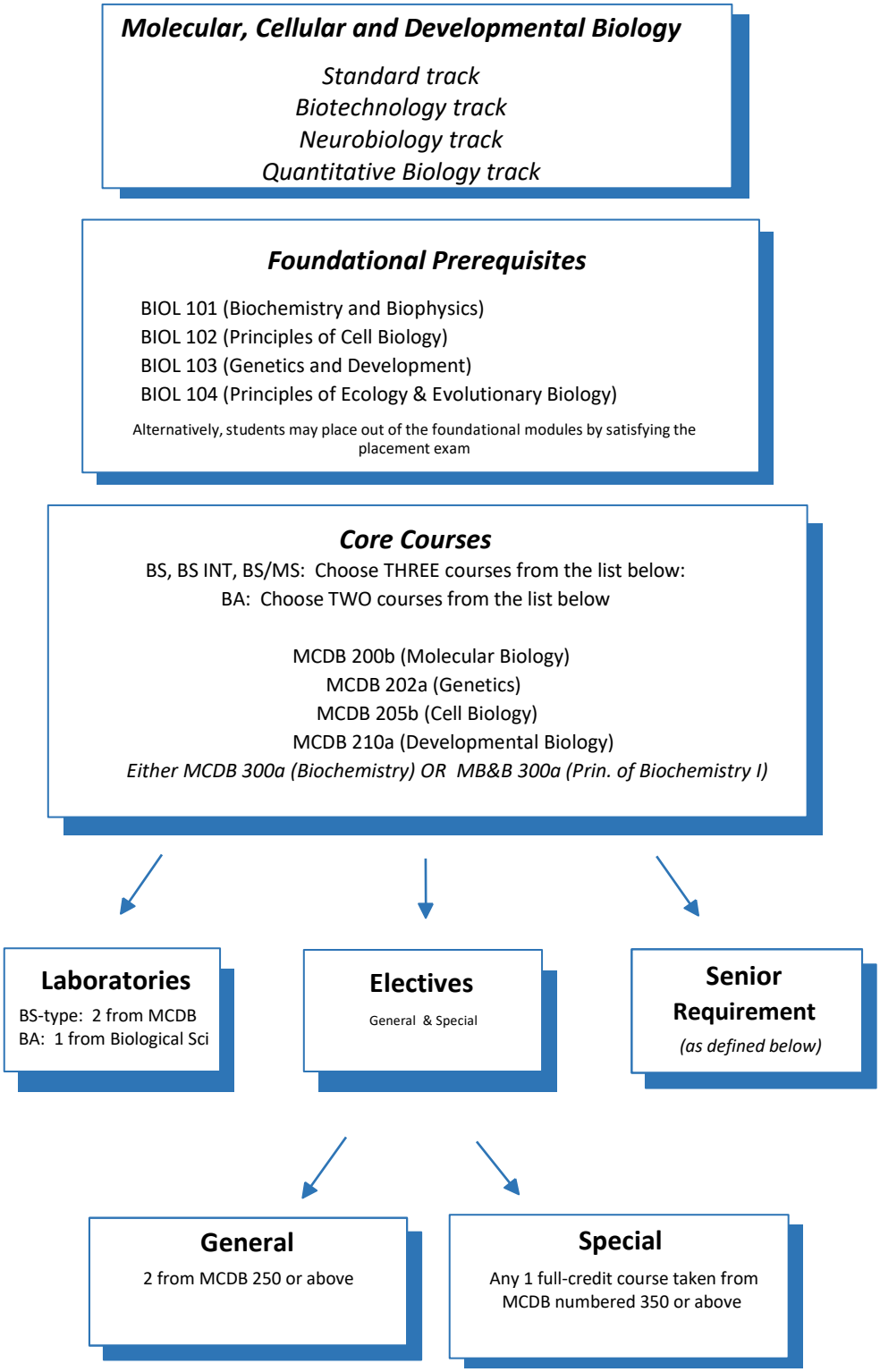
MCDB 103b, **Cancer**. Alexia Belperron
MW 1.00-2.15
Introduction to the biology of cancer, with a focus on leukemia, skin cancer, and cancers linked to infection. Topics include genetics, biochemistry, immunity, infection agents, and challenges for prevention and treatment. High school biology required. Preference given to freshmen and sophomores.

MCDB 105a or b, **An Issues Approach to Biology**. Fall: John Carlson, Joshua Gendron, Mark Hochstrasser; Spring: Dieter Soll, Patrick Sung, Robert Bazell
MW 11.35-12.25
Biological concepts taught in context of current societal issues, such as emerging diseases, genetically modified organisms, green energy, stem cell research, and human reproductive technology. Emphasis on biological literacy to enable students to evaluate scientific arguments.

MCDB 106a, **Biology of Malaria, Lyme, and Other Vector-Borne Diseases.** Alexia Belperron
MW 1.00-2.15
Introduction to the biology of pathogen transmission from one organism to another by insects; special focus on malaria and Lyme disease. Biology of the pathogens including modes of transmission, establishment of infection and immune responses; the challenges associated with vector control, prevention, development of vaccines, and treatments. Preference given to freshmen and sophomores*. Prerequisite: High school biology.*

MCDB 109b, **Immunity and Contagion**. Paula Kavathas
TTh 2.30-3.45
Introduction to the basics of the immune system; strategies to fight pathogens while maintaining harmony with our microbiome. Discussion of specific microbes such as influenza, HIV, and HPV; historical analysis of the polio vaccine and the AIDS epidemic.

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.



Pre-Requisites for: BA

Biology			
Foundation Modules	2 terms 1/2 credit per module	BIOL 101a or b	Biochemistry and Biophysics
		BIOL 102a or b	Principles of Cell Biology
		BIOL 103a or b	Genetics and Development
		BIOL 104a or b	Principles of Ecology & Evolutionary Biology
Chemistry			
General	2 terms	CHEM 161/165; or 163/167; or its equivalent*	
Physics	1 terms	PHYS 170 or higher*	
Math			
Calculus	1 term	MATH 115 or higher	
		**(For students satisfying one or more prerequisites with AP scores, requirement is still to take any 3 terms of CHEM and PHYS courses at Yale with at least 1 from each department)*	

Pre-Requisites for: BS, BS INT & BS/MS

Biology			
Foundation Modules	2 terms 1/2 credit per module	BIOL 101a or b	Biochemistry and Biophysics
		BIOL 102a or b	Principles of Cell Biology
		BIOL 103a or b	Genetics and Development
		BIOL 104a or b	Principles of Ecology & Evolutionary Biology
Chemistry			
General	2 terms	CHEM 161/165; or 163/167; or its equivalent	
General Labs	2 terms	CHEM134L/136L	
Organic	1 term	CHEM 174 or CHEM 175 or CHEM 220	
Organic Labs	1 term	CHEM 222L; or CHEM 223L; or CHEM 226L	
Physics	2 terms	PHYS 170/171 or higher	
Math			
Calculus	1 term	MATH 115 or higher	

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. STAT 105a or 100b 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 www.yale.edu/yalecollege/publications/ycps/.

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/freshman-handbook/academic-information/special-programs-placement-preregistration/biology/

Requirements by Major

Below are the requirements formally approved by the Yale College Faculty for the Classes of 2018 and beyond. Students in the Class of 2017 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 2018 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, 506 KBT (432-9389)
Craig Crews, 452 KBT (432-9364)
Farren Isaacs, 802 KBT (432-3783)
Kenneth Nelson, 710A KBT (432-5013)
Joseph Wolenski, 330 KBT (432-6912)

Neurobiology track advisors:
Paul Forscher, 222 KBT (432-6344)
Haig Keshishian, 640A KBT (432-3478)
Robert Wyman, 610A KBT (432-3475)
Weimin Zhong, 616B KBT (432-9233)

Quantitative Biology track advisors:
Murat Acar, WB31 201A (737-3255)
Damon Clark, 232 KBT (432-0750)
Thierry Emonet, 1048 KBT (432-3516)
Douglas Kankel, 1118A KBT (432-3532)

MCDB – BA

The BA Degree – 11.5 or 12.5 Total Credits (total credits depends on senior requirement choice)

Pre-Requisites **6.0 Credits.**	BIOL 101a or b Biochemistry & Biophysics BIOL 102a or b Principles of Cell Biology BIOL 103a or b Genetics and Development BIOL 104a or b Principles of Ecology & Evolutionary Biology [these 4 modules are ½ semester in length and equal .5 credits each] [Students with an AP Biology score of 5 will be eligible to take the Yale Administered placement exam for these foundational modules – and subsequently place out of one or more.] 2 terms of General Chemistry (161/165; or 163/167; or its equivalent)* 1 term of Physics (170 or higher)* 1 term of Math (115 or higher; or STAT course at Yale) *For students satisfying one or more prerequisites with AP scores, requirement is still to take any 3 terms of CHEM and PHYS courses at Yale with at least 1 from each department.
Core Courses **2.0 Credits.**	*Core Courses – choose any 2* MCDB 200b – Molecular Biology MCDB 202a – Genetics MCDB 205b – Cell Biology MCDB 210a – Developmental Biology MCDB 300a – Biochemistry; ***OR*** MB&B 300a – Principles of Biochemistry I
General Electives **2.0 Credits.**	Two general electives from MCDB numbered 250 or above. Two laboratory courses from either MCDB 342La and 343La; or 344Lb and 345Lb can be used together as one elective credit. If used as an elective, these laboratories cannot also fulfill the laboratory requirement. *(May choose 2 from either the Core list above, or MCDB 250 or above courses)*
Special Electives **1.0 Credits.**	One special elective from MCDB numbered 350 or higher
Laboratories **.5 Credits.**	One laboratory from the Biological Sciences. *(This may include labs from MCDB, EEB, or MB&B)*
Senior Requirement **0 – 1.0 Credits.**	Choose One of the following which must be taken in Senior Year o MCDB 475 a or b (1 term of Independent Research); o Senior Essay (no credit)

MCDB – BS and BS INT

The Standard BS Degree – 18.5 Total Credits
The Standard BS INT Degree – 20.5 Total Credits

Pre-Requisites **9.5 Credits.**	BIOL 101a or b Biochemistry & Biophysics BIOL 102a or b Principles of Cell Biology BIOL 103a or b Genetics and Development BIOL 104a or b Principles of Ecology & Evolutionary Biology [these 4 modules are ½ semester in length and equal .5 credits each] [Students with an AP Biology score of 5 will be eligible to take the Yale Administered placement exam for these foundational modules – and subsequently place out of one or more.] 2 terms of General Chemistry (161/165; or 163/167; or its equivalent) 2 terms of General Chemistry Labs (134L/136L) 1 term of Organic Chemistry -(174, 175, or 220) 1 term of Organic Chemistry Lab (222L, 223L, or 226L) 2 terms of Physics (170, 171 or higher) 1 term of Math 115 or higher *(or STAT course)*
Core Courses **3.0 Credits.**	*Core Courses – choose any 3* MCDB 200b – Molecular Biology MCDB 202a – Genetics MCDB 205b – Cell Biology MCDB 210a – Developmental Biology MCDB 300a – Biochemistry; ***OR*** MB&B 300a – Principles of Biochemistry I
General Electives **2.0 Credits.**	Two general electives from MCDB numbered 250 or above. Two laboratory courses from either MCDB 342La and 343La; or 344Lb and 345Lb can be used together as one elective credit. If used as an elective, these laboratories cannot also fulfill the laboratory requirement. *(May choose an additional 2 from either the Core list above, or MCDB 250 or above courses. Second term of Organic Chem and Statistics course acceptable.)*
Special Electives **1.0 Credits.**	One special elective from MCDB numbered 350 or higher
Laboratories **1.0 Credits (or more).**	Two laboratory courses required from MCDB
Senior Requirement **2.0 Credits – BS.** **4.0 Credits – BS INT.**	Choose One of the following which must be taken in Senior Year *BS*: MCDB 485/486 (2 terms of Independent Research); MCDB 475 (two contiguous terms of MCDB 475, at least one of which must be taken during the senior year) *BS INT:* MCDB 495/496 (2 terms of *Intensive* Independent Research)

Interdisciplinary Tracks

As alternatives to the standard MCDB track, students can choose either the biotechnology, neurobiology or the quantitative biology tracks. The requirements for each of these interdisciplinary tracks differ somewhat from those of the standard major.

	Biotechnology	***Neurobiology***	***Quantitative Biology***
Prerequisites *BA: 6.0 Credits* *BS: 9.5 Credits*	Same as BA or BS	Same as BA or BS	Same as BA or BS
Core Courses *BA: 3.0 Credits* *BS: 4.0 Credits*	Same as BA or BS *PLUS*:* MCDB 370 *While these are required for the track, they will be counted as an elective for the major	Same as BA or BS *PLUS*:* MCDB 320 *While these are required for the track, they will be counted as an elective for the major	Same as BA or BS *PLUS*:* MCDB 330 *While these are required for the track, they will be counted as an elective for the major
General Electives *1.0 Credits*	Same as BA or BS ***ADDITIONAL CHOICES:*** BENG 351 BENG 352 BENG 410 BENG 435 CENG 210 CENG 411 CPSC 437 CPSC 445 CPSC 470 CPSC 475 MB&B 420 MB&B 443	Same as BA or BS ***ADDITIONAL CHOICES:*** BENG 410 CPSC 475 MCDB 240 MCDB 310 MCDB 315 MCDB 361 MCDB 415 MCDB 425 MCDB 430 MCDB 440 PSYC 200 PSYC 270 PSYC 320 PSYC 376 *(Note: PSYC 110 is a prerequisite for many PSYCH courses, but does NOT substitute as an elective for any track)*	Same as BA or BS ***ADDITIONAL CHOICES:*** CENG 320 CPSC 475 CPSC 440 BENG 467/ENAS 567 MATH 246 MATH 251 MB&B 452 MB&B 320 MB&B 435 MB&B 523 MCDB 361 MCDB 461 PHYS 402
Special Electives *1.0 Credits*	Same as BA or BS	Same as BA or BS	Same as BA or BS
Laboratories *BA: 0.5 Credits* *BS: 1.0 Credits (or more)* *(2 laboratory courses required for the BS)*	Same as BA or BS At least 1 Lab must be from MCDB 341L-345L. *(BENG 335L or CENG 412L can substitute for 2 ½ credit labs with permission)*	Same as BA or BS	Same as BA or BS
Senior Requirements *BA: 0-1.0 Credits* *BS: 2.0 Credits* *BS INT: 4.0 Credits*	Same as BA or BS	Same as BA or BS	Same as BA or BS

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

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 to 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. 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. 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 page 18 below for 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 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 members and the director of undergraduate studies. Opportunities can be found on the following web sites: http://mcdb.yale.edu/research, http://yura.undergradresearch.org/database, and http://world.yale.edu/faculty-research-profile-database as well as listed on the bulletin board outside of the Office of the Director of Graduate Studies (KBT 1220). Detailed descriptions of previous research programs in MCDB can also be found on page 35 of this booklet.

Research Courses

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.

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.

Upperclassmen: Several options exist for students to fulfill the Senior Requirement for MCDB. They are as follows:

MCDB BA

MCDB 475a or b:	Senior Independent Research (one term)
OR	
Senior Essay:	15-20 page Senior Essay evaluating current research in the field of Biology for students seeking the BA degree.

MCDB BS

MCDB 485/486:	Senior Research MCDB BS Major (two terms)

MCDB BS INT

MCDB 495/496:	Senior Research Intensive (two terms)

MCDB BS/MS

MCDB 585/595:	Intensive Research in MCDB for BS/MS Candidates

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.

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.

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 MCDB: 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 http://www.yale.edu/yser/fellowships.html. 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.

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.

First, each entering student is assigned a freshman counselor, 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 science. The second advisor is also a member of the student's residential college, 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. The dean has ultimate authority over the student's decisions for courses and programs of study. If the freshman advisor is not a member of a science department in Yale College, 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.
An important issue for prospective MCDB majors is to consider taking chemistry during the first year. This is because a number of 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.

...and Beyond

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 the major. Students in the standard MCDB major may contact the MCDB Registrar, Crystal Adamchek 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 faculty fellows and their affiliated colleges is presented on page 41 of this booklet. Students in the neurobiology, biotechnology or quantitative biology tracks should consult the advisors specified above with the tracks. The sophomore year advisor usually remains a student's advisor for the following two years as well, but it is possible to switch 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 area, he/she 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 faculty advisor. However a 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.

Advisors

All 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 issue. The list of all MCDB faculty (both primary and secondary) is listed on page 41 of this booklet.

Statutorily the DUS is the formal faculty advisor for all double major and BS/MS students.

NOTE: The MCDB Faculty Advisors are clearly identified under the Research and Faculty Interests listed in this booklet (p. 41).

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. Catalogues for every American and most Canadian medical schools are available on the WEB.

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. Individual medical school course requirements for American and Canadian applicants can be found online at https://students-residents.aamc.org/choosing-medical-career/article/required-premedical-coursework-and-competencies/

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 :http://www.yale.edu/yalecollege/international/

Application to both the programs and to the Studies Abroad Committee should be done early in the semester preceding the semester spent abroad. Summer programs also exist that may be used to fulfill some degree requirements and, in some cases, credit can be transferred. How the credit earned in programs abroad can be applied to fulfilling the MCDB major requirements depends on the program chosen and should be discussed with the DUS early in planning.

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 adviser 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 595ab, 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 his or her 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 located in two buildings on science hill (Kline Biology Tower (KBT) 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.

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 is located in the concourse level of the Kline Biology Tower and has replaced the Kline Science Library while retaining the library's former collection in the biological sciences and adds to that additional and substantial functionality in computing with their state-of-the-art StatLab. Please visit their web site for additional information. http://csssi.yale.edu/

Computer Facilities: Yale Information and Technology Services (ITS) provides both mainframe and microcomputer resources to the student community. A variety of computer languages and programs are supported. Biomedical Computer Facilities, located at the Medical School, and accessed through remote or local terminals, are available for DNA and protein sequence analysis. The residential colleges are fully networked for access to Yale computing facilities and the Internet.

Peabody Museum of Natural History: 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. Of particular interest to those studying the history and diversity of life are its world-famous holdings of fossil vertebrates, including dinosaurs (150,000 units), fossil invertebrates (300,000 units), and fossil plants (350,000 units), as well as its collections of modern birds (130,000 units), insects (1,250,000 units), other animals (300,000 units), and plants (250,000 units). Research and work-study opportunities with any of the scientific staff members of the Museum are accessible to students. The Peabody Museum has opened a satellite gallery, the Peabody2, located a 1 Broadway in New Haven.

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.

Imaging Facilities: The MCDB Department operates a state-of-the-art light microscope imaging facility directed by Dr. Joseph Wolenski. 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 avelengths. 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): We are a non-profit academic Core Facility for DNA Sequencing and Fragment Analysis. This service facility is located on the first floor of the ESC within the YIBS-MSCG Center. Its services are utilized by over 600 users from Yale as well as other academic institutions and private companies from across the United States and around the world. Yale users have priority over external customers and reduced rates. Training and job opportunities for Yale students are available during both academic and summer months. Please visit their web site for additional information 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. The major animal care facility for small mammals for the Arts and Sciences campus is also located on Science Hill.

Herbarium: The Yale Herbarium consists of 350,000 systematically arranged plant specimens from the algae to vascular plants. The collection includes significant type specimens in the mosses and ferns with a representation of most families and important genera of the flowering plants.

Peabody Museum Field Station: The Marine Biology facility on Long Island Sound is comprised of an on-shore laboratory, a 41-acre salt marsh, and a 17 acre island. Facilities include salt water holding tanks, a shop, and a small boat fleet. It is approximately 30 minutes from the Yale campus.

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. Michael Donoghue (Sterling Professor of Ecology and Evolutionary Biology) is the Director of the Marsh Botanical Gardens. Eric Larson is the garden manager who leads a staff that includes, Chris Bolick, Plant Research Facilities Manager, David Garinger, Curator of Greenhouse Plant collections, Bobby Rak, Research Aide and Christine Weiss, Horticulturist.

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, and the West Campus Analytical Chemistry Core. Please visit their web site for more information: http://westcampus.yale.edu/research/scientific-core-facilities

Courses in MCDB

The letter "a" following a course number indicates a fall term course; "b" indicates a spring term course; "G" indicates courses offered to undergraduate and graduate students; courses without an "a" or "b" are year-long; "*" indicates bracketed courses are not offered in the academic year. Note: The most current information on courses can always be found on OCI.

REQUIRED: BIOL FOUNDATION COURSES

BIOL 101a or b. **Biochemistry and Biophysics.**
Fall: Michael Koelle (Samantha Lin)
Spring: Anthony Koleske (Carter Takacs)
MW 11.35-12.50, 1 HTBA
Foundational study of life at the molecular level. Topics include the three-dimensional structures and function of large biological molecules, the human genome, and the design of antiviral drugs to treat HIV/AIDS. *Prerequisite: The first of four modules in a year-long foundational biology sequence; meets for the first half of the term.*

BIOL 102a or b. **Principles of Cell Biology.**
Fall: Mark Mooseker (Samantha Lin)
Spring: Valerie Horsley (Carter Takacs)
MW 11.35-12.50, 1 HTBA
Foundational study of cell biology and membrane physiology. Topics include organization and functional properties of biological membranes, membrane physiology and signaling, rough endoplasmic reticulum and synthesis of membrane/secretory membrane proteins, endocytosis, the cytoskeleton, and cell division. *Prerequisite: The second of four modules in a year-long foundational biology sequence; meets for the second half of the term.*

BIOL 103a or b. **Genetics and Development.**
Fall: Vivian Irish (Carter Takacs)
Spring: Weimin Zhong (Samantha Lin)
MW 11.35-12.50, 1 HTBA
Genes, genetics, and developmental biology. How genes control development and disease; Mendel's rules; examples of organ physiology. *Prerequisite: The third of four modules in a year-long foundational biology sequence; meets for the first half of the term.*

BIOL 104a or b. **Principles of Ecology and Evolutionary Biology.**
Fall: Thomas Near (Carter Takacs)
Spring: Michael Donoghue (Samantha Lin)
MW 11.35-12.50, 1 HTBA
Ecology, evolutionary biology, animal behavior, and the history of life. Evolutionary transitions and natural selection. Adaptation at genic, chromosomal, cellular, organismal, and supra- organismal levels. Distributional and social consequences of particular suites of organismal adaptations. *Prerequisite: The fourth of four modules in a year-long foundational biology sequence; meets for the second half of the term.*

INTRODUCTORY COURSES WITHOUT PREREQUISITES

MCDB 040b. **Science and Politics of Cancer.**
Robert Bazell
TTh 1.00-2.15
Fundamentals of cell biology, Darwinian evolution, immunology, and genetics that underlie cancer; the history of cancer science and treatment; historical and current policy issues. *Enrollment limited to freshmen. Preregistration required; see under Freshman Seminar Program.*

MCDB 050a. **Immunology and Microbes.**
Paula Kavathas
TTh 2.30-3.45
Introduction to the immune system and its interaction with specific microbes. Attention both to microbes that cause illness, such as influenza, HIV, and HPV, and to microbes that live in harmony with humans, collectively called the microbiome. Readings include novels and historical works on diseases such as polio and AIDS. *Enrollment limited to freshmen. Preregistration required; see under Freshman Seminar Program.*

MCDB 103b. **Cancer.**
Alexia Belperron
MW 1.00-2.15
Introduction to the biology of cancer, with a focus on leukemia, skin cancer, and cancers linked to infection. Topics include genetics, biochemistry, immunity, infection agents, and challenges for prevention and treatment. *Intended for non–science majors and underclassmen. High school biology required. Preference given to freshmen and sophomores.*

MCDB 105a or b/MB&B 105a or b. **An Issues Approach to Biology.**
Fall: John Carlson, Joshua Gendron, Mark Hochstrasser
Spring: Dieter Soll
MW 11.35-12.25 1 HTBA
Biological concepts taught in context of current societal issues, such as emerging diseases, genetically modified organisms, green energy, stem cell research, and human reproductive technology. Emphasis on biological literacy to enable students to evaluate scientific arguments.

MCDB 106a/HLTH 155a. **Biology of Malaria, Lyme, and Other Vector-Borne Diseases.**
Alexia Belperron
MW 1.00-2.15
Introduction to the biology of pathogen transmission from one organism to another by insects; special focus on malaria, dengue, and Lyme disease. Biology of the pathogens including modes of transmission, establishment of infection, and immune responses; the challenges associated with vector control, prevention, development of vaccines, and treatments*. Intended for non–science majors; preference to freshmen and sophomores. Prerequisite: high school biology.*

MCDB 109b. **Immunity and Contagion.**
Paula Kavathas
TTh 2.30-3.20 Meets RP
Introduction to the basics of the immune system; strategies to fight pathogens while maintaining harmony with our microbiome. Discussion of specific microbes such as influenza, HIV, and HPV; historical analysis of the polio vaccine and the AIDS epidemic. *Enrollment limited to freshmen and sophomores.*

MCDB CORE COURSES

[Choose any 2 for the BA degree. Choose any 3 for the BS and BS INT degrees.]

MCDB 200b. **Molecular Biology.**
Anna Pyle, Farren Isaacs
MW 9.00-10.15
A study of the fundamental principles of molecular biology, including the experimental methodologies used in biological research. Topics include the structure, function, and chemical behavior of biological macromolecules (DNA, RNA, and protein), chromosome and genome organization, replication and maintenance of the genome, transcriptional and translational regulation, microRNAs and other noncoding RNAs, RNA processing, systems biology, and synthetic biology. Designed to provide an accelerated venue for MCDB majors and other students seeking to understand the molecular basis for gene expression and the resultant implications for medicine and biological engineering. *Prerequisite: CHEM 161, 165, or 167 and BIOL 101, or with permission of instructor.*

MCDB 202a. **Genetics.**
Stephen Dellaporta, Joshua Gendron
TTh 11.35-12.50
An introduction to classical, molecular, and population genetics of both prokaryotes and eukaryotes and their central importance in biological sciences. Emphasis on analytical approaches and techniques of genetics used to investigate mechanisms of heredity and variation. Topics include transmission genetics, cytogenetics, DNA structure and function, recombination, gene mutation, selection, and recombinant DNA technology. *Prerequisite: BIOL 103 or equivalent performance on the corresponding biological sciences placement examination.*

MCDB 205b. **Cell Biology.**
Thomas Pollard, David Breslow, Megan King
TTh 9.00-10.15
A comprehensive introductory course in cell biology. Emphasis on the general principles that explain the molecular mechanisms of cellular function. *Prerequisite: BIOL 101 and 102, or equivalent performance on the corresponding biological sciences placement examinations, or a score of 5 on the Advanced Placement test in Biology, or a score of 710 or above on the SAT Biology M test, or MCDB 200.*

MCDB 210a. **Developmental Biology.**
Scott Holley, Douglas Kankel, Josien van Wolfswinkel
TTh 1.00-2.15
This course provides a survey of the molecular and genetic control of embryonic development, cell-cell communication and cell differentiation. Emphasis is on mechanistic investigation in model organisms that reveal fundamental concepts explaining human birth defects and disease. Topics include: gastrulation; neural and mesoderm induction; limb development; heart and vascular development; craniofacial development; adult and embryonic stem cells; regeneration; evolution and development. *Prerequisites: BIOL 101, 102, and 103, or equivalent performance on the corresponding biological sciences placement examinations.*

CHOOSE EITHER MCDB 300 <u>OR</u> MBB 300

MCDB 300aG/MB&B 200a. **Biochemistry.**
Ronald Breaker, Nicole Clay, Donald Engelman
MWF 10:30-11:20
An introduction to the biochemistry of animals, plants, and microorganisms, emphasizing the relations of chemical principles and structure to the evolution and regulation of living systems. *Prerequisites: BIOL 101, or equivalent performance on the corresponding biological sciences placement examinations; one term of organic chemistry; or with permission of instructor.*

MBB 300aG. **Principles of Biochemistry I.**

Michael Koelle, Matthew Simon, Andrew Miranker

TTh 11.35-12.50

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

MCDB LABORATORIES

[Choose any 1 for BA degree (may also choose labs from EEB or MB&B for the BA degree). Choose any 2 MCDB labs for BS and BS INT degrees.]

MCDB 201Lb. **Molecular Biology Laboratory.**

Maria Moreno

M or W 1.30-5.30 Meets RP WR

An introduction to Synthetic Biology. Basic molecular biology training in a project-based laboratory setting. Experiments analyze gene function through techniques of PCR, genomic and cDNA cloning, DNA sequence analysis, and protein expression and purification. Instruction in experimental design, data analysis, and interpretation. *Prerequisite: With permission from instructor or concurrently with or after MCDB 200. Juniors and seniors interested in exposure to molecular biology techniques are welcome. Special registration procedures apply. Interested students must contact the instructor and attend an organizational meeting during the first week of classes.*

MCDB 203La. **Laboratory for Genetics.**

Iain Dawson

MT or W 1.45-5.00

Introduction to laboratory techniques used in genetic analysis. Genetic model organisms - bacteria, yeast, *Drosophila*, and *Arabidopsis* - are used to provide practical experience with various classical and molecular genetic techniques including cytogenetics, complementation, epistasis and genetic suppressors, mutagenesis and mutant analysis, recombination and gene mapping, isolation and manipulation of DNA, and transformation of model organisms. *Prerequisite: Concurrently with or after MCDB 202.*

MCDB 221La. **Model Organisms in Biological Research.**

Maria Moreno

TWTh or F 1:30-5:30

An introduction to research and common methodologies in the biological sciences with an emphasis on the utility of model organisms. Techniques and methods commonly used in biochemistry, cell biology, genetics and molecular and developmental biology; experimental design; data analysis and display; scientific writing. *Prerequisite: With permission of instructor, or concurrently with or after BIOL 101, 102, or 103.*

MCDB 251Lb. **Laboratory for Biology of Reproduction and Development.**

Seth Guller

TW or Th 1.30-5.00

This laboratory course will focus largely on aspects of human reproductive biology, thereby establishing a strong connection with normal reproductive function. Mouse tissue models will also be employed. Clinically relevant topics to be covered include the use of human tissue and cell models to study ovarian, uterine, and placental structure and function. The role of tissue specific cellular differentiation, human trophoblast function, and the roles of steroid hormones, in the regulation of uterine, placental, and ovarian function will be tested. *Enrollment limited. Concurrently with or after MCDB 210 or 250. Not open to freshmen. Special registration procedures apply. Students must consult the instructor prior to the first week of classes.*

MCDB 291Lb. **Laboratory for Microbiology.**

Iain Dawson

TW or Th 2.30-5.20

Practical approaches used when working with microbes, primarily bacteria. Topics include microscopy, culture techniques, biochemical/metabolic assays, and basic environmental and medical microbiology. *Concurrently with or after MCDB 290b. Electronic permission key required; students should contact the instructor.*

MCDB 301La/MB&B 251La. **Laboratory for Biochemistry.**

Aruna Pawashe

T or Th 1.30-5.30

An introduction to current experimental methods in molecular biology. *After or concurrently with MB&B 300 or MCDB 300. Limited enrollment. Preregistration required; e-mail instructor prior to the first week of classes.*

MCDB 303Lb. **Advanced Molecular Biology Laboratory.**

Maria Moreno, Kenneth Nelson

Tu 2.30-4.30 Meets RP

A laboratory course that provides advanced biology research skills. Weekly workshops focus on laboratory practice, experimental design, data analysis, reading of primary literature, scientific presentations, and scientific writing skills. Application of these skills in project-based laboratory training sponsored by a faculty member. *Enrollment limited. Special registration procedures apply; interested students must contact the instructor and attend an organizational meeting. This class is recommended to students in the sciences who are in their junior year and will be completing a senior research project for graduation.*

MCDB 321LaG. **Laboratory for Neurobiology.**

Haig Keshishian, Fernando Vonhoff, Robert Wyman

T or W 1.30- 5.30

Introduction to the neurosciences. Projects include the study of neuronal excitability, sensory transduction, CNS function, synaptic physiology, and neuroanatomy. *Concurrently with or after MCDB 320.*

MCDB 342La. **Laboratory in Nucleic Acids I.**

Kenneth Nelson

T or Th 1.30-4.30

A project from a research laboratory within the MCDB department, using technologies from molecular and cell biology. Laboratories meet twice a week for the first half of the term. Concurrently with or after MCDB 202, 205, or 300. *Enrollment limited. Special registration procedures apply. Students should contact the instructor during January of the year you intend to take the course.*

MCDB 343La. **Laboratory in Nucleic Acids II.**

Kenneth Nelson

T or Th 1.30-4.30

Continuation of MCDB 342La to more advanced projects in molecular and cell biology, such as making and screening cDNA libraries, microarray screening and analysis, or next-generation DNA sequencing. Laboratories meet twice a week for the second half of the term. *Prerequisite: MCDB 342L or with permission of instructor. Enrollment limited. Special registration procedures apply. Students should contact the instructor during January of the year you intend to take the course.*

MCDB 344Lb. **Experimental Techniques in Cellular Biology.**
Joseph Wolenski
M or W 1.30-6.30
A problems-based approach to questions in cell and molecular biology, with emphasis on experimental strategies and techniques. Topics include SDS-PAGE, immunoblots, column chromatography, mammalian cell culture, cell fractionation, light microscopy, drug studies, bacterial cultures, and methods of transfection and transformation. Prepares for MCDB 475, 485, or 495. Meets during January and February. *Enrollment limited. Prerequisite: MCDB 205. Special registration procedures apply. Students must contact the instructor in at least 18 months in advance.*

MCDB 345Lb. **Experimental Strategies in Cellular Biology.**
Joseph Wolenski
MW 1.30-6.30
Continuation of MCDB 344L, with increased emphasis on experimental design and interpretation of data. Research projects involving protein purification are semi-independent. Focus on developing an independent research project in modern biomedical research. Students participate in journal discussions, formal seminars, and presentations of data to peers. Prepares for MCDB 475, 485, or 495. Enrollment limited. Meets during March and April. *Prerequisite: MCDB 344L. Special preregistration procedures apply. Students must contact the instructor.*

MCDB GENERAL ELECTIVE COURSES

[Choose 2 for either the BA, BS, or BS Intensive degree.]

NOTE: BIOL 101, 102, 103 and 104, or equivalent performance on the corresponding biological sciences placement examinations are prerequisites for MCDB courses numbered 200 and above. ***Any of the Core Courses above may also be considered general electives once the Core requirements are met.***

MCDB 250b. **Biology of Reproduction.**
Hugh Taylor
MWF 10.30-11.20
Introduction to reproductive biology, with emphasis on human reproduction. Development and hormonal regulation of reproductive systems; sexuality, fertilization, and pregnancy; modern diagnosis and treatment of reproductive and developmental disorders; social and ethical issues. *Prerequisite: BIOL 101, 102, and 103, or equivalent performance on the corresponding biological sciences placement examinations.*

MCDB 290b. **Microbiology.**
Christine Jacobs-Wagner, Stavroula Hatzios
TTh 1.00-2.15
Cell structure of bacteria, bacterial genetics, microbial evolution and diversity, bacterial development, microbial interaction, chemotaxis and motility, gene regulation, microbial genomics and proteomics, CRISPR, metabolism, infectious diseases, mechanisms of pathogenesis, host defense systems, viruses, gut microbiota in health and disease. *Prerequisites: BIOL 101 and 102, or equivalent performance on the corresponding biological sciences placement examinations; or a term of biochemistry, cell biology, or genetics, or molecular biology.*

MCDB 310aG/BENG 350aG. **Physiological Systems.**
Stuart Campbell, Peter Aronson, Emile Boulpaep, Elizabeth Holt, Mark Saltzman, David Zenisek
MWF 9.25-10.15
Regulation and control in biological systems, emphasizing human physiology and principles of feedback. Biomechanical properties of tissues emphasizing the structural basis of physiological control. Conversion of chemical energy into work in light of metabolic control and temperature regulation. *Prerequisites: CHEM 165 or 167, or PHYS 180a and 181b, or BIOL 101 and 102.*

MCDB 315b/PATH 670b. **Pathobiology: Mechanisms of Adaptation and Disease**
S. David Hudnall, Joanna Gibson, Jon Morrow, Jeffrey Sklar, Gilbert Moeckel
TTh 11.35-12.50 Meets RP
Human biology and disease as a manifestation of reaction to injury. Organ structure and function, cell injury, circulatory and inflammatory responses, disordered physiology, and neoplasia. *Enrollment limited; preference given to junior and senior majors in MCDB or MB&B. Prerequisite: MCDB 205 or 300 or 310.*

MCDB 320aG. **Neurobiology.**
Haig Keshishian, Paul Forscher
MWF 11.35-12.25
The excitability of the nerve cell membrane as a starting point for the study of molecular, cellular, and systems-level mechanisms underlying the generation and control of behavior. *Prerequisites: After a year of chemistry and Foundational Biology sequence BIOL 101-104. A course in physics is strongly recommended.*

MCDB 330aG. **Introduction to Dynamical Systems in Biology.**
Thierry Emonet, Damon Clark
TTh 2.30-3.45 (KBT 1214)
Biological systems make sophisticated decisions at many levels. This course explores the molecular and computational underpinnings of how these decisions are made, with a focus on modeling static and dynamic processes in example biological systems. We emphasize analytical and numerical models to explore the relationship between molecular mechanisms and behavior. Topics include molecular switches, regulatory networks, feedback, and signal transduction. The course contains significant instruction in Matlab, while students also read papers from the primary literature. The course aims to turn ball-and-arrow diagrams into quantitative models with testable predictions. This class is intended as an introduction to the higher level course MCDB 361. *Prerequisite: PHYS 170 or equivalent or with permission of instructor. [This course was previously MCDB 261].*

MCDB SPECIAL ELECTIVE COURSES

[Choose 1 for either the BA, BS or BS Intensive degree.]

MCDB 350a/MCDB 650a. **Epigenetics: From Basic Mechanism to Human Health.**
Nadya Dimitrova, Yannick Jacob, Josien Van Wolfswinkel
WF 11.35-12.50
Study of epigenetic states and the various mechanisms of epigenetic regulation, including histone modification, DNA methylation, nuclear organization, and regulation by non-coding RNAs. Detailed critique of papers from primary literature and discussion of novel technologies, with specific attention to the impact of epigenetics on human health. *Prerequisites: Foundational courses BIOL 101-104, and two MCDB 200-level courses (strongly recommended: MCDB 200 and MCDB 202) or with permission of instructor.*

MCDB 361bG/PHYS 562/CBB 562/MBB 562. **Dynamical Systems in Biology.**
Damon Clark, Thierry Emonet
TTh 2.30-3.45
Advanced topics related to dynamical processes in biological systems. Processes by which cells compute, count, tell time, oscillate, and generate spatial patterns. Time-dependent dynamics in regulatory, signal-transduction, and neuronal networks; fluctuations, growth, and form. Comparisons between models and experimental data. Use of MATLAB to create models. *Prerequisite: MCDB 261 or equivalent, or a 200-level biology course, or with permission of instructor.*

MCDB 370bG. **Biotechnology.**

Craig Crews, Nicole Clay, Kenneth Nelson, Joseph Wolenski

MW 11.35-12.50

The principles and applications of cellular, molecular, and chemical techniques that advance biotechnology. Topics include the most recent tools and strategies used by government agencies, industrial labs, and academic research to adapt biological and chemical compounds as medical treatments, as industrial agents, or for the further study of biological systems. *Prerequisites: MCDB 200 or 202 or 300.*

MCDB 380aG. **Advances in Plant Molecular Biology.**

Yannick Jacob, Vivian Irish, Josh Gendron, Lindsay Triplett

F 1.00-3.00 p.m.

Plants provide us with food, shelter, and medicines while shaping our environment. Plant biologists study basic processes in plant growth and development, to provide a foundation for addressing critical agricultural needs in response to a changing climate. This course is intended to inform students about the latest breakthroughs in plant sciences with an emphasis on molecular, cellular, and developmental biology. The topics will cover biotic and abiotic plant interactions, and development, genomics, proteomics, epigenetics and chemical biology in the context of plant biology. Students will also become familiarized with critically reading primary literature in plant sciences and discussing scientific publications with their peers and plant-related topics with non-experts. A special emphasis will be placed throughout the course on teaching students about advances in plant biotechnology. The pace of crop improvement is accelerating due to novel technologies. It is therefore imperative for the next generation of scientists to have basic understanding of plant biology so that they can be informed participants in the current societal debates about agrobiotechnology. *Prerequisites: BIOL 101-104 and two MCDB 200-level courses, or instructor permission.*

MCDB 387b. **The Eukaryotic Cell Cycle.**

Iain Dawson

T or Th 7.00-8.50 p.m.

The regulation and coordination of the eukaryotic cell cycle examined by means of a detailed critique of primary literature. Particular attention to the processes of development, differentiation, and oncogenic disease. Enrollment limited, with preference to juniors and seniors. *Prerequisites: BIOL 101, 102, and 103, or equivalent performance on the corresponding biological sciences placement examinations; MCDB 202, 205, or 210. Electronic permission key required. Students must contact the instructor prior to the first class meeting.*

MCDB 415bG. **Cellular and Molecular Physiology.**

Frederick Sigworth

MWF 9.25-10.15

Study of the processes that transfer molecules across membranes. Topics include the different classes of molecular machines that mediate membrane transport. Emphasis on interactions among transport proteins in determining the physiologic behaviors of cells and tissues. *Intended for seniors majoring in the biological sciences. Recommended preparation: MCDB 205, 310, 320, or permission of instructor.*

MCDB 425aG/MB&B 425aG. **Basic Concepts of Genetic Analysis.**

Tian Xu, Marc Hammarlund, Richard Lifton, Zhaoxia Sun

MW 11.35-12.50

The universal principles of genetic analysis in eukaryotes. Reading and analysis of primary papers that illustrate the best of genetic analysis in the study of various biological issues. Focus on the concepts and logic underlying modern genetic analysis. *Prerequisite: MCDB 200 or equivalent.*

MCDB 430aG/IBIO 530. **Biology of the Immune System.**

Carla Rothlin, Peter Cresswell, Kevan Herold, Akiko Iwasaki, Susan Kaech, Ruslan Medzhitov, Eric Meffre, Joao Pedro Pereira, David Schatz, Mark Shlomchik

MWF 9.25-10.15

The development of the immune system. Cellular and molecular mechanisms of immune recognition. Effector responses against pathogens; immunologic memory and vaccines. Human diseases including allergy, autoimmunity, cancer, immunodeficiency, HIV/AIDS. *After MCDB 300.*

*MCDB 435a. **Landmark Papers in Cell Biology.**

Joel Rosenbaum

T 7.00-9.00

Discussion and critical evaluation of selected research papers that were important in determining the directions of modern cell biological research. Emphasis on the nature of the problem, evaluation of experimental approaches and results, and the authors' interpretation of the results. The grade is highly dependent on weekly discussion by all participants. Prospective students should fill out the form sent by the MCDB Registrar, Crystal Adamchek, prior to the first week of classes. Students who have taken upper level courses in cell biology, biochemistry and genetics will be given priority. This course is only open to Seniors.

MCDB 450b. **The Human Genome.** Stephen Dellaporta, Nadya Dimitrova

M 3.30-5.30

A focus on the primary scientific literature covering the principles of genomics and its application to the investigation of complex human traits and diseases. Topics include the technology of genome sequencing and resequencing, the characterization of sequence and structural variation in human populations, haplotype and linkage disequilibrium analysis, genome-wide association studies, the comparative genomics of humans and our closest relatives, and personalized genomics and medicine. *Enrollment limited to 15. Students should contact the instructor prior to the first week of classes. Prerequisite: MCDB 202; a course in statistics is strongly recommended.*

MCDB 452bG/CPSC 752b/MB&B 752b/CBB 752. **Bioinformatics: Practical Application of Simulation and Data Mining.**

Mark Gerstein

MW 1.00-2.15

Techniques in data mining and simulation applied to bioinformatics, the computational analysis of gene sequences, macromolecular structures, and functional genomics data on a large scale. Sequence alignment, comparative genomics and phylogenetics, biological databases, geometric analysis of protein structure, molecular-dynamics simulation, biological networks, microarray normalization, and machine-learning approaches to data integration. *Prerequisites: MB&B 301 and MATH 115, or permission of instructor.*

*MCDB 461b. **Advanced Seminar in Systems Biology.**

Murat Acar

F 3.30-5.30

A focus on the primary scientific literature covering the topics of gene network design, stochasticity in gene expression, and evolution of genes and networks, in the context of both prokaryotic and eukaryotic systems. Detailed critique of the approaches, data analysis, controls, results, and conclusions of selected current and classic papers in the field. *Prerequisites: Advanced undergraduate level courses: MCDB 261 or MCDB 351 recommended.*

MCDB 482a. **Advanced Seminar in Cell Biology: Intracellular Signal Transduction.**

Craig Crews

M 7.00-8.50 p

Discussion of intracellular signal transduction pathways. Detailed critique of experimental approaches, controls, results, and conclusions of selected current and classic papers in this field.

**These courses are bracketed for 2017-18.*

MCDB INDEPENDENT RESEARCH

MCDB 474a or b **Independent Research**

Joseph Wolenski, David Breslow, Stavroula Hatzios

HTBA

Research projects under faculty supervision taken as Pass/Fail only. This is the only independent research course available to Underclassmen. Students are expected to spend approximately ten hours per week in the laboratory. Written assignments include a short research proposal summary, at the beginning of the term, approved by the Yale faculty sponsor and the instructor in charge of the course. A final research report is required at the end of the term. Students should line up a research laboratory during the term preceding the research. Guidelines for the course should be obtained from the office of the director of undergraduate studies or downloaded from the Classes server. Written proposals are due by the end of the first week of the semester.

MCDB 475a or b. **Senior Independent Research**

Joseph Wolenski, David Breslow, Stavroula Hatzios

HTBA

Research projects under faculty supervision, to fulfill the senior requirement in MCDB. Students are expected to spend approximately ten hours per week in the laboratory. Written assignments include a short research proposal summary, at the beginning of the term, approved by the Yale faculty sponsor and the instructor in charge of the course. A final research report is required at the end of the term, before a letter grade is given. Seniors taking this course to fulfill the senior requirement must give an oral presentation of their research at the end of the term. Students who take this course more than once must reapply each term; students planning to conduct two terms of research should consider enrolling in MCDB 485a, 486b. Students should line up a research laboratory during the term preceding the research. Guidelines for the course should be obtained from the office of the director of undergraduate studies or downloaded from the Classes server. Written proposals are due by the end of the first week of the semester. This course is only open to Senior MCDB students.

MCDB 485a and 486b. **Senior Research**

Joseph Wolenski, David Breslow, Stavroula Hatzios

HTBA Credit/Year Only

Individual two-term laboratory research projects under the supervision of a faculty member. Students are expected to spend ten to twelve hours per week in the laboratory. Written assignments include a short research proposal summary due at the end of the first week of classes, a grant proposal due at the end of the first term, and a research report summarizing experimental results due at the end of the second term. Students are required to make an oral presentation as well as attend a minimum of two research seminar sessions per term. A poster session is held at the end of the spring term. Students should line up a research laboratory during the term preceding the research. Guidelines for the course should be obtained from the office of the director of undergraduate studies or downloaded from the Classes server. This course is only open to Senior MCDB students.

MCDB 495a and 496b. **Senior Research Intensive**

Joseph Wolenski, David Breslow, Stavroula Hatzios

HTBA Credit/Year Only

Qualified students may undertake directed research in some field of biology during the senior year. Before registering for this course, the student must be accepted for a research project by a Yale faculty member with a research program in experimental biology and obtain the approval of the instructor in charge of the course. Students spend approximately twenty hours per week in the laboratory, and make written and oral presentations of their research to students and advisers. Written assignments include a proposal summary due at the end of the first week of classes, a grant proposal due at the end of the first term, and a research report summarizing experimental results due at the end of the second term. Students must attend a minimum of two

research seminar sessions (including their own) per term. Students are also required to present their research during both the fall and spring terms. A poster session is held at the end of the spring term. Guidelines for the course are covered in detail in an information sheet that students should obtain from the office of the director of undergraduate studies early in the final term of the junior year. This course is only open to Senior MCDB students pursuing the MCDB BS INT degree.

BS/MS COURSES

The following courses are required for students in the joint BS/MS Program with Yale College. These students are also expected to meet with other MCDB majors performing independent research. This is usually coordinated by the instructor in charge of the MCDB Independent Research courses 475a/b, 485a, 486b, 495a, 496b.

MCDB 585b **Research in MCDB for BS/MS Candidates**
Douglas Kankel
HTBA
A two-credit course taken in the third-to-last term (the second term of the junior year). At the start of this course, each student forms a committee composed of their adviser and two faculty members that meet to discuss the research project. At the end of this course, students complete a detailed prospectus describing their thesis project and the work completed thus far. The committee evaluates an oral and written presentation of this prospectus; the evaluation determines whether the student may continue in the combined program.

MCDB 595ab. **Intensive Research for BS/MS Candidates**
Douglas Kankel
HTBA
A four-credit, year-long course (two credits each term) that is similar to MCDB 495a, 496b and is taken during the senior year. During this course, students give an oral presentation describing their work. Students must attend a minimum of three research seminar sessions (including their own) per term. Students are also required to present their research during both the fall and spring terms. At the end of the course, a student is expected to present his or her 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 other requirements, the student is awarded the combined BS/MS degree.

MCDB GRADUATE COURSES

With permission of the instructor, advanced undergraduates may take graduate courses for credit. If you are interested in one of these consult the instructor and you will need to fill out a special form that should be available in your residential college dean's office.

MCDB 500aU/MB&B 500aU. **Biochemistry.**
See MCDB 300 for primary description.

MCDB 517b/ENAS 517b/MB&B517b/PHYS 517b. **Methods and Logic in Interdisciplinary Research.**
Lynne Regan, Enrique De La Cruz, Eric Dufresne, Thierry Emonet, Paul Forscher, Megan King, Michael Levene, Simon Mochrie, Corey O'Hern, Thomas Pollard, Anna Rhoades, Corey Wilson
MW 5.00-7.00
This half-term IGPPEB class is intended to introduce students to integrated approaches to research. Each session is led by faculty with complementary expertise and discusses papers that use different approaches to the same

topic (for example, physical and biological or experiment and theory). *Counts as 0.5 credit toward graduate course requirements. Required for students in IGPPEB.*

MCDB 530aU/IBIO 530a. **Biology of the Immune System.**
See MCDB 430 for primary description.

MCDB 550aU/C&MP 550aU/ENAS 550aU. **Physiological Systems.**
See MCDB 310 for primary description.

MCDB 560bU/C&MP 560bU/ENAS 570bU. **Cellular and Molecular Physiology: Molecular Machines in Human Disease.**
Emile Boulpaep, Fred Sigworth
MWF 9:25–10:15
The course focuses on understanding the processes that transfer molecules across membranes at the cellular, molecular, biophysical, and physiologic levels. Students learn about the different classes of molecular machines that mediate membrane transport, generate electrical currents, or perform mechanical displacement. Emphasis is placed on the relationship between the molecular structures of membrane proteins and their individual functions. The interactions among transport proteins in determining the physiologic behaviors of cells and tissues are also stressed. Molecular motors are introduced and their mechanical relationship to cell function is explored. Students read papers from the scientific literature that establish the connections between mutations in genes encoding membrane proteins and a wide variety of human genetic diseases.

MCDB 561aU/MB&B 561aU/CB&B 561a/PHYS 561a. **Intro to Dynamical Systems in Biology.**
See MCDB 330 for primary description.

MCDB 562aU/PHYS 562a/CBB 562a/MBB 562a/MCDB 361a. **Dynamical Systems in Biology**.
See MCDB 361 for primary description.

MCDB 570bU. **Biotechnology.**
See MCDB 370 for primary description

MCDB 602a/CBIO 602a/MB&B 602a. **Molecular Cell Biology.**
Sandra Wolin, Michael Caplan, Christopher Carroll, Craig Crews, Pietro De Camilli, Megan King, Thomas Melia, In-Hyun Park, Thomas Pollard, James Rothman, Martin Schwartz
MW 1:45–3.00
A comprehensive introduction to the molecular and mechanistic aspects of cell biology for graduate students in all programs. Emphasizes fundamental issues of cellular organization, regulation, biogenesis, and function at the molecular level.

MCDB 603a/CBIO 603a. **Seminar in Molecular Cell Biology.**
Megan King, Michael Caplan, Christopher Carroll, Craig Crews, Pietro De Camilli, Shawn Ferguson, Thomas Melia, Thomas Pollard, James Rothman, Martin Schwartz, Sandra Wolin
Th 9.00–11.00
A graduate-level seminar course in modern cell biology. The class is devoted to the reading and critical evaluation of classical and current papers. The topics are coordinated with the MCDB 602a lecture schedule. *Concurrent or previous enrollment in MCDB 602a is required.*

MCDB 625aU/GENE 625a/MB&B 625aU. **Basic Concepts of Genetic Analysis.**
See MCDB 425 for primary description.

MCDB 630b/MB&B 630b. **Biochemical and Biophysical Approaches in Molecular and Cellular Biology.**

Thomas Pollard, Karen Reinisch and Staff.

TTh 2.30–3.45

This graduate course introduces the theory and application of biochemical and biophysical methods to study the structure and function of biological macromolecules. The course considers the basic physical chemistry required for research in cellular and molecular biology but does not require a previous course in physical chemistry. The class consists of lectures and discussion of research papers utilizing various methods.

MCDB 650a. **Epigenetics: From Basic Mechanism to Human Health.**

See MCDB 350 for primary description.

MCDB 660a. **Anatomy, Physiology, and Development of Trees and Other Vascular Plants.**

Graeme Berlyn

MW 4.00-5.20

Morphogenesis and adaptation of vascular plants considered from seed formation and germination to maturity. Physiological and developmental processes associated with structural changes in response to environment discussed from both a phylogenetic and an adaptive point of view.

MCDB 670a. **Advanced Seminar in Biochemistry and Genetics.**

Sid Altman, Ronald Breaker, Stephen Dellaporta

W 1.30-3.20

New aspects of the molecular biology of RNA, ribonucleoproteins, and prions. Topics include the localization and function of RNA and ribonucleoproteins, siRNAs and microRNAs; the role of RNA in dosage compensation, chromosome silencing, and gene regulation; novel ribozymes and RNA technology; prions. Discussion; involvement and attendance are required.

MCDB 677b/GENE 777b. **Mechanisms of Development.**

Valerie Reinke and Staff

W 1.30–3.20

An advanced course on the mechanisms of animal development focusing on the genetic specification of cell organization and identity during embryogenesis and somatic differentiation. The use of evolutionarily conserved signaling pathways to carry out developmental decisions in a range of animals is highlighted. Course work includes student presentations, critical analysis of primary literature, and a research proposal term paper.

MCDB 680aU. **Advances in Plant Molecular Biology.**

See MCDB 380 for primary description.

MCDB 720aU/NBIO 720a/NSCI 720a. **Neurobiology.**

See MCDB 320 for primary description.

MCDB 743b/GENE 743b/MB&B 743bU. **Advanced Eukaryotic Molecular Biology.**

Mark Hochstrasser, Karla Neugebauer, Patrick Sung

TTh 11.35–12.50

Selected topics in transcriptional control, regulation of chromatin structure, mRNA processing, mRNA stability, RNA interference, translation, protein degradation, DNA replication, DNA repair, site-specific DNA recombination, somatic hypermutation. Prerequisite: biochemistry or permission of the instructor.

MCDB 752bU/CB&B 752b/CPSC 752bU/MB&B 752bU. **Bioinformatics: Practical Application of Simulation and Data Mining.**

Mark Gerstein

MW 1.00-2.15

Bioinformatics encompasses the analysis of gene sequences, macromolecular structures, and functional genomics data on a large scale. It represents a major practical application for modern techniques in data mining and simulation. Specific topics to be covered include sequence alignment, large-scale processing, next-generation sequencing data, comparative genomics, phylogenetics, biological database design, geometric analysis of protein structure, molecular-dynamics simulation, biological networks, normalization of microarray data, mining of functional genomics data sets, and machine learning approaches for data integration. Prerequisites: biochemistry and calculus, or permission of the instructor.

MCDB 900a/CBIO 900a/GENE 900a. **First-Year Introduction to Research and Rotations – Grant Writing and Scientific Communication.**

Valerie Horsley
M 4.00-5.30

Grant writing, scientific communication, and laboratory rotation talks for Molecular Cell Biology, Genetics, and Development track students.

MCDB 901b/CBIO 901b/GENE 901b. **First-Year Introduction to Research-Ethics: Scientific Integrity in Biomedical Resarch.**

Joerg Bewersdorf and Staff
Th 4.15–5.45

Ethics and laboratory rotation talks for Molecular Cell Biology, Genetics, and Development track students.

MCDB 902a/903b. **Advanced Graduate Seminar.**

Fall: Matthew Rodeheffer, Damon Clark
Spring: Valerie Horsley
3 HTBA

This course allows students to hone their presentation skills through yearly presentation of their dissertation work. Two students each give 30-minute presentations in each class session. Students will be required to present every year beginning their third year in the MCDB program. Each MCDB graduate student will be required to attend at least 80% of the class sessions. Two faculty members will co-direct the course, attend the seminars, and provide feedback to the students.

MCDB 911a/CBIO 911a/GENE 911a. **First Laboratory Rotation.**

Valerie Horsley and Staff
HBTA

First laboratory rotation for Molecular Cell Biology, Genetics, and Development track students.

MCDB 912b/CBIO 912b/GENE 912b. **Second Laboratory Rotation.**

Valerie Horsley and Staff
3 HTBA

Second laboratory rotation for Molecular Cell Biology, Genetics, and Development track students.

MCDB 913b/CBIO 913a/GENE 913b. **Third Laboratory Rotation.**

Valerie Horsley and Staff
3 HTBA

Third laboratory rotation for Molecular Cell Biology, Genetics, and Development track students.

MCDB 950a and 951b. **Second-Year Research.**

Staff
3 HTBA

By arrangement with Faculty.

2016-2017 Undergraduate Research Projects

Research Faculty & Department	***Project Title***
Addy, Nii *(Psychiatry)*	The Investigation of muscarinic receptors and their role in the mediation of both anxiety and cocaine-seeking behavior in rodent models.
Ameen, Nadia *(Pediatrics/Gastroenterology)*	Pathogenesis of Diarrheal Diseases
Anderson, Karen *(Pharmacology/MBB)*	Probing the Structure, Kinetics, and Pharmacological Properties of Novel NNRTIs That Target HIV-1 Reverse Transcriptase
Arnsten, Amy *(Neuroscience)*	The MI Muscarinic Receptor as a Potential Therapeutic Target for Schizophrenia
Ben Mamoun, Choukri *(Infectious Diseases)*	Diagnosis and Treatment of Human Babesiosis
Bindra, Ranjit *(Therapeutic Radiology)*	Investigation of PARPi Sensitivity in IDH-1 mutant pediatric glioma Creation of Inducible INI1 Gene for Small Molecule Screening of Novel Rhabdoid Tumor Inhibitors
Blumenfeld, Hal *(Neurology)*	Deep Brain Stimulation Optogenetic activation/inhibition of input to subcortical arousal regions Uncovering the relationship between absence seizure behavioral severity and underlying electrophysiological changes
Braddock, Demetrios *(Pathology)*	Expression of ENPP7 Protein and Therapeutic Responses in Mice Creation of stable stem cell line for NPP1 protein production for therapeutic use in mouse models
Breaker, Ronald *(MCDB)*	Investigating the link between ole RNA and c-di-amp sinase in bacteria Discovery of Novel Structured Noncoding RNAs Investigating the Intermolecular Interactions of a Bacterial Noncoding RNA
Cafferty, William *(Neurology)*	Transcriptomic analysis of intact CST neurons to identify proteins relevant to neuronal Growth and Recovery after SCI
Caplan, Michael *(C&M Physiology)*	Investigating interactions between polycystin proteins and cellular oxygen sensing machinery in regards to autosomal polycystic kidney disease
Cardin, Jess *(Neuroscience)*	Electrophysiology of the Primary Visual Cortex during Stimulation and Optogenetic Manipulation of Neuromodulators Adding Insult to Injury: The Compounded Effects of Prenatal Valproic Acid and CASPR2 Knockout on Cortical Circuits in Autism Spectrum Disorder Schizophrenia Role of GABAergic Neurons in the Cortical Network

Chakraborty, Raja *(Cardiology)*	The role of CBP and p300 on TET2 Regulation and Intimal hyperplasia
Chandra, Sreeganga *(C&M Physiology)*	Defining the α-synuclein interactome
Chang, Sandy *(Pathology)*	Characterization of POT1 mutants in a CTC1-depleted telomere background
Chang, Steve *(Psychology)*	The role of serotonin in dominance-induced social gaze dynamics
Chen, Lieping *(Immunobiology)*	Converting Poorly Immunogenic Tumors to Inflamed Tumors Examining PD-1H Signaling Pathways
Colon-Ramos, Daniel *(Cell Biology)*	Transforming Sensation into Behavior: Examining the Regulation of Gelagans Temperature Preference and Thermotaxis Behavior
Crawford, Jason *(Chemistry)*	Structure and Function of a Novel Polysulfide Natural Product
Crews, Craig *(MCDB)*	Application of the Halo TagHy36 system to the Hsp70Dna/chaperone cycle in vitro Investigating PROTAC-induced degradation of the MET oncoyne in the context of exion M skipping mutations Linker Length Mediates Ternary Complex Formation and Explains Degredation of Haloprotac Library Exploration into the Requirement of Orphan Genes in Salamander Limb Regeneration
DeLanerolle, Nihal *(Neurosurgery)*	Neurobiology of Hyperthermic Seizures in the Rat
DiMaio, Daniel *(Genetics)*	Determining molecular toggle-switches regulating transmembrane domain interactions with the erythropoietin receptor
Dimitrova, Nadya *(MCDB)*	Investigating the sequence-function relationship of cancer-associated lincRNA-p21 Molecular and Cellular Characterization of p53 Regulated Long Non-coding RNAs
Dominiguez-Villar, Margarita	Examination of CDL Surface Markers that Define Th1-Trge
Emonet, Thierry *(MCDB)*	2-D Collective Migration of Bacteria in Semisolid Agar

Fikrig, Erol *(Infectious Diseases)*	Investigating Aegis aegypti salivary proteins for potential as targets in Zika and dengue virus vaccines Alternative Routes of Transmission of Zika Virus The Role of Defensin Beta 118/129 and Defensin Alpha 3 during Zika Virus Infection Further investigation of several Aedes aegypti salivary proteins, including a SNARE-like protein for potential as targets in ZIKV and DENV vaccines
Finberg, Karin *(Pathology)*	How the p.Arg88Ile mutation affects Fpn function
Flannery, Clare *(OB/GYN)*	Characterizing the Molecular and Cellular Relationship Between Gestational Diabetes Mellitus, Obesity, and Fetal Outcomes
Gonzalez, Anjelica *(Biomedical Engineering)*	The Role of Endothelial Cell Paracrine Factors in Regulating Pericyte Cell Phenotype and Function
Gruen, Jeffrey *(Pediatrics)*	Analysis of the protein binding site in KIAA0319
Guo, Shangqin *(Cell Biology)*	Reprogramming Hemotropoletic Progenitors into Insulin-Producing Beta-like Cells Creating a Florescent cell cycle speed tracker Reprogramming hematoporietic stem and progenitor cells into insulin-producing Beta-cells
Grutzendler, Jaime *(Neurology)*	mCherry Aggregation
Hammarlund, Marc *(Genetics)*	Investigating the role of rab-27 in axon regeneration in C elegans
Higley, Michael *(Neuroscience)*	Determining the effects of ketamine on the somatodendritic distribution of GABAergic synapses Cell-Specificity of Noradrenergic Modulation in Layer V of Mouse Visual Cortex
Hirschi, Karen *(Cardiology)*	Characterization of Gap Junction Formation between Mouse Neural Stem Cells and Endothelial Cells Sufficiency of G2 Arrest on Arteriovenous Specification
Holley, Scott *(MCDB)*	Characterizing the roles of Syndecan-2 and Estrogen-Related Receptor Gamma A in Zebrafish Segmentation
Horsley, Valerie *(MCDB)*	Wnt/B-Catenin signaling and its role in p63 regulation during epidermal fate commitment The Interactions of Blood and Lymphatic Endothelial Cells in Wound Healing
Isaacs, Farren *(MCDB)*	Engineering Genetically Recoded Organisms using Multiplex Automated Genome Engineering Implementing Multiplex Automated Genome Engineering (MAGE) in Rhizobia

Jacob, Yannick *(MCDB)*	Epigenetic modification to increase CRISPR/Cas9 efficiency in A. thaliana
Kazmierczak, Barbara *(Infectious Diseases)*	Effect of Host Cells on Competition between T3SS-negative and –positive Pseudomonas aeruginosa Investigating Membrane Derived Intrinsic Antibiotic Resistance in Pseudomonas aeruginosa
Keshishian, Haig *(MCDB)*	The Role of Calcium Signaling in Synaptic Refinement at the Drosophila Neuromuscular Junction
Kibbey, Richard *(Endocrinology)*	Development of a High Throughput Screen for Metabolite Flux from Mass Spectrometry
King, Megan *(Cell Biology)*	The Impact of Nuclear Compartmentalization on DSB Repair Pathway Choice
Koleske, Anthony *(MB&B)*	Arg:cortactin interactions in the control of actin polymerization Characterization of c-terminal Arg Acin-Binding Domain Potential Importance of BRAG1 and arg-mediated phosphorylation for maintaining spine normal neuronal structure
Kriegel, Martin *(Immunobiology)*	The Role of an Autoimmunity-Associated Genetic Polymorphism in Shaping Human Gut Commensal Communities
Kupfer, Gary *(Pediatrics)*	Deciphering the Mechanism of HTLV-1 Tax-Induced Chemosensitization to Counteract Tumor Drug Resistance
Lin, Haifan *(Cell Biology)*	Investigating the Binding of Pim-PiRNA complexes to target DNA Piwi in Genome Integrity Comparing Maternal and Zygotic HP1a Regulation in CNS and Germ Cells of Late Stage *Drosophila* Embryos
Lindenbach, Brett *(Microbial Pathogenesis)*	Evolving small, antiviral membrane proteins
Lombroso, Paul *(Neuroscience)*	Pharmacological Inhibition of STEP Ameliorates Dendritic Pathology in Alzheimer's Disease
McCormick, David *(Neuroscience)*	Neurobiological Pathways of Social Auditory Recognition
McPartland, James *(CSC/Psychology)*	The Effects of Sleep Disturbances on Resting Brain Power in Autism Spectrum Disorder
Medzhitov, Ruslan *(Immunobiology)*	Effect of noxious substances on Intestional Permeability, Peristalsis, and mucus production
Nicoli, Stefania *(Cardiology)*	CRISPR/Cas9 facilitated knock in of KalTA4 reporter for in vivo localization of miR 223 in the zebrafish hematopoietic system
Nitabach, Michael *(C&M Physiology)*	Learning and decision-making in Drosophila: A look at neural implementation of reinforcement learning models

O'Connor, Kevin *(Neurology)*	Characterization of Autoantibody Production in Myasthenia Gravis (MG) Characterization of Autoantibodies in Myasthenia Gravis
Palm, Noah *(Immunobiology)*	Developing new Techniques to Manipulate Microbiota Species
Park, In-Hyun *(Genetics)*	Investigation of Function of IRF5 in Lupus Using Human iPSCs Defining the pathways specifying SST and PV GABAergic neurons using human brain Organoids
Pollard, Thomas *(MCDB)*	Two-color Live-Cell Super-Resolution Microscopy of Endocytic Patches in Fission Yeast
Ratner, Elena *(OB/GYN)*	CRISPR-Mediated Manipulation of BRCA2 in Epithelial Ovarian Cancer Progression and Therapeutic Response
Redmond, D. Eugene *(Psychiatry)*	Parkinsons
Regan, Lynne *(MB&B)*	Using a Protein Monolayer to Create Functional 2-Dimensional Arrays
Rodeheffer, Matthew *(Comparative Medicine)*	Determining the dietary mechanisms of adipocyte hyperplasia in obesity
Saltzman, Mark *(Biomedical Engineering)*	Circulation Half-Life Quantification & Applications
Scheinost, Dustin *(MDRAD)*	Study of Pituitary Size and Stress in Postpartum Women
Shadel, Gerald *(Pathology)*	Micro RNA-Directed Regulation of Mitochondrial Function
Silasi, Michelle *(OB/GYN)*	Epigenetic regulation of IP-10 by hCG through the PRC2 complex in the decidua
Steitz, Thomas *(MB&B)*	Structure and Function of the New GTPase, HflX, on the Ribosome
Strittmatter, Stephen *(Neurology)*	Prion Protein Signaling pathways in Alzheimer's Disease Characterizing the interaction of mGluR5 and PrPc, a neuronal surface interaction crucial to the pathophysiology of Alzheimer's Disease
Sung, Patrick *(MB&B)*	Activity of Exo1 and Dna2 at 8 oxo guanine
Tattersall, Peter *(Genetics)*	Characterizing a parvoviral immunotherapy vector for melanoma treatment
Toomre, Derek *(Cell Biology)*	TEV Protease Assay
Turner, Paul *(E&EB)*	Antibiotic Resistance E Coli
van Wolfswinkel, Josien *(MCDB)*	Function of SMEDWI-1 Protein in Planarian Biology

Wysolmerski, John *(Endocrinology)*	The Effect of PTHIR on Secretory Differentiation Phenotype
Xiao, Andrew (MGEN)	Epigenetic modification of methylation of the fifth carbon of cytosine (5mC), hydroxymethylation of cytosine (5hmC) mapping in organismal development and as a transcriptional controller
Yan, Qin *(Pathology)*	Enzymatic Regulation of H3K27 Methylation Contributing to Trastuzumab (Herceptin) Resistance In HER2+ Breast Cancer Cells Identifying Essential Epigenetic Regulators in Cell Proliferation and their Carcinogenic Effects
Zhao, Hongyu *(Biostatistics)*	Genome sequencing technology to identify mutations in both coding and non-coding regions
Zhou, Jiangbing *(Neurosurgery)*	Synthesis and Evaluation of Small Molecule-Derived Hydrogels for Drug Delivery

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 3 students were awarded the Boell and 4 students were awarded the Belknap.

MCDB Faculty

Acar, Murat

Asst. Prof., Mol Cell & Dev Biology and Physics
*[Ezra Stiles College Fellow & **MCDB Faculty Advisor**]*

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

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Bahmanyar, Shirin

Asst. Prof., Mol Cell & Dev Biology
*[Berkeley College Fellow & **MCDB Faculty Advisor**]*

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

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Bazell, Robert

Adjunct Prof., Mol Cell & Dev Biology

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Belperron, Alexia

Res. Sci., Medicine (Rheumatology) & Lect., Mol Cell & Dev Biology; Advisor, Center for Science and Quantitative Reasoning

Study of Immune Responses and Pathogenesis of Tick-Borne Diseases

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Phone: 203-785-7665

Breaker, Ronald R.

Sterling Professor, Mol Cell & Dev Biology; Investigator, Howard Hughes Med. Inst.
*[Jonathan Edwards College Fellow & **MCDB Faculty Advisor**]*

The discovery and analysis of noncoding RNAs, including riboswitches and ribozymes, and the engineering of novel RNA and DNA* enzymes *by directed evolution.

KBT 506, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
ronald.breaker@yale.edu
Phone: 203-432-9389

Breslow, David

Asst. Prof., Mol Cell & Dev Biology
[MCDB Faculty Advisor]

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

KBT 926, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
David.Breslow@yale.edu
Phone: 203-432-8280

Carlson, John R.

Eugene Higgins Prof., Mol Cell & Dev Biology
*[Pierson College Fellow & **MCDB Faculty Advisor**]*

The molecular basis of olfaction, taste, and mate recognition in Drosophila and insects that transmit global disease.

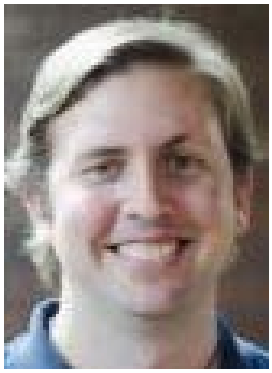
KBT 1128, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
john.carlson@yale.edu
Phone: 203-432-3541

Chandra, Sreeganga

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

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

BCMM 154D, 295 Congress Ave
PO Box 9812
New Haven, CT 06536-0812
sreeganga.chandra@yale.edu
Phone: 203-785-6172



Clark, Damon

Asst. Prof., Mol Cell & Dev Biology
*[Grace Hopper College Fellow & **MCDB Faculty Advisor**]*

Drosophila visual behaviors and circuitry; computational and modeling approaches to neural computation.

KBT 224, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
damon.clark@yale.edu
Phone: 203-432-0750

Clay, Nicole

Asst. Prof., Mol Cell & Dev Biology
*[Branford College Fellow & **MCDB Faculty Advisor**]*

Plant innate immunity and bio-defenses.

KBT 734, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
nicole.clay@yale.edu
Phone: 203-432-5890

Cooley, Lynn

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

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

SHM I329b, 333 Cedar St
PO Box 208005
New Haven, CT 06520-8005
lynn.cooley@yale.edu
Phone: 203-432-2733

Crews, Craig M.

Lewis B. Cullman Prof., Mol Cell & Dev Biology, Prof., Pharm & Chemistry
*[Pauli Murray College Fellow & **MCDB Faculty Advisor**]*

Exploration and control of signal transduction pathways using chemical probes.

KBT 400, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
craig.crews@yale.edu
crewslab.yale.edu
Phone: 203-432-9364

Dawson, Iain

Lecturer, Mol Cell & Dev Biology
*[Branford College Fellow & **MCDB Faculty Advisor**]*

Regulation of cell cycle in Drosophila melanogaster.

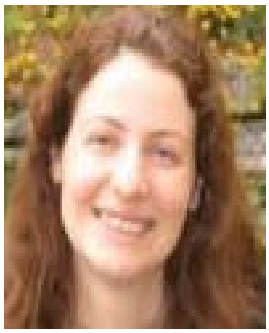
KBT 600, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
iain.dawson@yale.edu
Phone: 203-432-4539

Dellaporta, Stephen L.

Prof., Mol Cell & Dev Biology
*[Silliman College Fellow & **MCDB Faculty Advisor**]*

Sex determination and cell death in plants.

OML 450a, 165 Prospect St
PO Box 208104
New Haven, CT 06520-8104
stephen.dellaporta@yale.edu
Phone: 203-432-3895

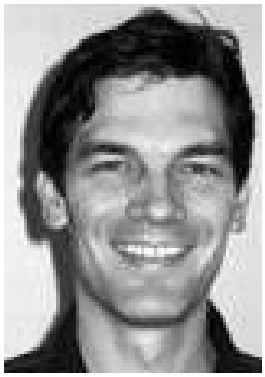


Dimitrova, Nadya

Asst. Prof., Mol Cell & Dev Biology
*[Pierson College Fellow & **MCDB Faculty Advisor**]*

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

KBT 936, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
nadya.dimitrova@yale.edu
Phone: 203-432-3492



Emonet, Thierry

Assoc. Prof., Mol Cell & Dev Biology and Physics; Dir. Grad Studies Mol Cell & Dev Biology
*[Jonathan Edwards College Fellow & **MCDB Faculty Advisor**]*

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

KBT 1048, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
thierry.emonet@yale.edu
Phone: 203-432-3516

Forscher, Paul

Prof., Mol Cell & Dev Biology
*[Davenport College Fellow & **MCDB Faculty Advisor**]*

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

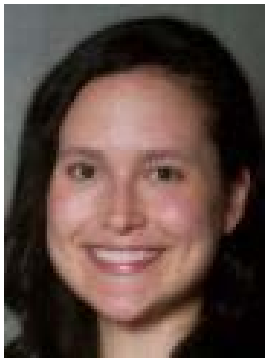
KBT 222, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
paul.forscher@yale.edu
Phone: 432-6344, 432-6345

Gendron, Joshua Martin

Asst. Prof., Mol Cell & Dev Biology
*[Berkeley College Fellow & **MCDB Faculty Advisor**]*

Plants, circadian clock, protein degradation.

KBT 706, 219 Prospect St
New Haven, CT 06511-2106
joshua.gendron@yale.edu
Phone: 432-7317



Hatzios, Stavroula K.

Asst. Prof., Mol Cell & Dev Biology
*[Branford College Fellow & **MCDB Faculty Advisor]***

The lab works on a broad range of chemical and biological tools to explore the functional proteome of bacterial infections. We are interested in understanding what bacterial and host proteins are active during infection, how they impact molecular interactions between pathogen and host, and how infection-associated environmental cues influence protein function at the host-microbe interface, using

Helicobacter pylori and Vibrio cholera in order to uncover biochemical pathways that shape severe gastrointestinal diseases including gastric cancer and cholera.

840 West Campus Dr
Adv Biosciences Ctr, 305B
PO Box 27391
West Haven, CT 06516-7391
Stavroula.Hatzios@yale.edu
Phone: 737-8121

Hochstrasser, Mark W

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

We work at the crossroads of biochemistry and genetics and take advantage of the many tools offered by budding yeast as a model eukaryote. The lab studies the dynamics of protein modification by ubiquitin and ubiquitin-related proteins and degradation by the proteasome.

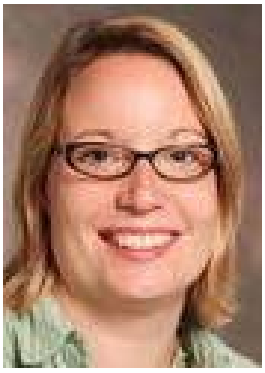
BASS 224, 266 Whitney Ave
PO Box 208114
New Haven, CT 06520-8114
mark.hochstrasser@yale.edu
Phone: 203 432-5101

Holley, Scott A.

Prof. Mol Cell & Dev Biology
*[Timothy Dwight College Fellow & **MCDB Faculty Advisor**]*

The systems developmental biology and biomechanics of spinal column development.

KBT 1034, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
scott.holley@yale.edu
Phone: 203-432-3230



Horsley, Valerie

Assoc. Prof., Mol Cell & Dev Biology
*[Pierson Fellow & **MCDB Faculty Advisor**]*

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

KBT 226, 219 Prospect St
PO BOX 208103
New Haven, CT 06520-8103
valerie.horsley@yale.edu
Phone: 203-436-9126

Irish, Vivian

Chair and Prof., Mol Cell & Dev Bio, Prof Ecology/ Evolutionary Bio
*[Davenport College Fellow & **MCDB Faculty Advisor**]*

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

OML 252a, 165 Prospect St
PO Box 208104
New Haven, CT 06520-8104
vivian.irish@yale.edu
Phone: 203-432-5572

Isaacs, Farren

Assoc. Prof., Mol Cell & Dev Biology
*[Jonathan Edwards College Fellow & **MCDB Faculty Advisor**]*

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

300 Heffernan Dr #B31
PO Box 27391
West Haven, CT 06516-7391
farren.isaacs@yale.edu
Phone: 203-432-3783

Iwasaki, Akiko

Waldemar von Zedtwitz Prof., Immunobiology and Mol Cell & Dev Biology, Investigator, Howard Hughes Medical Institute

Immune responses to viruses and vaccine design.

TAC S-655b, 300 Cedar St
PO Box 208011
New Haven, CT 06520-8011
akiko.iwasaki@yale.edu
Phone: 203-785-2919

Jacob, Yannick

Asst. Prof., Mol Cell & Dev Biology
*[Trumbull College Fellow & **MCDB Faculty Advisor**]*

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

OML 352B, 165 Prospect St
PO Box 208104
New Haven, CT 06520-8104
yannick.jacob@yale.edu

Phone: 203-432-8908

Jacobs-Wagner, Christine

Dir. Microbial Sciences Institute; Prof. Mol Cell & Dev Biology; Investigator Howard Hughes Med Inst; Prof. Microbial Pathogenesis
*[Saybrook College Fellow & **MCDB Faculty Advisor**]*

Mechanisms underlying bacterial multiplication and physiology.

ABC, Building 840 (Rm 264A), 300 Heffernan Dr
PO Box 27391
West Haven, CT 06516-7391
christine.jacobs-wagner@yale.edu
Phone: 203-737-7219

Kankel, Douglas R.

Prof. & Dir. Undergrad Studies, Mol Cell & Dev Biology
*[Benjamin Franklin College Fellow & **MCDB Faculty Advisor**]*

Nervous system development and function in Drosophila melanogaster.

KBT 1220, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
douglas.kankel@yale.edu
Phone: 203-432-3839

Kavathas, Paula

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

Study of immune response in lung cancer patients undergoing immunotherapy.

TAC S-641a, 300 Cedar St
PO Box 208035
New Haven, CT 06520-8035
paula.kavathas@yale.edu
Phone: 203-785-6223

Keshishian, Haig S.

Prof., Mol Cell & Dev Biology
*[Morse College Fellow & **MCDB Faculty Advisor**]*

Factors governing the formation of synaptic connections during development.

KBT 640a, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
haig.keshishian@yale.edu
Phone: 203-432-3478

Miller-Jensen, Kathryn

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

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

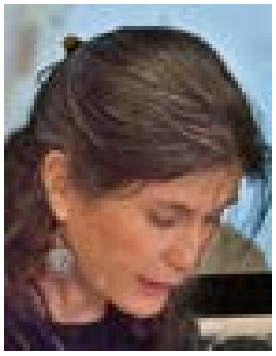
MEC 311, 55 Prospect St
PO Box 208260
New Haven, CT 06520-8260
kathryn.miller-jensen@yale.edu
Phone: (203) 432-4265

Mooseker, Mark S.

Ross Granville Harrison Prof., Mol Cell & Dev Biology
*[Grace Hopper College Fellow & **MCDB Faculty Advisor**]*

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

KBT 352, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
mark.mooseker@yale.edu
Phone: 203-432-3468



Moreno, Maria

Research Scientist & Lect. Mol Cell & Dev Biology, Academic Dir. Science, Technology & Research Scholars (STARS) Program
*[**MCDB Faculty Advisor**]*

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

OML 451, 165 Prospect St
PO Box 208104
New Haven, CT 06520-8104
maria.moreno@yale.edu
Phone: 203-436-4161

Nelson, F. Kenneth

Assoc. Rsrch. Scientist & Lect. Mol Cell & Dev Biology
*[Morse College Fellow & **MCDB Faculty Advisor**]*

Flow cytometry analysis and sorting.

KBT 716, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
kenneth.nelson@yale.edu
Phone: 203-432-5013

Pollard, Thomas D.

Sterling Prof., Mol Cell & Dev Biology, Prof. MB&B
*[Morse College Fellow & **MCDB Faculty Advisor**]*

Molecular mechanisms of actin-based cellular movements.

KBT 548, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
thomas.pollard@yale.edu
Phone: 203-432-3565

Pyle, Anna Marie

William Edward Gilbert Prof., Mol Cell & Dev Biology; Investigator Howard Hughes Med Inst; Prof. Chemistry
*[**MCDB Faculty Advisor**]*

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).

KBT 826, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
anna.pyle@yale.edu
Phone: 203-432-5633

Rodeheffer, Matthew

Asst. Prof., Comparative Med and Mol Cell & Dev Biology

Obesity, which is defined as an 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 extremely limited. The research in my laboratory is directed toward elucidating the cellular and molecular mechanisms that regulate fat mass and contribute to the development of obesity and obesity associated pathologies, such as diabetes and heart disease.

BML 329d, 310 Cedar Street
PO Box 208016
New Haven, CT 06520-8016
matthew.rodeheffer@yale.edu
Phone: 203-737-3370

Rosenbaum, Joel L.

Prof., Mol Cell & Dev Biology
*[Silliman College Fellow & **MCDB Faculty Advisor**]*

The assembly of cilia and its dependence on Intraflagellar Transport (IFT); the role of IFT proteins in ciliopathies; cilia as secretory organelles involved in cell and organismal communication.

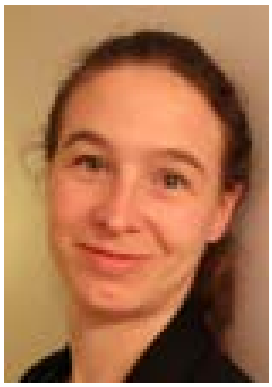
KBT 310a, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
joel.rosenbaum@yale.edu
Phone: 203-432-3472

Schepartz, Alanna

Sterling Prof., Chemistry, Prof., Mol Cell & Dev Biology

Our laboratory studies questions that span the combined interfaces of chemistry, biology, medicine, biophysics, and biotechnology. We seek to understand the fundamental chemistry that controls and regulates protein and small molecule interactions in cells and apply this knowledge to manipulate cell function and drive the development of next-generation therapeutics.

CRB 310, 275 Prospect St
PO Box 208107
New Haven, CT 0652907196
alanna.schepartz@yale.edu
Phone: 203-432-5094

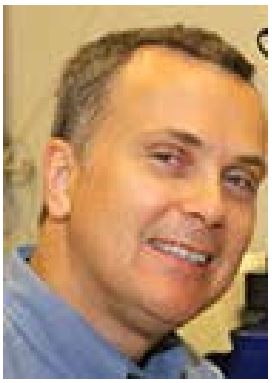


van Wolfswinkel, Josien

Asst. Prof., Mol Cell & Dev Biology
*[Branford College Fellow & **MCDB Faculty Advisor**]*

Study of RNA biology and genome regulation of pluripotent stem cells using the regenerating flatworm Schmidtea mediterranea.

KBT 1032, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
Josien.van.Wolfswinkel@yale.edu
Phone: 203-432-3520



Wolenski, Joseph S.

Research Scientist & Lecturer Mol Cell & Dev Biology, Dir. Light Microscopy Imaging Facility
*[Berkeley College Fellow & **MCDB Faculty Advisor**]*

Fluorescence microscopy imaging

KBT 330, 219 Prospect St
PO Box 208103
New Haven, CT 0620-8103
joseph.wolenski@yale.edu
Phone: 203-432-6912

Wyman, Robert J.

Prof., Mol Cell & Dev Biology
*[Grace Hopper Fellow & **MCDB Faculty Advisor**]*

Molecular biology and neurophysiology of gap junctions; genetic control of neural circuit development.

KBT 610a, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
robert.wyman@yale.edu
Phone: 203-432-3475

Zhong, Weimin

Assoc. Prof., Mol Cell & Dev Biology
*[Davenport College Fellow & **MCDB Faculty Advisor**]*

Regulation of stem cells and development of the mammalian neocortex.

KBT 616b, 219 Prospect St
PO Box 208103
New Haven, CT 06520-8103
weimin.zhong@yale.edu
Phone: 203-432-9233

Standard Track Worksheet

20__ | ***MCDB*** | ***BA***

SID _____ **Research Lab Mentor:** _____

Student: _____ **MCDB Faculty Advisor:** _____

BIOL Prerequisites:	**Placement Exam Score**		***Course #***	***Semester***	***Grade***	***Place Out***
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***	***Place Out***
General Chemistry				
(2 terms -161/165; or 163/167; or its equivalent)				

PHYSICS Prerequisites:	***Course #***	***Semester***	***Grade***	***Place Out***
Physics *(1 term of 170 or higher)*				

MATH Prerequisites:	***Course #***	***Semester***	***Grade***	***Place Out***
Math 115 or higher				

Core Courses: *BA - Choose any 2*	***Course #***	***Semester***	***Grade***
MCDB 200b Molecular Biology			
MCDB 202a Genetics			
MCDB 205b Cell Biology			
MCDB 210a Developmental Biology			
EITHER: MCDB 300a Biochemistry ***OR:*** MB&B 300a Principles of Biochemistry I			

GENERAL ELECTIVES: *(2 Total)*	***Course #***	***Semester***	***Grade***
BA: Choose 2 from above list or from MCDB 250 or above			
*(2nd term Orgo Chem and Statistics **NOT** acceptable for BA)*			
Additional Courses: (used to report Major GPA & Distinction in the Major)			

SPECIAL ELECTIVE:	***Course #***	***Semester***	***Grade***
BA: Choose 1 from MCDB 350 or above			

LABS:	***Course #***	***Semester***	***Grade***
BA: Choose 1 lab			
(from Biological Sciences: MCDB/EEB/MB&B Labs)			

SENIOR REQUIREMENT	***Course #***	***Semester***	***Grade***
BA: Senior Essay or 1 term of MCDB 475 Senior Independent Research MCDB			

Standard Track Worksheet

20__ | ***MCDB*** | ***BS & BS INT***

SID _____ **Research Lab Mentor:** _____

Student: _____ **MCDB Faculty Advisor:** _____

BIOL Prerequisites:	**Placement Exam Score**		***Course #***	***Semester***	***Grade***	***Place Out***
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***	***Place Out***
General Chemistry				
(2 terms -161/165; or 163/167; or its equivalent)				
General Chemistry Labs				
(2 terms - 134L/136L)				

ORG CHEM Prerequisites: *(BS & BS/INT only)*	***Course #***	***Semester***	***Grade***
Organic Chemistry *(1 term - 174a; or 175b; or 220a)*			
Organic Chemistry Lab *(1 term - 222L; or 223L; or 226L)*			
(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 Prerequisites:	***Course #***	***Semester***	***Grade***	***Place Out***
Physics *(170/171; or180/181; or 200/201; or 260/261)*				
BS & BS INT: 2 terms				

MATH Prerequisites:	***Course #***	***Semester***	***Grade***	***Place Out***
Math 115 or higher				

CORE COURSES: *(BS & BS INT - Choose any 3)*	***Course #***	***Semester***	***Grade***
MCDB 200b Molecular Biology			
MCDB 202a Genetics			
MCDB 205b Cell Biology			
MCDB 210a Developmental Biology			
EITHER: MCDB 300a Biochemistry ***OR:*** MB&B 300a Principles of Biochemistry I			

GENERAL ELECTIVES: *(2 Total)*	***Course #***	***Semester***	***Grade***
BS & BS/INT: Choose 2 from above list or from MCDB 250 or above			
(2nd term Orgo Chem and Statistics acceptable for BS/BS INT ***ONLY*** *)*			
Additional Courses: (used to report Major GPA & Distinction in the Major)			

SPECIAL ELECTIVE:	***Course #***	***Semester***	***Grade***
BS & BS INT: Choose 1 from MCDB 350 or above			

LABS:	***Course #***	***Semester***	***Grade***
BS & BS INT: Choose 2 labs (must be from MCDB)			

SENIOR REQUIREMENT:		***Course #***	***Semester***	***Grade***
BS: *(2 terms of Senior Research)*				
MCDB 475 a or b	Senior Independent Research in MCDB			
MCDB 485/486	Senior Research MCDB BS Major			
**MCDB 485/486 is preferred - but 2 terms of MCDB 475 (+ summer) will satisfy this req*				
BS INT: *(2 terms of Senior Research Intensive)*				
MCDB 495/496	Senior Research Intensive MCDB BS INT Major			

Biotechnology Track Worksheet 20__

MCDB	BA

SID _____ **Research Lab Mentor:** _____

Student: _____ **MCDB Faculty Advisor:** _____

BIOL Prerequisites:	**Placement Exam Score**		***Course #***	***Semester***	***Grade***	***Place Out***
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***	***Place Out***
General Chemistry				
(2 terms -161/165; or 163/167; or its equivalent)				

PHYSICS Prerequisites:	***Course #***	***Semester***	***Grade***	***Place Out***
Physics *(1 term of 170 or higher)*				

MATH Prerequisites:	***Course #***	***Semester***	***Grade***	***Place Out***
Math 115 or higher				

CORE COURSES: *BA - Choose 2*			***Course #***	***Semester***	***Grade***
	MCDB 200b	Molecular Biology			
	MCDB 202a	Genetics			
	MCDB 205b	Cell Biology			
	MCDB 210a	Developmental Biology			
EITHER: MCDB 300a Biochemistry ***OR:*** MB&B 300a Principles of Biochemistry I					

GENERAL ELECTIVES: *(2 Total)*				***Course #***	***Semester***	***Grade***
Required Track Course: MCDB 370b Biotechnology						
AND Choose 1 additional elective below						
BENG 351a	Biomedical Engineering I	CENG 412b	Chemical Engineering Laboratory			
BENG 352b	Biomedical Engineering II	CPSC 437a	Introduction to Databases			
BENG 410a	Basis of Bioimaging & Biosensing	CPSC 445b	Introduction to Data Mining			
BENG 435b	Biomaterial - Tissue Interactions	CPSC 470a	Artificial Intelligence			
BENG 457b	Biomechanics	CPSC 475b	Comp. Vision & Bio Perception			
BENG 464b	Tissue Engineering	MBB 420a	Macromolecular Structure			
CENG 210a	Chem Eng & Process Modeling	MBB 421b	Macromolecular dynamics			
CENG 411a	Separation & Purification Processes	MBB 443b	Eukaryotic Molecular Biology			

SPECIAL ELECTIVE:	***Course #***	***Semester***	***Grade***
BA: Choose 1 from MCDB 350 or above			

LABS:	***Course #***	***Semester***	***Grade***
BA: Choose 1 lab			
(from Biological Sciences: MCDB/EEB/MB&B Labs)			

SENIOR REQUIREMENT:	***Course #***	***Semester***	***Grade***
BA: Senior Essay or 1 term of MCDB 475 Senior Independent Research MCDB			

Biotechnology Track Worksheet

20__ | ***MCDB*** | ***BS & BS INT***

SID _____ **Research Lab Mentor:** _____

Student: _____ **MCDB Faculty Advisor:** _____

BIOL Prerequisites:	**Placement Exam Score**		***Course #***	***Semester***	***Grade***	***Place Out***
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***	***Place Out***
General Chemistry				
(2 terms -161/165; or 163/167; or its equivalent)				
General Chemistry Labs				
(2 terms - 134L/136L)				

ORG CHEM Prerequisites *(BS & BS/INT only)*	***Course #***	***Semester***	***Grade***
Organic Chemistry *(1 term - 174; or 175; or 220)*			
Organic Chemistry Lab *(1 term - 222L; or 223L; or 226L)*			
(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 Prerequisites:	***Course #***	***Semester***	***Grade***	***Place Out***
Physics *(170/171; or180/181; or 200/201; or 260/261)*				
BS & BS INT: 2 terms				

MATH Prerequisites:	***Course #***	***Semester***	***Grade***	***Place Out***
Math 115 or higher				

CORE COURSES: *(BS & BS INT - Choose any 3)*		***Course #***	***Semester***	***Grade***
MCDB 200b	Molecular Biology			
MCDB 202a	Genetics			
MCDB 205b	Cell Biology			
MCDB 210a	Developmental Biology			
EITHER: MCDB 300a Biochemistry ***OR:*** MB&B 300a Principles of Biochemistry I				

GENERAL ELECTIVES: *(2 Total)*				***Course #***	***Semester***	***Grade***
Required Track Course: MCDB 370b Biotechnology						
AND Choose 1 additional elective below						
BENG 351a	Biomedical Engineering I	CENG 412b	Chemical Engineering Laboratory			
BENG 352b	Biomedical Engineering II	CPSC 437a	Introduction to Databases			
BENG 410a	Basis of Bioimaging & Biosensing	CPSC 445b	Introduction to Data Mining			
BENG 435b	Biomaterial - Tissue Interactions	CPSC 470a	Artificial Intelligence			
BENG 457b	Biomechanics	CPSC 475b	Comp. Vision & Bio Perception			
BENG 464b	Tissue Engineering	MB&B 420a	Macromolecular Structure			
CENG 210a	Chem Eng & Process Modeling	MB&B 421b	Macromolecular dynamics			
CENG 411a	Separation & Purification Processes	MB&B 443b	Eukaryotic Molecular Biology			

SPECIAL ELECTIVES:	***Course #***	***Semester***	***Grade***
BS & BS INT: Choose 1 from MCDB 350 or above			

LABS:	***Course #***	***Semester***	***Grade***
BS & BS INT: Choose 2 labs (must be from MCDB)			

SENIOR REQUIREMENT:		***Course #***	***Semester***	***Grade***
BS: *(2 terms of Senior Research)*				
MCDB 475 a or b	Senior Independent Research in MCDB			
MCDB 485/486	Senior Research MCDB BS Major			
**MCDB 485/486 is preferred - but 2 terms of MCDB 475 (+ summer) will satisfy this req*				
BS INT: *(2 terms of Senior Research Intensive)*				
MCDB 495/496	Senior Research Intensive MCDB BS INT Major			

Neurobiology Track Worksheet

20__ | ***MCDB*** | ***BA***

SID _____ **Research Lab Mentor:** _____

Student: _____ **MCDB Faculty Advisor:** _____

BIOL Prerequisites:	**Placement Exam Score**		***Course #***	***Semester***	***Grade***	***Place Out***
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***	***Place Out***
General Chemistry				
(2 terms -161/165; or 163/167; or its equivalent)				

PHYSICS Prerequisites:	***Course #***	***Semester***	***Grade***	***Place Out***
Physics *(1 term of 170 or higher)*				

MATH Prerequisites:	***Course #***	***Semester***	***Grade***	***Place Out***
Math 115 or higher				

CORE COURSES: *BA - Choose any 2*			***Course #***	***Semester***	***Grade***
	MCDB 200b	Molecular Biology			
	MCDB 202a	Genetics			
	MCDB 205b	Cell Biology			
	MCDB 210a	Developmental Biology			
EITHER: MCDB 300a Biochemistry ***OR:*** MB&B 300a Principles of Biochemistry I					

GENERAL ELECTIVES: *(2 Total)*				***Course #***	***Semester***	***Grade***
Required Track Course: MCDB 320a Neurobiology						
AND Choose 1 additional elective below						
BENG 410a	Basis of Bioimaging & Biosensing	MCDB 361b	Dynamical Systems in Biology			
CPSC 475b	Comp Vision & Biol Perception	MCDB 430a	Biology of the Immune System			
MCDB 250b	Biololgy of Reproduction	MCDB 440b	Brain Development & Plasticity			
MCDB 315b	Pathobiology: Mechanisms of Adaptation & Disease	PSYC 270a	Research Methods Behavorial Neuro			
MCDB 415b	Cellular & Molecular Physiology	PSYC 320a	Cognitive Neuroscience			
MCDB 425a	Basic Concepts Genetic Analysis	PSYC 376a	Basics of Learning and Memory			

SPECIAL ELECTIVE:	***Course #***	***Semester***	***Grade***
BA: Choose 1 from MCDB 350 or above			

LABS:	***Course #***	***Semester***	***Grade***
BA: Choose 1 lab			
(from Biological Sciences: MCDB/EEB/MB&B)			

SENIOR REQUIREMENT:	***Course #***	***Semester***	***Grade***
BA: Senior Essay or 1 term of MCDB 475 Senior Independent Research MCDB			

Neurobiology Track Worksheet

20__ | ***MCDB*** | ***BS & BS INT***

SID _____ **Research Lab Mentor:** _____

Student: _____ **MCDB Faculty Advisor:** _____

BIOL Prerequisites:	**Placement Exam Score**		***Course #***	***Semester***	***Grade***	***Place Out***
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***	***Place Out***
General Chemistry				
(2 terms -161/165; or 163/167; or its equivalent)				
General Chemistry Labs				
(2 terms - 134L/136L)				

ORG CHEM Prerequisites: *(BS & BS/INT only)*	***Course #***	***Semester***	***Grade***
Organic Chemistry *(1 term - 174a; or 175b; or 220a)*			
Organic Chemistry Lab *(1 term - 222L; or 223L; or 226L)*			
(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 Prerequisites:	***Course #***	***Semester***	***Grade***	***Place Out***
Physics *(170/171; or180/181; or 200/201; or 260/261)*				
BS & BS INT: 2 terms				

MATH Prerequisites:	***Course #***	***Semester***	***Grade***	***Place Out***
Math 115 or higher				

CORE COURSES: *(BS & BS INT - Choose any 3)*	***Course #***	***Semester***	***Grade***
MCDB 200b Molecular Biology			
MCDB 202a Genetics			
MCDB 205b Cell Biology			
MCDB 210a Developmental Biology			
EITHER: MCDB 300a Biochemistry ***OR:*** MB&B 300a Principles of Biochemistry I			

GENERAL ELECTIVES: *(2 Total)*			***Course #***	***Semester***	***Grade***
Required Track Course: MCDB 320a Neurobiology					
AND Choose 1 additional elective below					
BENG 410a	Basis of Bioimaging & Biosensing	MCDB 361b	Dynamical Systems in Biology		
CPSC 475b	Comp Vision & Biol Perception	MCDB 430a	Biology of the Immune System		
MCDB 250b	Biololgy of Reproduction	MCDB 440b	Brain Development & Plasticity		
MCDB 315b	Pathobiology: Mechanisms of Adaptation & Disease	PSYC 270a	Research Methods Behavorial Neuro		
MCDB 415b	Cellular & Molecular Physiology	PSYC 320a	Cognitive Neuroscience		
MCDB 425a	Basic Concepts Genetic Analysis	PSYC 376a	Basics of Learning and Memory		

SPECIAL ELECTIVE:	***Course #***	***Semester***	***Grade***
BS & BS INT: Choose 1 from MCDB 350 or above			

LABS:	***Course #***	***Semester***	***Grade***
BS & BS INT: Choose 2 labs (must be from MCDB)			

SENIOR REQUIREMENT:		***Course #***	***Semester***	***Grade***
BS: *(2 terms of Senior Research)*				
MCDB 475 a or b	Senior Independent Research in MCDB			
MCDB 485/486	Senior Research MCDB BS Major			
**MCDB 485/486 is preferred - but 2 terms of MCDB 475 (+ summer) will satisfy this req*				
BS INT: *(2 terms of Senior Research Intensive)*				
MCDB 495/496	Senior Research Intensive MCDB BS INT Major			

Quantitative Biology Track Worksheet

20___ | ***MCDB*** | ***BA***

SID _____ **Research Lab Mentor:** _____

Student: _____ **MCDB Faculty Advisor:** _____

BIOL Prerequisites:	**Placement Exam Score**		***Course #***	***Semester***	***Grade***	***Place Out***
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***	***Place Out***
General Chemistry				
(2 terms -161/165; or 163/167; or its equivalent)				

PHYSICS Prerequisites:	***Course #***	***Semester***	***Grade***	***Place Out***
Physics *(1 term of 170 or higher)*				

MATH Prerequisites:	***Course #***	***Semester***	***Grade***	***Place Out***
Math 115a or b or higher				

Core Courses: *BA - Choose any 2*			***Course #***	***Semester***	***Grade***
	MCDB 200b	Molecular Biology			
	MCDB 202a	Genetics			
	MCDB 205b	Cell Biology			
	MCDB 210a	Developmental Biology			
EITHER: MCDB 300a Biochemistry ***OR:*** MB&B 300a Principles of Biochemistry I					

GENERAL ELECTIVES: (2 Total)				***Course #***	***Semester***	***Grade***
Required Track Course: MCDB 330 Intro Dynamical Systems in Biology						
AND Choose 1 additional elective below						
MCDB 320a	Neurobiology	MATH 251b	Stochastic Processes			
MCDB 361b	*Dynamical Systems in Biology *(preferred track elective)*	MB&B 302b	Principles of Biophysics			
BENG 467b	Systems Biology of Signaling	MB&B 435a	Mathematical Methods in Biophysics			
CENG 320a	Immunoengineering	MB&B 452b	Bioinformatics: Mining & Simulation			
CPSC 440b	Numerical Computation	MB&B 523a	Biological Physics			
CPSC 475a	Comp. Vision & Bio Perc.	PHYS 402b	Advanced Classical Physics			
MATH 246b	Ordinary Differential Equations					

SPECIAL ELECTIVE:	***Course #***	***Semester***	***Grade***
BA: Choose 1 from MCDB 350 or above			

LABS:	***Course #***	***Semester***	***Grade***
BA: Choose 1 lab			
(from Biological Sciences: MCDB/EEB/MB&B Labs)			

SENIOR REQUIREMENT	***Course #***	***Semester***	***Grade***
BA: (Senior Essay or 1 term of MCDB 475 Senior Independent Research)			

Quantitative Biology Track Worksheet

20___ | ***MCDB*** | ***BS & BS INT***

SID _____ **Research Lab Mentor:** _____

Student _____ **MCDB Faculty Advisor:** _____

BIOL Prerequisites:	**Placement Exam Score**		***Course #***	***Semester***	***Grade***	***Place Out***
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***	***Place Out***
General Chemistry				
(2 terms -161/165; or 163/167; or its equivalent)				
General Chemistry Labs				
(2 terms - 134L/136L)				

ORG CHEM Prerequisites *(BS & BS/INT only)*	***Course #***	***Semester***	***Grade***
Organic Chemistry *(1 term - 174; or 175; or 220)*			
Organic Chemistry Lab *(1 term - 222L; or 223L; or 226L)*			
(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 Prerequisites:	***Course #***	***Semester***	***Grade***	***Place Out***
Physics *(170/171; or180/181; or 200/201; or 260/261)*				
BS & BS INT: 2 terms				

MATH Prerequisites:	***Course #***	***Semester***	***Grade***	***Place Out***
Math 115 or higher				

CORE COURSES: *(BS & BS INT - Choose any 3)*	***Course #***	***Semester***	***Grade***
MCDB 200b Molecular Biology			
MCDB 202a Genetics			
MCDB 205b Cell Biology			
MCDB 210a Developmental Biology			
EITHER: MCDB 300a Biochemistry ***OR:*** MB&B 300a Principles of Biochemistry I			

GENERAL ELECTIVES: *(2 Total)*	***Course #***	***Semester***	***Grade***
Required Track Course: MCDB 330 Intro Dynamical Systems in Biology			
AND Choose 1 additional elective below			
MCDB 320a Neurobiology / MATH 251b Stochastic Processes			
MCDB 361b *Dynamical Systems in Biology *(preferred track elective)* / MB&B 302b Principles of Biophysics			
BENG 467b Systems Biology of Signaling / MB&B 435a Mathematical Methods in Biophysics			
CENG 320a Immunoengineering / MB&B 452b Bioinformatics: Mining & Simulation			
CPSC 440b Numerical Computation / MB&B 523a Biological Physics			
CPSC 475a Comp Vision & Bio Perc. / PHYS 402b Advanced Classical Physics			
MATH 246b Ordinary Differential Equations			

SPECIAL ELECTIVES:	***Course #***	***Semester***	***Grade***
BS & BS INT: Choose 1 from MCDB 350 or above			

LABS:	***Course #***	***Semester***	***Grade***
BS & BS INT: Choose 2 labs (must be from MCDB)			

SENIOR REQUIREMENT:	***Course #***	***Semester***	***Grade***
BS: *(2 terms of Senior Research)*			
MCDB 475 a or b / Senior Independent Research in MCDB			
MCDB 485/486 / Senior Research MCDB BS Major			
**MCDB 485/486 is preferred - but 2 terms of MCDB 475 (+ summer) will satisfy this req*			
BS INT: *(2 terms of Senior Research Intensive)*			
MCDB 495/496 / Senior Research Intensive MCDB BS INT Major			

MCDB 474 – Independent Research

FOR Underclassmen & Non-Majors taken as PASS / FAIL

MCDB 474 Student Contract

As a student conducting independent research for Yale College course credit in MCDB 474, I agree to the following:

I am expected to devote, on average, 10-12 hr/week in the lab to this research. I am aware that failure to do so will result in my withdrawal from the course. I will make every effort to attend my research mentor's laboratory meetings and present my research at least once in my research mentor's lab.

Name: _____ (Please Print)

Signature: _____ Phone: _____ Class _____

Email Address: _____

Research Mentor: _____ Dept.: _____(Please Print)

Title for Research: _____

MCDB 474 Research Mentor Contract:

One of the provisions for agreeing to accept a student into your laboratory for course credit in MCDB 474 is that you agree to the following:

I will expect that each 474 student in my laboratory commit an average of 10-12 hours of effort per week in the lab. If this is not the case, by mid semester of the term I will notify the student and the MCDB 474 coordinator that an increase in effort is expected. I am aware that failure to meet this expectation will result in the student's withdrawal from the course. I expect 474 students in my laboratory to attend our laboratory meetings and present their research at least once in the lab.

Student: _____ (Please Print)

Research Mentor: _____ (Please Print)

Signature of Research Mentor: _____

Department: _____ Phone: _____

Email Address: _____

It is the Student's responsibility to obtain the signatures and upload this form to the Canvas Assignment section.

If you have questions, contact crystal.adamchek@yale.edu

Due dates: Student and Mentor Contract; 1 Page Summary:
Fall: WEDNESDAY, SEPTEMBER 8, 2017
Spring: TUESDAY, JANUARY 26, 2018

Final Report Due:
Fall: FRIDAY, DECEMBER 9, 2017
Spring: FRIDAY, APRIL 28, 2018

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

To: Prospective MCDB 474a or b Students
From: Independent Research Courses Coordinator: Joseph Wolenski, David Breslow, Stavroula Hatzios

This is intended to give you an introduction and guidelines to the MCDB 474 (a and b) course. Students should always check the Canvas course site for additional information.

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**.

All papers should be uploaded to the Assignment section of Canvas by the deadlines stated. Additionally, please follow these formatting instructions: include a title page with the following information: (a) Title of Research, (b) Student Name, (c) Course & Term (i.e., MCDB 474 F14), and (e) PI Name. Make sure to include a header on pages 2 through end with (a) Student Name, (b) Course & Term, and (c) Page Number. Save papers in pdf format using the following nomenclature: *StudentLastName_FirstName_MCDBCourse_Term&Year.pdf.* ***Don't forget to send a copy to your PI (research mentor)!***

Safety Requirements:

Note that you will need to fulfill various safety and associated requirements to begin research, depending on your field of study. If you will be working with radioisotopes in a laboratory you must have attended a radiation safety training seminar at Yale. You will not be able to start your experiments unless this requirement is fulfilled. In addition, you should discuss with your supervisor whether you should take a chemical safety course. For further information on both these topics call the University Safety Dept. at Tel. 5-3550.

If your proposed research involves animal use your professor **must** have an approval for this protocol from IACUC. Your professor must send a new form to IACUC to include you in the protocol once your project has been approved. Finally, if you have not already done so, you need to complete an IACUC course before research can begin.

Course Requirements:

Student and Research Mentor Contracts: Due date: (1 week after start of classes).
These should be uploaded to the Assignments section of Canvas. Contracts are attached to these guidelines.

Summary Proposal: Due date: (1 week from first day of classes)
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 ~ 0.5 - 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 her/his NIH or NSF grants. This summary is due ***one week after the first day of classes.***
The types of proposal that are inappropriate 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: last day of classes***.***

A 12-15 page double-spaced report in the form of a typical **Research Journal** is due on the last day of classes uploaded to the Assignment section in Canvas. 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 your 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

FOR SENIOR REQUIREMENT

MCDB 475 Student Contract

As a student conducting independent research for Yale College course credit in MCDB 475, I agree to the following:

I am expected to devote, on average, 10-12 hr/week in the lab to this research. I am aware that failure to do so will result in my withdrawal from the course. I will make every effort to attend my research mentor's laboratory meetings and present my research at least once in my research mentor's lab. I will attend at least 2 of the MCDB Oral Presentation sessions and will present my research at one of them. I will make every effort to schedule my MCDB Oral Presentations at the time that fits with my mentor's schedule.

Name: _____ (Please Print)

Signature: _____ Phone: _____ Class _____

Email Address: _____

Research Mentor: _____ Dept.: _____(Please Print)

Title for Research: _____

MCDB 475 Research Mentor Contract:

One of the provisions for agreeing to accept a student into your laboratory for course credit in MCDB 475 is that you agree to the following:

I will expect that each 475 student in my laboratory commit an average of 10-12 hours of effort per week in the lab. If this is not the case, by mid semester of the term I will notify the student and the MCDB 475 coordinator that an increase in effort is expected. I am aware that failure to meet this expectation will result in the student's withdrawal from the course. I expect 475 students in my laboratory to attend our laboratory meetings and present their research at least once in the lab. I will attend my student's MCDB Oral Presentation. If I am unable to attend, I will ask another member of my laboratory to attend.

Student: _____ (Please Print)

Research Mentor: _____ (Please Print)

Signature of Research Mentor: _____

Department: _____ Phone: _____

Email Address: _____

It is the Student's responsibility to obtain the signatures and upload this form to the Canvas Assignment section.
If you have questions, please email crystal.adamchek@yale.edu

Due dates: Student and Mentor Contract; 1 Page Summary:
Fall: WEDNESDAY, SEPTEMBER 8, 2017
Spring: TUESDAY, JANUARY 26, 2018

Final Report Due:
Fall: FRIDAY, DECEMBER 9, 2017
Spring: FRIDAY, APRIL 28, 2018

MCDB 475 – Senior Independent Research

FOR SENIOR REQUIREMENT

To: Prospective MCDB 475a or b Students

From: Independent Research Courses Coordinator: Joseph Wolenski, David Breslow, Stavroula Hatzios

This is intended to give you an introduction and guidelines to the MCDB 475 (a and b) course. Students should always check the Canvas course site for additional information.

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 question. The course also requires a final written paper in the format of a **Research Article**.

All papers should be uploaded to the Assignment section in Clanvas by the deadlines stated. Additionally, please follow these formatting instructions: include a title page with the following information: (a) Title of Research, (b) Student Name, (c) Course & Term (i.e., MCDB 475 F14), and (e) PI Name. Make sure to include a header on pages 2 through end with (a) Student Name, (b) Course & Term, and (c) Page Number. Save papers in pdf format using the following nomenclature: *StudentLastName_FirstName_MCDBCourse_Term&Year.pdf.* ***Don't forget to send a copy to your PI (research mentor).***

Safety Requirements:

Note that you will need to fulfill various safety and associated requirements to begin research, depending on your field of study. If you will be working with radioisotopes in a laboratory you must have attended a radiation safety training seminar at Yale! You will not be able to start your experiments unless this requirement is fulfilled. In addition, you should discuss with your supervisor whether you should take a chemical safety course. For further information on both these topics call the University Safety Dept. at Tel. 5-3550.

If your proposed research involves animal use your professor **must** have an approval for this protocol from IACUC. Your professor must send a new form to IACUC to include you in the protocol once your project has been approved. Finally, if you have not already done so, you need to complete an IACUC course before research can begin.

Course Requirements:

Student and Research Mentor Contracts: Due date: (1 week after start of classes).

These should be uploaded to the Assignment section of Canvas. Contracts are attached to these guidelines.

Summary Proposal: Due date: (1 week after start of classes)

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 ~ 0.5 - 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 her/his NIH or NSF grants. This summary is due ***one week after start of classes.***

The types of proposal that are inappropriate 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: last day of classes**.**

A 12-15 page double-spaced report in the form of a typical **Research Journal** is due on the last day of classes uploaded to the Assignment section in Canvas. Well in advance of this deadline, you should meet with your research mentor to plan a general outline for your paper and engage him or her 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 your 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 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

MCDB 485 Student Contract:

As a student conducting year-long independent research for Yale College course credit and to fulfill the Senior requirement for the MCDB BS, I agree to the following:

I am expected to devote an average of 10-12 hr/week in the lab to this research. I am aware that failure to do so will result in my withdrawal from the course. I will make every effort to attend my research mentor's laboratory meetings, and present my research at least once/term in my research mentor's lab. I will attend at least 2 of the MCDB Oral Presentation sessions in the **SPRING** and will present my research at one of them. I will make every effort to schedule my MCDB Oral Presentations at the time that fits with my mentor's schedule.

Name: _____ (Please Print)

Signature: _____ Phone: _____ Class _____

Email Address: _____

Research Mentor: _____ Dept.: _____(Please Print)

Title for Research: _____

_____

MCDB 485 Research Mentor Contract:

I will expect that each 495 student in my laboratory commit an average of at least 10 hours effort per week in the lab. If this is not the case, by mid semester of the term I will notify the student and the MCDB 485 coordinators that an increase in effort is expected. I am aware that failure to meet this expectation will result in withdrawal from the course. I expect 485 students in my laboratory to attend our laboratory meetings and present their research at least once/term in the lab. I will attend my student's MCDB Oral Presentation in the **SPRING**. If I am unable to attend, I will ask another member of my laboratory to attend.

Student: _____ (Please Print)

Research Mentor: _____ (Please Print)

Signature of Research Mentor: _____

Department: _____ Phone: _____

Email Address: _____

It is the Student's responsibility to obtain the signatures and upload this form to the Canvas Assignment section.
If you have questions, contact crystal.adamchek@yale.edu

Due dates: Student and Mentor Contract and 1 Page Summary: WEDNESDAY, SEPTEMBER 8, 2017

Spring Oral Presentations: TBD Oral Presentations meet in KBT 1202 typically from 4:00 – 6:00 pm or 6:00 – 8:00 pm over several evenings in mid-late March and early April

Final Report Due:
Fall: FRIDAY, DECEMBER 9, 2017
Spring: FRIDAY, APRIL 28, 2018

Poster Symposium: Mid April (2-4pm) (Location TBD)

MCDB 485 – Senior Research

To: Prospective MCDB 485 students

From: Independent Research Courses Coordinator: John Carlson, Joseph Wolenski

Below is an introduction and guidelines to the MCDB 485 course. Students should always check the Canvas course site for additional information.

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 two semesters of experimental work (the minimum time expectation is 10-12 hr/week in the lab) aimed at generating data using experimental strategies designed to test an interesting research problem. In most cases the project will test a specific hypothesis. Only MCDB seniors may take this course, and only to fulfill the Senior Requirement for the MCDB BS degree.

Submission and Formatting Instructions for all written work: All papers should be uploaded to the Assignment section in Canvas by the deadlines stated. ***Additionally, please follow these formatting instructions:*** include a title page with the following information: (a) Title of Research, (b) Student Name, (c) Course & Term, and (e) PI Name. Make sure to include a header on pages 2 through end with (a) Student Name, (b) Course & Term and (c) Page Number. Save papers as a pdf using the following nomenclature: *StudentLastName_FirstName_MCDBCourse_Term&Year.pdf.* ***Do Please send a copy to your PI!***

Safety Requirements:

Note that you will need to fulfill various safety and associated requirements to begin research, depending on your field of study. If you will be working with radioisotopes in a laboratory you must have attended a radiation safety training seminar at Yale. You will not be able to start your experiments unless this requirement is fulfilled. In addition, you should discuss with your supervisor whether you should take a chemical safety course. For further information on both these topics call the University Safety Dept. at Tel. 5-3550.

If your proposed research involves animal use your professor **must** have an approval for this protocol from IACUC. Your professor must send a new form to IACUC to include you in the protocol once your project has been approved. Finally, if you have not already done so, you need to complete an IACUC course before research can begin.

Course Requirements:

Student and Research Mentor Contracts: Due date: (1 week after start of classes).

These should be uploaded to the Canvas Assignment section. Contracts are attached to these guidelines.

Summary Proposal: Due date: (1 week after start of classes)

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 her/his NIH or NSF grants. This summary is due ***one week after start of classes.***

The types of proposal that are inappropriate 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: (last day of classes)

A 5 page (double spaced) **Grant Proposal** is due on the ***last day of classes***. 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

Oral Presentations – SPRING only for MCDB 485 students 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 will make an oral presentation to a small group of students. Following a 10 minute presentation, students are expected to pose 2 or 3 questions to the group for discussion. There will be approximately 6 students presenting at each of the sessions. Students must present at one session and attend one additional small group session as a member of the audience.

Attendance will be taken. Failure to attend the 2 sessions will result in a loss of a half grade (e.g. a recommended A- will be lowered to a B+). All presentations will be held in KBT 1202; typically, from 4:00 – 6:00 pm or 6:00 -8:00 pm over several evenings. Spring: March/ April (TBD).

All students in the MCDB 485/486 courses are expected to attend a minimum of 2 MCDB Oral Presentation sessions in the Spring term, *(i.e., you will present at one session and attend 1 additional session for a total of 2 sessions)*. Signups will be handled through the Canvas site. All students should try to find a mutually agreeable time with their Research Mentors for their MCDB Oral Presentations. We have tried to be as flexible as possible in making these arrangements. Students will be expected to adhere to the time schedule as noted on Canvas. Each student must have a verified time slot for his/her presentation. Failure to attend both sessions will result in a loss of a half grade (*e.g.* a recommended A- will be lowered to a B+). You will not be required to attend any sessions in the Fall term.

These presentations should be made using Powerpoint. We will have a digital projector available; however, you should plan on bringing your own laptop to plug into the system. Talks are 10 minutes followed by 3-5 minutes for discussion/questions. Time and presentation order will be enforced.

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, his/her attendance at the session at which you are presenting is expected; if she/he 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 her/his schedule.

Spring Poster Symposium: Due Date: Mid April

The Poster Symposium will be held Mid April from 2-4pm – location to be determined. 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 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.

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.

If you continue in research, the first presentation you are likely to give at a scientific meeting is a poster, so this will be good practice. The fewer words and the LARGER THEY ARE WRITTEN make it easier for people to notice and examine your poster. If a poster contains a great deal of text in small font, the audience may not read it. The same applies to data. Tables with large numbers of entries may be ignored. Simple figures with a concise conclusion for each are optimal. You should begin to organize your poster well in advance and you should allow at least one day for planning it and at least one day for producing the various parts of it. Bring it to the session ready to assemble. Please keep in mind that content should take precedence over form. It is much more important that your poster be clear, informative, and thoughtful than that it look highly professional. Aesthetic appeal is of course nice, but the science is paramount. Finally, **discuss your presentation with your colleagues and research mentor well before the session** and if you have any further questions/concerns bring the preliminary poster to show the instructor in charge.

Spring Report – Research Journal: Due date: Last Day of Classes

A 12-15 page double-spaced paper is due on the last day of classes 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 your 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. The MCDB research coordinator retains final grade determination if the recommended grade is at variance with the overall quality/scope of the performance of other course participants. A final grade deduction will be taken if a student fails to attend at least two MCDB Oral Presentation sessions. Failure to attend the two sessions will result in a loss of a half grade (*e.g.* a recommended A- will be lowered to a B+). Your mentor will be asked to recommend an interim grade of satisfactory (S) or unsatisfactory (U) at the end of the Fall term based on your laboratory effort and Fall research paper. Students receiving an unsatisfactory grade will be asked to meet with the instructor in charge and the mentor to identify problems and outline strategies for improvement. In the Spring semester, students will receive a letter grade that will be retroactively applied to the Fall term.

MCDB 495 – Senior Research Intensive

MCDB 495 Student Contract:

As a student conducting year-long independent research for Yale College course credit and to fulfill the Senior requirement for the MCDB BS INT, I agree to the following:

I am expected to devote an average of 20 hr/week in the lab to this research. I am aware that failure to do so will result in converting my 495 enrollment to either MCDB 485 or 475 (single course credit) with the requisite requirements for those courses replacing those of 495. I will make every effort to attend my research mentor's laboratory meetings, and present my research at least once/term in my research mentor's lab. I will attend at least 2 of the MCDB Oral Presentation sessions in the **FALL** and will present my research at one of them. I will make every effort to schedule my MCDB Oral Presentations at the time that fits with my mentor's schedule.

Name: _____ (Please Print)

Signature: _____ Phone: _____ Class _____

Email Address: _____

Research Mentor: _____ Dept.: _____(Please Print)

Title for Research: _____

_____

MCDB 495 Research Mentor Contract:

I will expect that each 495 student in my laboratory commit an average of at least 20 hours effort per week in the lab. If this is not the case, by mid semester of the term I will notify the student and the MCDB 495 coordinators that an increase in effort is expected. I am aware that failure to meet this expectation will result in conversion of MCDB 495 into either MCDB 485 or 475 (reduction to 1 course unit/term). I expect 495 students in my laboratory to attend our laboratory meetings and present their research at least once/term in the lab. I will attend my student's MCDB Oral Presentation in the **FALL**. If I am unable to attend, I will ask another member of my laboratory to attend.

Student: _____ (Please Print)

Research Mentor: _____ (Please Print)

Signature of Research Mentor: _____

Department: _____ Phone: _____

Email Address: _____

It is the Student's responsibility to obtain the signatures and upload this form to the Canvas Assignment section.
If you have questions email crystal.adamchek@yale.edu .

Due dates: Student Contract, Mentor Contract and 1-2 page Summary: WEDNESDAY, SEPTEMBER 8, 2017
Fall Oral Presentations: TBD Oral Presentations meet in KBT 1202 typically from 4:00 – 6:00 pm or 6:00 – 8:00 pm over several evenings in early December

Final Report Due:
Fall: FRIDAY, DECEMBER 9, 2017
Spring: FRIDAY, APRIL 28, 2018

Poster Symposium: Mid April (2-4pm) (Location TBD)

MCDB 495 – Senior Requirement MCDB BS INT Major

To: Prospective MCDB 495 students

From: Independent Research Courses Coordinator: Joseph Wolenski, David Breslow, Stavroula Hatzios

Below is an introduction and guidelines to the MCDB 495 course. Students should always check the Canvas course site for additional information.

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 two semesters of experimental work, with a minimum time expectation of 20 hr/week in the lab, aimed at generating results using experimental strategies designed to address an interesting research problem. In most cases the project will test a specific hypothesis. Only MCDB seniors may take this course, and only to fulfill the Senior Requirement for the MCDB BS INT degree.

Submission and Formatting Instructions for All Written Work: All papers should be uploaded to the Assignment section in Canvas by the deadlines stated. ***Additionally, please follow these formatting instructions:*** include a title page with the following information: (a) Title of Research, (b) Student Name, (c) Course & Term, and (e) PI Name. Make sure to include a header on pages 2 through the end of the document with (a) Student Name, (b) Course & Term and (c) Page Number. Save papers as a pdf using the following nomenclature:
StudentLastName_FirstName_MCDBCourse_Term&Year.pdf. ***Do Please send a copy to your PI***

Safety Requirements:

Note that you will need to fulfill various safety and associated requirements to begin research, depending on your field of study. If you will be working with radioisotopes in a laboratory you must have attended a radiation safety training seminar at Yale. You will not be able to start your experiments unless this requirement is fulfilled. In addition, you should discuss with your supervisor whether you should take a chemical safety course. For further information on both these topics call the University Safety Dept. at Tel. 5-3550.

If your proposed research involves animal use your professor **must** have an approval for this protocol from IACUC. Your professor must send a new form to IACUC to include you in the protocol once your project has been approved. Finally, if you have not already done so, you need to complete an IACUC course before research can begin.

Course Requirements:

Student and Research Mentor Contracts: Due date: (1 week after start of classes).

These should be uploaded to the Assignment section of Canvas. Contracts are attached to these guidelines.

Summary Proposal: Due date: (1 week after start of classes)

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 her/his NIH or NSF grants. This summary is due ***one week after the start of classes.***

The types of proposal that are inappropriate 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: (last day of classes)

A 5-10 page (double spaced) **Grant Proposal** is due on the ***last day of classes***. 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 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.

TBD Oral Presentations meet in KBT 1202 typically from 4:00 – 6:00 pm or 6:00 – 8:00 pm over several evenings in early December.

Each student will make an oral presentation to a small group of students. Following a 10 minute presentation, students are expected to pose 2 or 3 questions to the group for discussion. There will be approximately 6 students presenting at each of the sessions. Students must present at one session and attend one additional small group session as a member of the audience.

Attendance will be taken. Failure to attend the 2 sessions will result in a loss of a half grade (e.g. a recommended A- will be lowered to a B+). All presentations will be held in KBT 1202.

All students in the MCDB 495/496 courses are expected to attend a minimum of 2 MCDB Oral Presentation sessions in the Fall term, *(i.e., you will present at one session and attend 1 additional session for a total of 2 sessions)*. Signups will be handled through the Canvas server. All students should try to find a mutually agreeable time with their Research Mentors for their MCDB Oral Presentations. We have tried to be as flexible as possible in making these arrangements. Students will be expected to adhere to the time schedule as noted on Canvas. Each student must have a verified time slot for his/her presentation. Failure to attend both sessions will result in a loss of a half grade (*e.g.* a recommended A- will be lowered to a B+). You will not be required to attend any sessions in the Spring term.

These presentations should be made using Powerpoint. We will have a digital projector available; however, you should plan on bringing your own laptop to plug into the system. Talks are 10 minutes followed by 3-5 minutes for discussion/questions. Time and presentation order will be enforced.

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, his/her attendance at the session at which you are presenting is expected; if she/he 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 her/his schedule.

Spring Poster Symposium: Due Date: Mid April

The Poster Symposium will be held Mid April from 2-4pm – location to be determined. 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 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.

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.

If you continue in research, the first presentation you are likely to give at a scientific meeting is a poster, so this will be good practice. The fewer words and the LARGER THEY ARE WRITTEN make it easier for people to notice and examine your poster. If a poster contains a great deal of text in small font, the audience may not read it. The same applies to data. Tables with large numbers of entries may be ignored. Simple figures with a concise conclusion for each are optimal. You should begin to organize your poster well in advance and you should allow at least one day for planning it and at least one day for producing the various parts of it. Bring it to the session ready to assemble. Please keep in mind that content should take precedence over form. It is much more important that your poster be clear, informative, and thoughtful than that it look highly professional. Aesthetic appeal is of course nice, but the science is paramount. Finally, **discuss your presentation with your colleagues and research mentor well before the session** and if you have any further questions/concerns bring the preliminary poster to show the instructor in charge.

Spring Report – Research Journal: Due date: Last Day of Classes

A 15-20 page double-spaced paper is due on the last day of classes 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 your 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. The MCDB research coordinator retains final grade determination if the recommended grade is at variance with the overall quality/scope of the performance of other course participants. A final grade deduction will be taken if a student fails to attend at least two MCDB Oral Presentation sessions. Failure to attend the two sessions will result in a loss of a half grade (*e.g.* a recommended A- will be lowered to a B+). Your mentor will be asked to recommend an interim grade of satisfactory (S) or unsatisfactory (U) at the end of the Fall term based on your laboratory effort and research proposal. Students receiving an unsatisfactory grade will be asked to meet with the instructor in charge and the mentor to identify problems and outline strategies for improvement. In the Spring semester, students will receive a letter grade that will be retroactively applied to the Fall term.

MCDB 585 – Research in MCDB for BS/MS Candidates

MCDB 585 Student Contract

As a student conducting independent research for Yale College course credit and the BS/MS Senior requirement, I agree to the following:

- I am expected to devote an average of 20 hr/week to this research. I am aware that failure to do so will result in withdrawal from the masters program.
- I will make every effort to attend my research mentor's laboratory meetings.
- I will attend at least three of the student MCDB Oral Presentation. I understand that failure to do so will result in a half letter grade reduction.

Name: _____ (Please Print)

Signature: _____ Phone: _____

Email Address: _____

Research Mentor: _____ Dept.: _____(Please Print)

Committee Member: _____ Dept: _____

Committee Member: _____ Dept:_____

Committee Member: _____ Dept:_____

Title for Research: _____

_____

_____

Please return this form to the Office of the Director of Undergraduate Studies:
1220 KBT, crystal.adamchek@yale.edu.

Due dates: Student Form (Contract): Due 1 week after start of Spring classes
Poster Session: Mid April (TBD) [Optional for MCDB 585 students]
Proposal with Research Plan to Committee & Office of DUS:
(before February, 2018)
MCDB Oral Presentations sessions: TBD (Optional attendance)
Presentation of Prospectus to Committee (schedule before last day of classes)

Written Prospectus due to Committee and office of the DUS via email to (crystal.adamchek@yale.edu) approximately 1 week before presentation.

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 20 hrs/week to their research.

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.

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 the office of the DUS a few days 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 single spaced, not including references.

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 2 of the MCDB Oral Presentations sessions**: Spring (Dates TBD)
585 students are *not* expected to give an oral presentation during these sessions.

7) Poster: Students are invited to attend the MCDB Poster Session Mid April, and may (*but are not required to*) present a poster.

MCDB 585 Committee Meeting Form – Spring

Student: _____ Date of Committee Meeting: _____

Thesis Advisor: _____ Dept: _____

Committee Member: _____ Dept: _____

Committee Member: _____ Dept: _____

Committee Member: _____ Dept: _____

Research Title : _____

_____

Proposal/Plan: _____

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Please return this form to the Office of the Director of Undergraduate Studies:
1220 KBT, crystal.adamchek@yale.edu.

MCDB 595 – Intensive Research in MCDB for BS/MS Candidates

MCDB 595 Student Contract

As a student conducting year-long independent research for Yale College course credit and the BS/MS Senior requirement, I agree to the following:

- I am expected to devote an average of 20 hr/week to this research. I am aware that failure to do so will result in withdrawal from the Masters program.
- I will make every effort to attend my research mentor's laboratory meetings.
- I will attend 2 of the student MCDB Oral Presentation sessions in the Fall term. I understand that failure to do so will result in a half letter grade reduction.
- I will make every effort to schedule my oral presentation at the time that fits with my mentor's schedule.

Name: _____ (Please Print)

Signature: _____ Phone: _____ Class _____

Email Address: _____

Research Mentor: _____ Dept.: _____(Please Print)

Committee Member: _____ Dept: _____

Committee Member: _____ Dept: _____

Committee Member: _____ Dept: _____

Title for Research: _____

_____

_____

Please return this form to the Office of the Director of Undergraduate Studies:
1220 KBT, crystal.adamchek@yale.edu.

Due dates: Committee Meetings: Fall and Spring
Oral Presentations meet in KBT 1202 in Fall: TBD Oral Presentations meet in KBT 1202 typically from 4:00 – 6:00 pm or 6:00 – 8:00 pm over several evenings in early December.

Poster: Mid-April (TBD)

Thesis due to committee at least one week before Thesis defense

Thesis defense (schedule and defend before last day of Classes)

Guidelines for MCDB 595

For 595:

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

MCDB Oral Presentations - FALL only for MCDB 595 students 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 will make an oral presentation to a small group of students. Following a 10 minute presentation, students are expected to pose 2 or 3 questions to the group for discussion. There will be approximately 6 students presenting at each of the sessions. Students must present at one session and attend one additional small group session as a member of the audience.

Attendance will be taken. Failure to attend the 2 sessions will result in a loss of a half grade (*e.g.* a recommended A- will be lowered to a B+). All presentations will be held in early December in KBT 1202; typically, from 4 – 6:00 pm or 6:00 -8 pm over several evenings.

All students taking MCDB 595 for Senior Requirement are expected to attend a minimum of 2 MCDB Oral Presentation sessions, *(i.e., you will present at one session and attend 1 additional session for a total of 2 sessions)*. Signups will be handled through the Canvas site. All students should try to find a mutually agreeable time with their Research Mentors for their MCDB Oral Presentations. We have tried to be as flexible as possible in making these arrangements. Students will be expected to adhere to the time schedule as noted on Canvas. Each student must have a verified time slot for his/her presentation. Failure to attend both sessions will result in a loss of a half grade (*e.g.* a recommended A- will be lowered to a B+).

These presentations should be made using Powerpoint. We will have a digital projector available; however, you should plan on bringing your own laptop to plug into the system. Talks are 10 minutes followed by 3-5 minutes for discussion/questions. Time and presentation order will be enforced.

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, his/her attendance at the session at which you are presenting is expected; if she/he 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 her/his schedule.

Poster: Students should present a poster for the research symposium in April.

The Poster Symposium will be held Mid April from 2-4pm – location to be determined. 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 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.

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.

If you continue in research, the first presentation you are likely to give at a scientific meeting is a poster, so this will be good practice. The fewer words and the LARGER THEY ARE WRITTEN make it easier for people to notice and examine your poster. If a poster contains a great deal of text in small font, the audience may not read it. The same applies to data. Tables with large numbers of entries may be ignored. Simple figures with a concise conclusion for each are optimal. You should begin to organize your poster well in advance and you should allow at least one day for planning it and at least one day for producing the various parts of it. Bring it to the session ready to assemble. Please keep in mind that content should take precedence over form. It is much more important that your poster be clear, informative, and thoughtful than that it look highly professional. Aesthetic appeal is of course nice, but the science is paramount. Finally, **discuss your presentation with your colleagues and research mentor well before the session** and if you have any further questions/concerns bring the preliminary poster to show the instructor in charge.

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 (attached) and provide to the Research Mentor for completion. The Research Mentor is expected to provide the completed form to the office of the DUS.

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 as to the date of the thesis defense – and provide the attached form to the research mentor before the defense. The Research Mentor is expected to provide the completed form to the office of the DUS.

Written Thesis:

- 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.
- 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.

MCDB 595 Committee Meeting Form – Fall / Spring
(Circle Appropriate Semester)

Student: _____ Date of Committee Meeting: _____

Thesis Advisor: _____ Dept: _____

Committee Member: _____ Dept: _____

Committee Member: _____ Dept: _____

Committee Member: _____ Dept: _____

Research: _____

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Proposal/Plan: _____

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Please return this form to the Office of the DUS: 1220 KBT, via email: crystal.adamchek@yale.edu
Copies to be provided to all Committee Members and Student from DUS office

Proposed MCDB 595 Grade (Fall): _____ **(letter grade) should reflect MCDB Oral Presentation, lab performance.*

Additional Factors for Grade Consideration by the Committee:

1. Progress made since last Committee meeting
2. Knowledge of scientific literature relevant to the research project
3. Thinking critically about research project
4. Demonstrating initiative and independence in experimental design and project directions
5. Motivation and work ethic
6. Technical competence at the bench, trouble-shooting ability
7. Quality and clarity of oral presentations

Proposed MCDB 595 Grade (Spring): _____ **(letter grade) should reflect MCDB Oral Presentation, Thesis Defense, written Thesis, Poster presentation and lab performance.*

LEGEND

Front Top Left: Daniel McQuaid (Yale ’18) pouring a gel to be used in western blotting analysis of cellular protein abundance. *[Photo Credit: Crystal Adamchek]*

Front Top Right: The Carlson lab studies the molecular and cellular basis of olfaction and taste in insects, including the model genetic organism *Drosophila* (the small one in the photo) and insects that transmit disease, such as the tsetse fly (the large one). Insects use their olfactory and taste systems to find the humans they bite. Insect-borne diseases afflict hundreds of millions of people each year. *[Photo Credit: Geoff Attardo]*

Front Top Middle: Spatial patterning of cell cycle regulators, MipZ (green) and ParA (red), in *Caulobacter crescentus* cells blocked for cell division. *[Photo Credit: Ivan Surovtsev]*

Front Bottom: Mohammed Malik (Yale ’18) and Wei Liu, members of the Gendron Lab, study the circadian clock and flowering phenotypes of Arabidopsis in KBT's green room. *[Photo Credit: Suyuna Eng Ren]*

Back Top Left: Frank Chen (Yale ’17) is preparing yeast strains for super resolution microscopy. *[Photo Credit: Thomas Pollard]*

Back Top Right: Sara Meyers, (Yale ’18) working on plasmid DNA purification in *Experimental Techniques in Cellular Biology* (MCDB 344) taught by Joseph S. Wolenski *[Photo Credit: Joseph Wolenski]*

Back Middle: A group photo of the MCDB 344 Laboratory class “Experimental Techniques in Cellular Biology” run by Joseph S. Wolenski *[Photo Credit: Joseph Wolenski]*

Back Bottom Left: Students in MCDB 344L learn essential protocols and research strategies. Jolanta Pach, (Yale ’18) is examining a centrosome preparation following centrifugation. *[Photo Credit: Joseph Wolenski]*

Back Bottom Right: Members of the MCDB Student Advisory Committee for the academic year 2017-2018. *[Photo Credit: Chanthia Ma (Yale ’17)]*

Artist rendering of the proposed Yale Science Building