Molecular, Cellular, Developmental Biology

2015 - 2016

This booklet is intended to supplement the Yale College Programs of Study for the Academic Year 2015-2016. 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 biology 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 48 faculty members, 63 postdoctoral fellows, and 38 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, and procedures for assessing environmental impact, this major can also be helpful in law and business 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

*(*Note: All courses list the Primary instructor first)*

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

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
A complex immune system evolved in multicellular organisms to survive against attacks by pathogens. The human immune system uses multiple strategies to respond to the various classes of pathogens. Most often, the system works well to respond to mutating organisms, but sometimes it may attack one's own cells in autoimmune disease, or even substances that are not threatening as in allergies. In this course, we will cover the variety of responses generated by our immune system, and learn about pathogenic microbes as well as normally not disease-producing microbes in the human microbiome. Specific microbes such as influenza, HIV, and HPV are discussed along with historical analysis of the development of vaccines such as polio and of the AIDs epidemic.

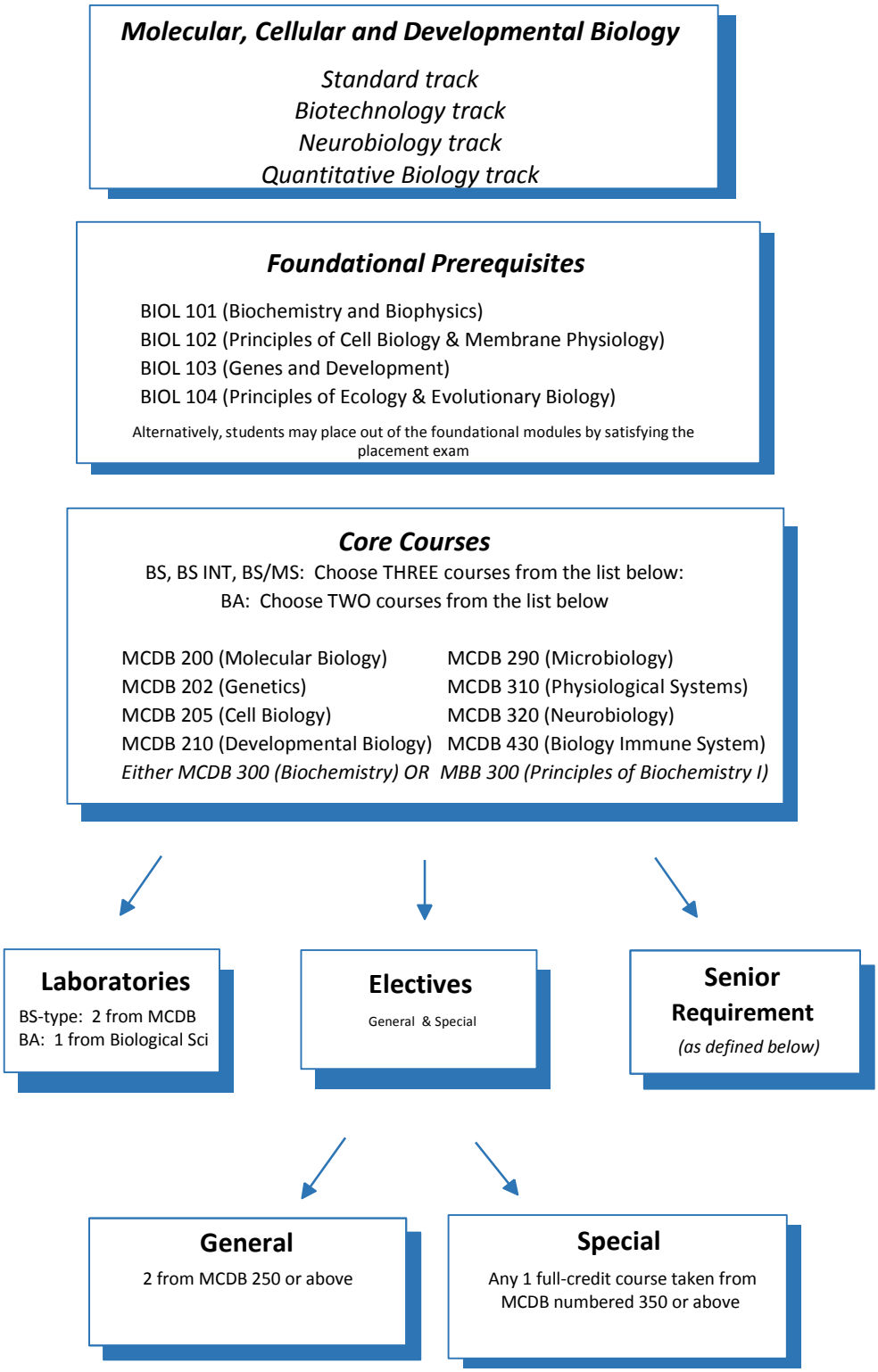
MCDB 103b, **Cancer**. Alexia Belperron
MW 1.00-2.15
Introduction to the biology of cancer, with a focus on leukemia, skin cancer, and cancers linked to infection. Topics include genetics, biochemistry, immunity, infection agents, and challenges for prevention and treatment. *Intended for non–science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

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

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 and establishment of infection; immune responses and the associated challenges to prevention and treatment. *Class is designed primarily for underclassmen.*

MCDB 109b, **Immunity and Contagion**. Paula Kavathas
TTh 2.30-3.45
Introduction to the human immune system, followed by study of microorganisms such as influenza, HIV, human papilloma virus and human microbiota. Discussion of the biology of each organism and interaction with the host immune system, reinforcing principles of immune function. *Enrollment limited to freshmen and sophomores.*

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	BIOL 101a or b	Biochemistry and Biophysics
	1/2 credit per module	BIOL 102a or b	Principles of Cell Biology & Membrane Physiology
		BIOL 103a or b	Genes and Development
		BIOL 104a or b	Principles of Ecology & Evolutionary Biology
Chemistry			
General	2 terms	CHEM 161/164; or 163/167; or its equivalent	
Physics	1 terms	PHYS 170 or higher	
Math			
Calculus	1 term	MATH 115 or higher (not including MATH 190)	
		(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	BIOL 101a or b	Biochemistry and Biophysics
	1/2 credit per module	BIOL 102a or b	Principles of Cell Biology & Membrane Physiology
		BIOL 103a or b	Genes and Development
		BIOL 104a or b	Principles of Ecology & Evolutionary Biology
Chemistry			
General	2 terms	CHEM 161/164; or 163/167; or its equivalent	
General Labs	2 terms	CHEM 134L/136L	
Organic	1 term	CHEM 174a; or 175b; or 220a	
Organic Labs	1 term	CHEM 222L; or 223L; or 226L	
Physics			
	2 terms	PHYS 170/171 or higher	
Math			
Calculus	1 term	MATH 115 or higher *(not including MATH 190)*	

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 or statistics (e.g. STAT 105 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 221L. 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. However, one or more of these foundational Biology courses may be explicitly required as prerequisites for upper-level MCDB courses. More information on the Placement Exam can be found at this website: http://yalecollege.yale.edu/biology-1.

Requirements by Major

Below are the requirements formally approved by the Yale College Faculty for the Classes of 2017 and beyond. Students in the Class of 2016 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 2017 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)
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 NEW 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 & Membrane Physiology BIOL 103a or b Genes 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) 1 term of Physics (170 or higher) 1 term of Math (115 or higher – not including Math 190; 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 200 – Molecular Biology MCDB 202 – Genetics MCDB 205 – Cell Biology MCDB 210 – Developmental Biology MCDB 290 – Microbiology MCDB 300 – Biochemistry; OR MBB 300 – Principles of Biochemistry I MCDB 310 – Physiological Systems MCDB 320 – Neurobiology MCDB 430 – Biology of the Immune System
General Electives **2.0 Credits.**	Two general electives from MCDB numbered 250 or above. Two laboratory courses from either MCDB 342L and 343L; or 344L and 345L 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, MB&B and ANTH).*
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/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 & Membrane Physiology BIOL 103a or b Genes 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 (174a; 175b; or 220a) 1 term of Organic Chemistry Lab (222L; or 223L; or 226L) 2 terms of Physics (170, 171 or higher) 1 term of Math 115 or higher *(not including Math 190; or STAT course)*
Core Courses **3.0 Credits.**	*Core Courses – choose any 3* MCDB 200 – Molecular Biology MCDB 202 – Genetics MCDB 205 – Cell Biology MCDB 210 – Developmental Biology MCDB 290 – Microbiology MCDB 300 – Biochemistry; OR MBB 300 – Principles of Biochemistry I MCDB 310 – Physiological Systems MCDB 320 – Neurobiology MCDB 430 – Biology of the Immune System
General Electives **2.0 Credits.**	Two general electives from MCDB numbered 250 or above. Two laboratory courses from either MCDB 342L and 343L; or 344L and 345L 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 laboratories 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	Same as BA or BS *PLUS:* MCDB 320	Same as BA or BS *PLUS:* MCDB 261
General Electives *1.0 Credits*	Same as BA or BS ***ADDITIONAL CHOICES:*** BENG 351 BENG 352 BENG 410 BENG 435 BENG 457 BENG 464 CENG 210 CENG 411 CENG 412 CPSC 437 CPSC 445 CPSC 470 CPSC 475 MBB 420 MBB 421 MBB 443	Same as BA or BS ***ADDITIONAL CHOICES:*** BENG 410 CPSC 475 MCDB 240 MCDB 310 MCDB 315 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 MBB 452 MBB 320 MBB 435 MBB 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)*	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 B.A. 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 individual 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 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 Independent Research: MCDB 485a/486b Senior Requirement MCDB BS. 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 Independent 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 it 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 Requirement MCDB BS Intensive, for four credits during their senior year.

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 in molecular biology, biochemistry, genetics, cell biology, neurobiology, physiology, computational biology, plant sciences, and evolution. 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://www.mcdb.yale.edu http://www.yale.edu/yusbs/researchinfo.html, as well as listed on the bulletin board outside of the Office of the Director of Graduate Studies (KBT 1220). Detailed descriptions of research programs in MCDB can also be found on page 41 of this booklet.

Research Courses

Independent study courses earns 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".

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

MCDB BS

MCDB 485/486:	Research in MCDB: for students seeking the BS degree.

MCDB BS INT

MCDB 495/496:	Intensive Research in MCDB: for students seeking the BS INT degree.

MCDB BS/MS

MCDB 595: Intensive Research in MCDB for BS/MS Candidates: for students seeking the BS/MS degree.

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 475a or b before their senior year, but it does not substitute for other course requirements. MCDB 475 counts toward the 36 credits required for the Yale College degree; but other than meeting the senior requirement, MCDB 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.

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 475a or b Independent Research in MCDB: 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 Requirement MCDB BS Major: 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 Requirement MCDB BS INT Major: 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 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 is possible through several programs. More information can be found at: http://yalecollege.yale.edu/student-services/funding-opportunities 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 twelve 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 that are held in the fall before classes get started.

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 48 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 first page 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 48 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. 46).

Recommendations for Premedical Students

The Yale Pre-Med Office (Undergraduate Career Services) http://ocs.yale.edu/content/premedical-studies-yale-college distributes the following table to students interested in pursuing the Pre-Med track at Yale.

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 Medical School Admissions Requirements (MSAR).

Grades of C or higher are required in all areas noted below.

Chemistry (General) **(One year recommended of both lecture and lab, unless placing into advanced level courses and have acceleration credits on transcript)**	
Lecture	161 and 163; 165 and 167; check department web site for more advanced options
Lab	134L and 136L
If during freshman year you complete Freshman Organic Chemistry or regular Organic Chemistry and labs, and receive two acceleration credits to fulfill inorganic chemistry, you typically only need an additional term of biochemistry. Check the requirements of medical schools to be certain that they will accept this combination. Refer to the Medical School Admission Requirements.	
Chemistry (Organic) **(One year recommended of both lecture and lab)**	
Lecture	Freshman Organic Chemistry 174a and 175b; Sophomore Organic Chemistry 220 and 221 or 230
Lab	222L and 223L
Biochemistry **(One term of lecture recommended)**	
Lecture	MCDB 300B or MB&B 300a (some majors will require MB&B 301B)
Lab	MB&B 251La/MCDB 301La

Biology **(One year recommended of both lecture and lab)**	
Lecture Lab	BIOL 101, 102, 103 & 104 modules; any other combination of upper level biology courses. Any combination of MCDB and/or E&EB labs; MBB 251 and BENG 355 are also acceptable.
Physics **(One year recommended of both lecture and lab)**	
Lecture Lab	170a and 171b, 180a and 181b, 200a and 201b, or 260a and 261b 165La and 166Lb, or 205L and 206L
College Math **(One term recommended of each; Calculus requirement may vary if you have acceleration credits)**	
Calculus Statistics	through MATH 115 or 116; MATH 120 is required for some majors; ENAS 151 is also acceptable STAT 100-109; or STAT 238; or PSYC 200; or SOCY 162; or Biostatics in a graduate department
Psychology and Sociology **(One term recommended of each)**	
Psychology Sociology	Introductory Psychology Health of the Public SOCY126b Demography, Gender, and Health SOCY 361 Inequality in America SOCY 314 Gender, Race, Genetic Testing SOCY 311
English **(Two terms recommended)**	
• Any course in the English Department; most courses in the Literature Department; courses in literature from cultural departments (taught in English Translation are acceptable to fulfill this requirement.	

- Some medical schools will accept Writing Intensive (WR) courses to fulfill one term; many medical schools prefer at least one writing course.

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 in the AAMC publication, Medical School Admission Requirements, which is available in the Health Professions Department at the Office of Undergraduate Career Services.

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 should obtain a copy of the OCS publication, *General Information About MD/PhD Programs*. All are available on the OCS website at http://ocs.yale.edu/sites/default/files/MD-PhD-programs.pdf or at the OCS office.

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 particular 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 (275,000 units), and fossil plants (100,000 units), as well as its collections of modern birds (100,000 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.

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 Canto 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 modern light microscope imaging facility supervised by Dr. Joseph Wolenski. These microscopes are available to the Yale scientific

community at competitive hourly rates. Equipment includes two Zeiss LSM 510 confocal inverted microscopes, including one with near infrared two-photon imaging capabilities and a temperature controlled stage. The Department also houses a spinning disk confocal microscope and a Nikon wide-field microscope equipped with a color camera for histological slides and a sensitive CCD camera for excellent fluorescence imaging.

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.research.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. Eric Larson, the garden manager leads a staff that includes David Garinger, indoor plant curator, Chris Bolick research plant curator, 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 permission from the instructor is needed. 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 (Surjit Chandhoke)
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 and Membrane Physiology.**
Fall: Valerie Horsley (Samantha Lin)
Spring: Mark Mooseker (Surjit Chandhoke)
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. **Genes and Development.**
Fall: Vivian Irish (Surjit Chandhoke)
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: Leo Buss (Surjit Chandhoke)
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.*

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.*

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.*

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

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 and Lyme disease. Biology of the pathogens including modes of transmission and establishment of infection; immune responses and the associated challenges to prevention and treatment. *Intended for non–science majors. Prerequisite: high school biology.*

*MCDB 109b. **Immunity and Contagion.**
Paula Kavathas
TTh 2.30-3.20 Meets RP
Introduction to thebasics 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
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 biological function. *Prerequisite: CHEM 112 and 113, or 114 and 115, or 118, or a score of 5 on the Advanced Placement test in Biology, or BIOL 101 or equivalent performance on the corresponding biological sciences placement examination; 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

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, Vivian Irish, Douglas Kankel

TTh 1.00-2.15

Cellular differentiation and its genetic and molecular control; fertilization, cleavage, and morphogenesis of plants and animals; polarity and positional information; organogenesis and development of specialized tissues; evolution and development. *Prerequisites: BIOL 101, 102, and 103, or equivalent performance on the corresponding biological sciences placement examinations.*

MCDB 290b. **Microbiology.**

Christine Jacobs-Wagner

TTh 1.00-2.15

Cell structure of microorganisms, bacterial genetics, microbial evolution and diversity, microbial development, microbial interaction, chemotaxis and motility, gene regulation, microbial genomics, host defense systems, infectious diseases, viruses, and biological weapons. *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.*

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

MCDB 300bG/MB&B 200b. **Biochemistry.**

Ronald Breaker, Nicole Clay

MWF 9.25-10.15

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

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 125 or 220.*

MCDB 310aG/BENG 350aG. **Physiological Systems.**
Stuart Campbell, Peter Aronson, Emile Boulpaep, Elizabeth Holt, Mark Saltzman, David Zenisek
MWF 9.25-10.15

The course develops a foundation in human physiology by examining the homeostasis of vital parameters within the body, and the biophysical properties of cells, tissues, and organs. Basic concepts in cell and membrane physiology are synthesized through exploring the function of skeletal, smooth, and cardiac muscle. The physical basis of blood flow, mechanisms of vascular exchange, cardiac performance, and regulation of overall circulatory function are discussed. Respiratory physiology explores the mechanics of ventilation, gas diffusion, and acid-base balance. Renal physiology examines the formation and composition of urine and the regulation of electrolyte, fluid, and acid-base balance. Organs of the digestive system are discussed from the perspective of substrate metabolism and energy balance. Hormonal regulation is applied to metabolic control and to calcium, water, and electrolyte balance. The biology of nerve cells is addressed with emphasis on synaptic transmission and simple neuronal circuits within the central nervous system. The special senses are considered in the framework of sensory transduction. Weekly discussion sections provide a forum for in-depth exploration of topics. Graduate students evaluate research findings through literature review and weekly meetings with the instructor. *Prerequisites: CHEM 113 or 115 or PHYS 180a and 181b, or BIOL 101 and 102.*

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. *After a year of chemistry; a course in physics is strongly recommended.*

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 LABORATORIES

[Choose any 1 for BA degree (may also choose labs from EEB/MBB/ANTH for the BA degree). Choose any 2 MCDB labs for BS and BS IINT degrees.]

MCDB 201Lb. **Molecular Biology Laboratory.**
Maria Moreno
M or W 1.30-5.30 Meets RP WR

Basic molecular biology training in a project-based laboratory setting. Experiments analyze gene function through techniques of PCR, plasmid and cDNA cloning, DNA sequence analysis, and protein expression and purification. Instruction in experimental design, data analysis, and interpretation. *Prerequisite: For freshmen and sophomores. Concurrently with or after MCDB 200. 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 biological research and common methodologies in the biological sciences with an emphasis on the utility of model organisms. Techniques and methods commonly used in biochemistry, genetics and molecular and developmental biology, experimental design, data analysis and display, and scientific writing. *Prerequisite: Concurrently with or after BIOL 101, 102, and 103, or equivalent performance on the placement exam, or by permission of instructor.*

MCDB 241Lb. **Laboratory for Biology of Reproduction and Development.**

Josh Johnson

TW or Th 1.30-5.00

Laboratory investigation of reproductive and developmental processes. Emphasis on mammalian reproduction and embryonic development in classic vertebrate and invertebrate systems. Topics include gametogenesis, ovulation, hormonal control of reproduction, and investigation of embryogenesis in the frog and the fruit fly Drosophila. *Enrollment limited. Concurrently with or after MCDB 210 or 240. 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

T 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 good laboratory practice, advanced molecular biology topics, experimental design, data analysis and display, 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. For juniors who have completed MCDB 201L, 221L, or equivalent and are planning their senior research projects. No research laboratory experience required. Special registration procedures apply. Interested students must contact the instructors and attend an organizational meeting.*

MCDB 321LaG. **Laboratory for Neurobiology.**
Haig Keshishian, Brett Berke, 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 many of the technologies from molecular and cell biology. Laboratories meet twice a week for the first half of the term. With or after MCDB 202, 205, or 300. *Enrollment limited. Special registration procedures apply. Students must consult the instructor prior to the first week of classes.*

*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 must consult the instructor prior to the first week of classes.*

*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. Core Courses above may also be considered general electives once the Core requirements are met.

MCDB 240b. **Biology of Reproduction.**
Hugh Taylor, Josh Johnson
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 261bG. **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.*

MCDB 315b. **Biological Mechanisms of Reaction to Injury.**
S. David Hudnall, Joanna Gibson, Jon Morrow, Jeffrey Sklar
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 SPECIAL ELECTIVE COURSES

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

MCDB 361aG/PHYS 562/CBB 562/MBB 562. **Dynamical Systems in Biology.**
Damon Clark, Jonathan Howard
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 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 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. Students should contact the instructor prior to the first week of classes. *Prerequisites: courses in cell biology, biochemistry and genetics, or permission of instructor.*

*MCDB 450b. **The Human Genome.** Stephen Dellaporta
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.

MCDB INDEPENDENT RESEARCH

MCDB 475a or b. **Independent Research in MCDB.**
John Carlson
HTBA
Research projects under faculty supervision, ordinarily taken to fulfill the senior requirement. This course may be taken before the senior year, but it cannot substitute for other requirements. 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 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. Fulfills the senior requirement for the BA degree if taken in the senior year.

*MCDB 485a and 486b. **Senior Requirement MCDB BS Major.**
John Carlson
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 must attend (but are not required to present) 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. Fulfills the senior requirement for the MCDB BS degree if taken in the senior year.

*MCDB 495a and 496b. **Senior Requirement MCDB BS INT Major.**
John Carlson
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. Fulfills the senior requirement for the MCDB BS Intensive major.

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 in MCDB 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 500bU/MB&B 500bU. **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 562aU/PHYS 562a/CBB 562a/MBB 562a/MCDB 361a. **Dynamical Systems in Biology**.
See MCDB 361 for primary description.

MCDB 570bU. **Biotechnology.**
Craig Crews, Kenneth Nelson, Joseph Wolenski
MW 11.35-12.50
See MCDB 370 for primary description

MCDB 591b/ENAS 991b/MBB 591b/PHYS 991b. **Integrated Workshop.**
Lynne Regan, Joerg Bewersdorf, Simon Mochrie, Corey O'Hern
3 HTBA
This required course for students in IGPPEB involves hands-on laboratory modules with students working in pairs. A biology student is paired with a physics or engineering student; a computation/theory student is

paired with an experimental student. The modules are devised so that a range of skills are acquired, and students learn from each other.

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.**

Anna Pyle

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 in cellular and molecular biology but does not require a previous course in physical chemistry. One class per week is a lecture introducing a topic. The second class is a discussion of one or two research papers utilizing those methods.

MCDB 660a. **Structure, Function, and Development of Vascular Plants.**

Graeme Berlyn

TTh 4.00-5.15

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

F 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 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.**
Scott Holley
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.**
Staff
Th 4.00-5.30
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.**
Craig Crews and Staff
HBTA

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

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

2014-2015 Undergraduate Research Projects

Research Faculty & Dept.	*Project Titles*
Abrahams, Vikki *OB/GYN*	The Role of the Fas/Fas Ligand System in Regulating Trophoblast Responses to Viral ssRNA
Aronson, Peter *Int Med*	The Effects of Glycosylation on the Dimerization of SLC26A6
Bender, Jeffrey *Immuno*	mRNA Binding Proteins and miRNA: Competing Mechanisms Behind the Regulation of the Production of VEGF-C in Macrophages and their Effects on Lymphangiogenesis
Bindra, Ranjit *Ther Rad*	Development of Novel Live Cell Multicolor Competition Assay for High-Throughput Screening
	Development of a Novel, High-Throughput Assay to Assess Double-Strand Break DNA Repair in Cancer Cells
Blumenfeld, Hal *Neurology*	Finding a Mechanism for Intrinsic Brain Activity Effects of Absence Seizures on C3H/HeJ Mice Behavior
Bordey, Angelique *Neurosurgery*	Assessing Neurite Morphology in MTORC1 Hyperactive Cortical Neurons
Breaker, Ronald *MCDB*	T-Large Ribozymes: Natural Variants of Self-splicing RNAs that Generate RNA Minicircles
	The Exploration of Ligand Candidates for a New Riboswitch Class
Chandra, Sreeganga *Neurology*	Characterization of Auxilin Function and Phenotype
Cheng, Yung-chi *Pharmacology*	Induction of the NRF2 Transcription Pathway by Herbal Medicines
Chun, Hyung *Cardiology*	Role of miR-335 Downregulation as a Key Effector of Statin Pleiotropy in the Endothelium
Clark, Damon *MCDB*	Can Contrast Differences Trick the *Drosophila* Motion Detector?
Clay, Nicole *MCDB*	Artificial Evolution of Innate Immune receptors toward Pathogen-specific Perception in *Arabidopsis thaliana*

	Pathogen Recognition through FLS2 Receptor Evolution in *Arabidopsis*
Colon-Ramos, Daniel *Cell Biology*	The Role of Electrical Synapses in the AFD Thermosensory Neuron of the *Caenorhabditis elegans* Thermotaxis Circuit
	A Novel Role of *phosphofructokinase-1* in Synaptic Vesicle Cluster Maintenance in *C. elgans*
Craft, Joseph *Immunobiology*	Identification of Novel Immunomodulatory Compounds from Amazonian Endophytes
Crews, Craig *MCDB*	Developing a Halo Tag-based System for Intracellular Protein Heterodimerization
DiLeone, Ralph *Psychiatry*	Role of Lipopritein Lipase in Ventral Tegmental Area Regulation of Food Intake
Ferguson, Shawn *Cell Biology*	Characterization of a Novel Mechanism that Regulates Cellular Nutrient Homeostasis
Fikrig, Erol *Microbial Path*	Role of Mosquito Salivary Protein SG1L3 during *Plasmodium* Infection of Hepatocyte-Like Cell Line
Flannery, Clare *Endocrinology*	Gene Expression in Endometrial Hyperplasia and Carcinoma
Forscher, Paul *MCDB*	Effects of Serotonin Treatment on the Spatio-temporal Characteristics of Traction Force in the Growth Cone
Gerstein, Mark *MB&B*	Determining Conservation and Functional Significance of Positions Along the Human Tetratricopeptide Repeat Motif
Gonzalez, Anjelica *Biomed Eng*	Assessing Changes in Membrane Protein Expression During Neutrophil Transmigration using Isobaric Tags for Relative and Absolute Quantitation (iTRAQ)
	Determining the Expression Patterns of Leukocyte Adhesion Molecules on Endothelial Cells and Pericytes
Greco, Valentina *Genetics*	Spontaneous Tumor Regression is Driven by Wnt/Retinoic Acid Signaling Cross-Talk

Greer, Charles *Neurobiology*	Olfactory Sensory Neuron Development: Odorant Receptors are Expressed after Axons Reach the Olfactory Bulb
Grigorenko, Elena *Child Study Center*	Studying Genetic Variants of Oxytocin (OXT) and Receptor (OXTR) in Regards to Parenting
Handelsman, Jo *MCDB*	How to Stop Bacterial Mob Psychology: Novel Inhibitors of Quorum Sensing and Biofilm Formation
Herold, Kevan *Immunobiology*	Evaluating Differences in Natural Killer Cells and in T-Cells of Responders and Non-Responders to Anti-CD3 Therapy (Teplizumab) among Type I Diabetic Patients
Higley, Michael *Neurobiology*	The Behavioral and Morphological Effects of Brief, Uncontrollable Stress in Juvenile Mice
Horsley, Valerie *MCDB*	Characterization and Manipulation of Macrophages in Dermal Adipose Tissue
	Transforming Growth Factor-β Pathway Activation during Wound Healing for Adipocyte Stimulation of Fibroblast Migration and Synthesis of Extracellular Matrix Components
Hurwitz, Michael *Oncology*	Characterizing the Role of GEX-3 Interactors in Regulating Cell Engulfment
Isaacs, Farren *MCDB*	Higher Order Recoding of the Genetic Code Creating Two New Codon Channels for Synthetic Amino Acids
Ivanova, Natalia *Genetics*	Characterization of Developmental Pluripotency Associated Proteins 2 and 4 (Dppa 2/4)
Iwasaki, Akiko *Immunobiology*	Ire 1α Mediated Cell Death Evasion
Johnson, Joshua *OB/GYN*	The Role of the Sodium Iodide Symporter NIS in the Female Reproductive Tract
Jonas, Elizabeth *Endocrinology*	Bcl-x_L at the Synapse - Metabolism and Synaptic Plasticity
Kaech, Susan *Immunobiology*	Effects of TGF-β on Identity, Expression, and Migration of T_H1 and T_{FH} Effector Cells

Kazmierczak, Barbara *Infect Diseases*	Comparative Study on the Antibacterial Activity of Amazonian Endophyte Extracts Against Methicillin-resistant Staphylococcus aureus (MRSA)
Kidd, Kenneth *Genetics*	Single Nucleotide Polymorphic Variation in Eight Tunisian Populations
King, Megan*Cell Biology*	Measurement of Mechanical Tension Across KASH Proteins at *Schizosaccharomyces Pombe* Linc Complexes using Biosensors
Kliman, Harvey *Endocrinology*	The Relationship Between Serotonin and Autism
Ko, Albert *Public Health*	Putative Outer Membrane Protein is a Novel Virulence Factor for *Leptospira Interrogans*
Koo, Peter *Cancer Center*	Combining a CREB-CBP Inhibitor with an Hsp90 Inhibitor Produces a Synergistic Anti-Proliferative Effect in KRAS Mutant NSCLC
Kriegel, Martin *Immunobiology*	Exploring the Role of Gut Commensals in a Model of Antiphospholipid Syndrome
Kyriakides, Themis *Pathology*	Characterization of Microglia Phenotypes and their Effects during the Foreign Body Response
	Investigating the Role of TSP2 in Vascular Injury
Laubach, Mark *Neurology*	Noradrenergic Influences on Measures of Adaptive Control in the Medial prefrontal Cortex
Levy, Ifat *Comp Med*	Neural Correlates of Decision-Making under Riska nd Ambiguity in the Gain and Loss Domains
Lombroso, Paul *Child Study Center*	The Anti-STEP Activity of Ecuadorian Endophytic Natural Products
Loria, Patrick *Chemistry*	Isotpoically Labeling *Sulfolobus Solfataricus* PTP to Examine conformational Motions
Lusk, Patrick *Cell Biology*	Visualizing the Nuclear Pore Complex with Super Resolution Microscopy
McCarthy, Gregory *Psychology*	Race of Faces as Represented by Multi-Voxel Patterns

Medzhitov, Ruslan *Immunobiology*	The Role and Regulation of Yap1 in Cell Proliferation
	The Role of NFIL3 in Macrophage M2 Polarization
Meffre, Eric *Immunobiology*	The Elusive Nature of Human IgM+CD27+B Cells
Noonan, James *Genetics*	Identifying Target Genes of the Autism-Implicated Transcription Factor NFIA
Nguyen, Don *Pathology*	The Epigenetic Regulation of Lung Differentation and Cancer Metastasis
O'Connor, Kevin *Neurology*	Characterizing Antigen Experience of Tumor Inflintrating Lymphocytes in Seminomas
Parikh, Sunil *Infect Diseases*	DNA Fingerprinting of Parasites from Clinical Trials of Malaria in Uganda
Park, In-Hyun *Genetics*	The Elucidation of X Chromosome Status During Human Somatic Cell Reprogramming
	Generation of Human Cell Lines Carrying specific Mutations in *MeCP2*, a Gene Encoding Methyl CpG Binding Protein 2, via the use of the CRISPR/Cas9 Genome Editing System
Picciotto, Marina *Neurobiology*	Cholinergic Tone in the Amygdala Mediates Anxiety - and Depression-Like Behaviors in Mice
Pittenger, Christopher *Psychology*	Decidedly Uncertain in our Ambiguous Decisions: The Neurobiology of Decision-Making and Gender Differences in Uncertainty Intolerance
Pollard, Thomas *MCDB*	Type I Interphase Protein Nodes are Regulated by the Septation Initiation Network
Pusztai, Lajos *Medical Oncology*	The Role of Germ line Polymorphisms in Dictating the Effects of Somatic Mutations in Breast Cancer
Rinehart, Jesse *C&MP*	Investigating Renal Ion Transport Pathways Through Protein-Protein Interactions and a Synthetic WNK-SPAK System
Robek, Michael *Pathology*	Improving Oncolytic Viral Therapy for Hepatocellular Carcinoma using Recombiant Vesicular Stomatitis Virus

Rothlin, Carla *Immunobiology*	Protein S: A Suppressive Factor Expressed by Regulatory T Cells?
Schatz, David *Immunobiology*	Creating and Optimizing a System to Inducibly Express Activation-Induced Cytidine Deaminase (AID) in Ramos and ARP1 Cells
Schepartz, Alanna *Chemistry*	A Multiplex Automated Gene Engineering Approach to Optimize the Rewiring Potential of Synthetic Adaptor Proteins in Mammalian Cells
Shulman, Gerald *Endocrinology*	Characterizing the Role of BNIP3 in Hepatic Substrate Utilization
Slack, Frank *MCDB*	Auto-regulation of miR-125 microRNA Transcription
Small, Dana *Psychiatry*	The Effect of Calories from Liquids Versus Solids on Metabolic Response
Soll, Dieter *MB&B*	Substrates Range of Aminoacyl-tRNA Synthetases-Aminoacyl-tRNA Synthetases Substrate Poly-Specificities and its Substrate Range Alterations by tRNA Anticodon Variants
Strittmatter, Stephen *Genetics*	The role of Prion Protein in Dendritic Spine Density of CA1 Pyramidal and Layer V Barrel Cortex Neurons in Alzheimer's Disease Mice
Strobel, Scott *MB&B*	The Effect of Co-Culturing on the Biochemical Profiles of *Streptomyces* Species Isolated from Amazon Rainforest Plants
	The Effect of Co-Culturing on the Antibacterial Activity of Endophytic *Streptomyces* Isolated from Amazon Rainforest Plants
Sung, Patrick *MB&B*	The Fanconi Anemia Genetic Pathway and the DIDO Gene Locus: Regulators of Chromosomal Stability and DNA Damage
Taylor, Hugh *OB/GYN*	Characterization of Endometrial Cell Proliferation in a Hyperinsulinemic, Euglycemic Mouse Model
	Bisphenol-A Exposure *in utero* Modulates Extrogen Response in the Liver of CD-1 Mice
	The Differentiation of Endometrium Derived Stem Cells into Cardiomyocyte-like Cells *In Vitro*

Turner, Paul *EEB*	Exploring the Potential for Novel Antiviral Compounds Isolated from Endophytic Natural Products Characterization and Experimental Evolution of Thermotolerance in the Cystoviridae Family of Bacteriophage Viruses
Vaccarino, Flora *Child Psychiatry*	The Use of Patient-Derived iPSCs to Elucidate the Abnormally-Regulated Developmental Networks that Give Rise to Autism
Weidhaas, Joanne *Ther Rad*	The BRCA2 3'UTR SNP rs15869 as a Predictor of Radiation Sensitivity in Prostate Cancer Treatment

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

Murat Acar
Asst Prof Mol Cell & Dev Biology
300 Heffernan Dr #B31, West Haven, CT 06516
murat.acar@yale.edu
Phone: 203-737-3255
*[Ezra Stiles College Fellow & **MCDB Faculty Advisor**]*

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

Sidney Altman
Emeritis, Sterling Prof Mol Cell & Dev Biology and Chemistry
KBT 402, 219 Prospect St, New Haven, CT 06511-2106
sidney.altman@yale.edu
Phone: 203-432-3500
*[Trumbull College Fellow & **MCDB Faculty Advisor**]*

Role in vivo of an enzyme with a catalytic RNA subunit; mechanism of action of that enzyme; synthesis and testing of a new antibiotic.

Shirin Bahmanyar
Asst Prof Mol Cell & Dev Biology
KBT 810, 219 Prospect Street, New Haven, CT 06511-2106
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Phone: 203 432-5561
*[**MCDB Faculty Advisor**]*

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

Robert Bazell
Adjunct Prof Mol Cell & Dev Biology
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Alexia Belperron #
Res Sci Medicine (Rheumatology) & Lect Mol Cell & Dev Biology
TAC S-520, 333 Cedar Street New Haven, CT 06520-8056
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Phone: 203-785-7665

Development of novel Magnetic Resonance Spectroscopy (MRS) techniques.

Ronald R. Breaker
Henry Ford II Prof Mol Cell & Dev Biology; Investigator in Howard Hughes Med Inst; Chn Mol Cell & Dev Biology
KBT 506, 219 Prospect St, New Haven, CT 06511-2106
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Phone: 203-432-9389
*[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.

John R. Carlson
Eugene Higgins Prof of Molecular, Cellular & Developmental Biology
KBT 1128, 219 Prospect St, New Haven, CT 06511-2106
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Phone: 203-432-3541
*[Pierson College Fellow & **MCDB Faculty Advisor**]*

Olfaction and taste in Drosophila and malaria mosquitoes.

Surjit K. Chandhoke
Lect Mol Cell & Dev Biology; Assoc Rsrch Scientist Mol Cell & Dev Biology
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Phone: 203-432-3481
*[**MCDB Faculty Advisor**]*

Molecular mechanisms of cell motility and epithelial barrier regulation in the gastrointestinal tract.

Sreeganga Chandra #
Asst Prof of Neurology/CNNR and Mol Cell & Dev Biology
BCMM 154d, 295 Congress Ave, New Haven, CT 06519-1418
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Phone: 203-785-6172

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

Damon Clark
Asst Prof Mol Cell & Dev Biology
KBT 232, 219 Prospect St, New Haven, CT 06511-2106
damon.clark@yale.edu
Phone: 203-432-8402
*[Calhoun College Fellow & **MCDB Faculty Advisor**]*

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

Nicole Clay
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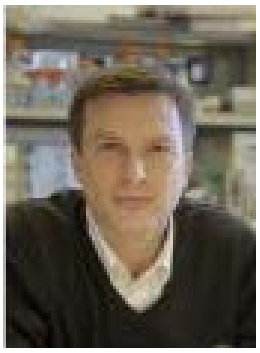
Phone: 203-432-4540
*[Branford College Fellow & **MCDB Faculty Advisor**]*

Plant innate immunity and bio-defenses.

Lynn Cooley #
Dean of the Graduate School, Jonathan Edwards College Fellow, C.N.H. Long Prof Genetics & Prof Cell Biology and Mol Cell & Dev Biology and Cell Biology
SHM I329b, 333 Cedar St, New Haven, CT 06510-3206
lynn.cooley@yale.edu
Phone: 203-785-5067

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



Craig M. Crews
Lewis B. Cullman Prof Mol Cell & Dev Biology, Prof Pharmacology & Chemistry
KBT 400, 219 Prospect St New Haven, CT 06511-2106
craig.crews@yale.edu
Phone: 203-432-9364
*[Pierson College Fellow & **MCDB Faculty Advisor**]*

Exploration and control of signal transduction pathways using chemical probes.

Iain Dawson
Lect Mol Cell & Dev Biology
219 Prospect St, New Haven, CT 06511-2106
iain.dawson@yale.edu
Phone: 203-432-6265
*[**MCDB Faculty Advisor**]*

Regulation of cell cycle in Drosophila melanogaster.

Stephen L. Dellaporta
Prof Mol Cell & Dev Biology
OML 450a, 219 Prospect St, New Haven, CT 06511-2106
stephen.dellaporta@yale.edu
Phone: 203-432-3895
*[Silliman College Fellow & **MCDB Faculty Advisor**]*

Sex determination and cell death in plants.

Nadya Dimitrova
Asst Prof Mol Cell & Dev Biol
KBT 936, 219 Prospect St, New Haven, CT 06511-2106
nadya.dimitrova@yale.edu
Phone: 203-432-3492
[MCDB Faculty Advisor]

The Dimitrova lab focuses on long non-coding RNAs (lncRNAs) and their roles in the regulation of critical cellular pathways during tumor development. Using advanced genomic, genetic and molecular biology tools, we study the contribution of lncRNAs to cancer-relevant processes at the cellular and organismal level. Our aim is to dissect the complex biology of this novel class of RNAs and to gain a deeper understanding of the contribution of lncRNAs in health and disease.

Thierry Emonet
Assoc Prof Mol Cell & Dev Biology and Physics
KBT 1048, 219 Prospect St, New Haven, CT 06511-2106
thierry.emonet@yale.edu
Phone: 203-432-3516
*[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.

Paul Forscher
Prof Mol Cell & Dev Biology
KBT 222, 219 Prospect St, New Haven, CT 06511-2106
paul.forscher@yale.edu
Phone: 432-6344, 432-6345
*[Davenport College Fellow & **MCDB Faculty Advisor**]*

Molecular mechanisms of axon guidance: cytoskeletal protein dynamics and related signal transduction.

Joshua Martin Gendron
Assist Prof Mol Cell & Dev Biology
KBT 706, 219 Prospect St, New Haven, CT 06511-2106
joshua.gendron@yale.edu
Phone: 432-3501
*[**MCDB Faculty Advisor**]*

Plants, circadian clock, protein degradation.

Jo Handelsman
(Leave of Absence) *Frederick Phineas Rose Prof & Howard Hughes Med Inst, Prof Mol Cell & Dev Biology*
KBT 904, 219 Prospect St, New Haven, CT 06511-2106
jo.handelsman@yale.edu
Phone: 203-432-9119
*[Jonathan Edwards College Fellow & **MCDB Faculty Advisor**]*

Studies the structure and function of microbial communities in soil and in insect guts using metagenomics, pathogenesis in a community context, chemical biology, and microbial signaling.

Mark W Hochstrasser #
Eugene Higgins Prof of MB&B and Prof. Mol Cell & Dev Biology
266 Whitney Avenue, BASS Rm 217, New Haven, CT 06511
mark.hochstrasser@yale.edu
Phone: 203 432-6507

Work in lab resides at the crossroads of biochemistry and genetics and takes advantage of the many research benefits offered by the yeast Saccharomyces cerevisiae as a model eukaryotic cell system.

Scott A. Holley
Assoc Prof Mol Cell & Dev Biology; Dir Grad Studies Mol Cell & Dev Biology
KBT 1034, 219 Prospect St, New Haven, CT 06511-2106
scott.holley@yale.edu
Phone: 203-432-3230
*[Timothy Dwight College Fellow & **MCDB Faculty Advisor**]*

Molecular, genetic and embryological analysis of segmentation in the zebrafish.

Valerie Horsley
Maxine F Singer PhD Asst Prof Mol Cell & Dev Biology
KBT 226, 219 Prospect St, New Haven, CT 06511-2106
valerie.horsley@yale.edu
Phone: 203-436-9126
*[Ezra Stiles College Fellow & **MCDB Faculty Advisor**]*

Study of the cellular and molecular mechanisms that control stem cell activity and function within the skin epithelium.

Vivian Irish
Prof Mol Cell & Dev Bio, Prof Ecology/Evolutionary Bio
OML 252a, 219 Prospect St, New Haven, CT 06511-2106
vivian.irish@yale.edu
Phone: 203-432-5572
*[Davenport College Fellow & **MCDB Faculty Advisor**]*

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

Farren Isaacs
Asst Prof Mol Cell & Dev Biology
300 Heffernan Dr #B31, West Haven, CT 06516
farren.isaacs@yale.edu
Phone: 203-432-3783
*[Jonathan Edwards College Fellow & **MCDB Faculty Advisor**]*

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

Akiko Iwasaki #
Prof Immunobiology and Mol Cell & Dev Biology and Mol Cell & Dev Biology
TAC S-655b, 300 Cedar St, New Haven, CT 06519-1612
akiko.iwasaki@yale.edu
Phone: 203-785-2919

Immune responses to herpes simplex viruses and influenza

Yannick Jacob
Asst Prof Mol Cell & Dev Biology
OML 352b, 219 Prospect St, New Haven, CT 06511-2106
Phone: 203-432-8908
yannick.jacob@yale.edu

We study how chromatin regulates DNA replication to promote genome stability; and the role of epigenetics in aging.

Christine Jacobs-Wagner
Dir Microbial Sciences Institute; Prof Mol Cell & Dev Biology; Investigator Howard Hughes Med Inst; Prof Microbial Pathogenesis
ABC Building 840 (Rm 317), 300 Heffernan Dr, West Haven, CT 06516
christine.jacobs-wagner@yale.edu
Phone: 203-432-5170; 203-737-6565
*[Saybrook College Fellow & **MCDB Faculty Advisor**]*

Mechanisms underlying bacterial multiplication and physiology.

Douglas R. Kankel
Prof & Dir Undergrad Studies Mol Cell & Dev Biology
KBT 1220, 219 Prospect St, New Haven, CT 06511-2106
douglas.kankel@yale.edu
Phone: 203-432-3839
*[Silliman College Fellow & **MCDB Faculty Advisor**]*

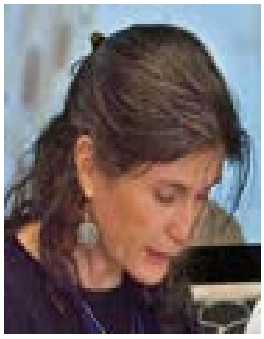
Nervous system development and function in Drosophila melanogaster.

Paula Kavathas #
Prof Lab Med, Genetics, Immunobiology and Mol Cell & Dev Biology; Assoc Chair Research; Dir, Sci Educ Outreach Prog
TAC S-641a, 300 Cedar Street, New Haven, CT 06519
paula.kavathas@yale.edu
Phone: 203-785-6223

Study of host-pathogen interactions in human trophoblast cells, a bacterial type II secretion system, and lateral gene transfer for genetic manipulation.

Haig S. Keshishian
Prof Mol Cell & Dev Biology
KBT 640a, 219 Prospect St, New Haven, CT 06511-2106
haig.keshishian@yale.edu
Phone: 203-432-3478
*[Morse College Fellow & **MCDB Faculty Advisor**]*

Factors governing the formation of synaptic connections during development.



Maria Moreno
Lect Mol Cell & Dev Biology; Assoc Rsrch Scientist Mol Cell & Dev Biology OML 452, 219 Prospect St, New Haven, CT 06511-2106 maria.moreno@yale.edu
Phone: 203-436-4161
*[**MCDB Faculty Advisor**]*

Cloning of the Yellow Stripe 1 gene and Tapetal Development and Function gene in Oryza sativa japonica.

Kathryn Miller-Jensen #
Asst Prof Bio Eng & Mol Cell Dev Biology
MEC 311, 55 Prospect Street, New Haven, CT 06511
kathryn.miller-jensen@yale.edu
Phone: (203) 432-4265
[Calhoun College Fellow]

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

Mark S. Mooseker
Ross Granville Harrison Prof of Mol Cell & Dev Biology
KBT 352, 219 Prospect St, New Haven, CT 06511-2106
mark.mooseker@yale.edu
Phone: 203-432-3468
*[Calhoun College Fellow & **MCDB Faculty Advisor**]*

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

F. Kenneth Nelson
Lect Mol Cell & Dev Biology; Assoc Rsrch Scientist Mol Cell & Dev Biology
KBT 716, 219 Prospect St, New Haven, CT 06511-2106
kenneth.nelson@yale.edu
Phone: 203-432-5013
*[Morse College Fellow & **MCDB Faculty Advisor**]*

Human genome sequencing and transcription factor activity analysis.

Thomas D. Pollard
Sterling Prof MCDB, Prof MBB
KBT 548, 219 Prospect St, New Haven, CT 06511-2106
thomas.pollard@yale.edu
Phone: 203-432-3565
*[Morse College Fellow & **MCDB Faculty Advisor**]*

Molecular mechanisms of actin-based cellular movements.

Anna Pyle
William Edward Gilbert Prof of Mol Cell & Dev Biology;
Investigator Howard Hughes Med Inst; Prof Chemistry
KBT 826, 219 Prospect St, New Haven, CT 06511-2106
anna.pyle@yale.edu
Phone: 203-432-5633
*[**MCDB Faculty Advisor**]*

Structure and function of catalytic RNA, RNA helicase mechanisms and the computational analysis of RNA structure.

Matthew Rodeheffer #
Asst Prof Comparative Med and Mol Cell & Dev Biology
BML 329d, 375 Congress Ave, New Haven, CT 06519-1404
matthew.rodeheffer@yale.edu
Phone: 203-737-3370

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.

Joel L. Rosenbaum
Prof Mol Cell & Dev Biology
KBT 310a, 219 Prospect St, New Haven, CT 06511-2106
joel.rosenbaum@yale.edu
Phone: 203-432-3472
*[Silliman College Fellow & **MCDB Faculty Advisor**]*

Cell organelle assembly; IFT and flagellar assembly, sensory function of cilia/flagella and the roll of cilia in disease (ciliopathies. Most of the current interest in cilia stems from our original research on IFT as defined in Chlamydomonas.

Alanna Schepartz #
Milton Harris PhD Prof Chemistry, Prof Mol Cell & Dev Biology
CRB 310, 225 Prospect St, New Haven, CT 06511-8499
alanna.schepartz@yale.edu
Phone: 203-432-5094

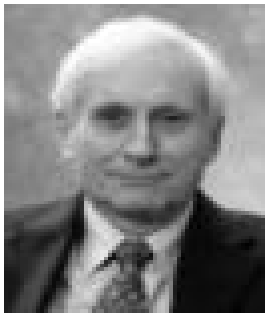
The Schepartz laboratory develops chemical tools to study and manipulate protein–protein and protein–DNA interactions inside the cell.

Joseph S. Wolenski
Rsrch Scientist & Lecturer Mol Cell & Dev Biology, Assoc Dir Summer Programs
KBT 330, 219 Prospect St, New Haven, CT 06511-2106
joseph.wolenski@yale.edu
Phone: 203-432-6912
*[Berkeley College Fellow & **MCDB Faculty Advisor**]*

Molecular analysis of myosin mechanochemistry.

Josien Van Wolfswinkel
Asst Prof Mol Cell & Dev Biology
KBT 1032, 219 Prospect St, New Haven CT 06511-2106
josien.van.wolfswinkel@yale.edu
Phone: 203-432-3520
[MCDB Faculty Advisor]

Planarians (or flatworms) are able to recover from any type of injury, and can even regrow a head and brain if they need to, due to the presence of a large population of adult pluripotent stem cells. We use these animals as a model to study the regulation of pluripotency in vivo, with a particular interest in RNA biology and epigenetic regulation in these cells, by applying a combination of molecular, cell biological, genetic, proteomic, and computational methods, as well as (single cell) sequencing and imaging techniques.



Robert J. Wyman
Prof Mol Cell & Dev Biology
KBT 610a, 219 Prospect St, New Haven, CT 06511-2106
robert.wyman@yale.edu
Phone: 203-432-3475
*[Calhoun College Fellow & **MCDB Faculty Advisor**]*

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

Weimin Zhong
Assoc Prof Mol Cell & Dev Biology
KBT 616b, 219 Prospect St, New Haven, CT 06511-2106
weimin.zhong@yale.edu
Phone: 203-432-9233
*[Davenport College Fellow & **MCDB Faculty Advisor**]*

Regulation of neural stem cells and development of the mammalian neocortex.

Worksheets for MCDB

Standard

Biotechnology

Neurobiology

Quantitative Biology

BS/MS

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 101 Biochemistry and Biophysics			BIOL 101			
BIOL 102 Prin of Cell Biology & Membrane Phys			BIOL 102			
BIOL 103 Genes and Development			BIOL 103			
BIOL 104 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 *(1 term - not including Math 190)*				

Core Courses: *BA - Choose any 2*				***Course #***	***Semester***	***Grade***
MCDB 200b	Molecular Biology	MCDB 290b	Microbiology			
MCDB 202a	Genetics	MCDB 310a	Physiological Systems			
MCDB 205b	Cell Biology	MCDB 320a	Neurobiology			
MCDB 210a	Developmental Biology	MCDB 430a	Biology of the Immune System			
EITHER: MCDB 300b 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/MBB/ANTHRO Labs)			

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

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 101 Biochemistry and Biophysics			BIOL 101			
BIOL 102 Prin of Cell Biology & Membrane Phys			BIOL 102			
BIOL 103 Genes and Development			BIOL 103			
BIOL 104 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 *(1 term - not including Math 190)*				

CORE COURSES: *(BS & BS INT - Choose any 3)*				***Course #***	***Semester***	***Grade***
MCDB 200b	Molecular Biology	MCDB 290b	Microbiology			
MCDB 202a	Genetics	MCDB 310a	Physiological Systems			
MCDB 205b	Cell Biology	MCDB 320a	Neurobiology			
MCDB 210a	Developmental Biology	MCDB 430a	Biology of the Immune System			
EITHER: MCDB 300b 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 Research)*				
MCDB 475 a or b	Independent Research MCDB			
MCDB 485/486	Senior Requirement MCDB BS Major			
**MCDB 485/486 is preferred - but 2 terms of MCDB 475 (+ summer) will satisfy this req*				
BS INT: *(2 terms of Intensive Research)*				
MCDB 495/496	Senior Requirement 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 101 Biochemistry and Biophysics			BIOL 101			
BIOL 102 Prin of Cell Biology & Membrane Phys			BIOL 102			
BIOL 103 Genes and Development			BIOL 103			
BIOL 104 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 *(1 term - not including Math 190)*				

CORE COURSES: *BA - Choose 2*				***Course #***	***Semester***	***Grade***
MCDB 200b	Molecular Biology	MCDB 290b	Microbiology			
MCDB 202a	Genetics	MCDB 310a	Physiological Systems			
MCDB 205b	Cell Biology	MCDB 320a	Neurobiology			
MCDB 210a	Developmental Biology	MCDB 430a	Biology of the Immune System			
EITHER: MCDB 300b 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/MBB/ANTHRO Labs)			

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

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 101 Biochemistry and Biophysics			BIOL 101			
BIOL 102 Prin of Cell Biology & Membrane Phys			BIOL 102			
BIOL 103 Genes and Development			BIOL 103			
BIOL 104 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 *(1 term - not including Math 190)*				

CORE COURSES: *(BS & BS INT - Choose any 3)*				***Course #***	***Semester***	***Grade***
MCDB 200b	Molecular Biology	MCDB 290b	Microbiology			
MCDB 202a	Genetics	MCDB 310a	Physiological Systems			
MCDB 205b	Cell Biology	MCDB 320a	Neurobiology			
MCDB 210a	Developmental Biology	MCDB 430a	Biology of the Immune System			
EITHER: MCDB 300b 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 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 Research)*				
MCDB 475 a or b	Independent Research MCDB			
MCDB 485/486	Senior Requirement MCDB BS Major			
**MCDB 485/486 is preferred - but 2 terms of MCDB 475 (+ summer) will satisfy this req*				
BS INT: *(2 terms of Intensive Research)*				
MCDB 495/496	Senior Requirement 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 101 Biochemistry and Biophysics			BIOL 101			
BIOL 102 Prin of Cell Biology & Membrane Phys			BIOL 102			
BIOL 103 Genes and Development			BIOL 103			
BIOL 104 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 *(1 term - not including Math 190)*				

CORE COURSES: *BA - Choose any 2*				***Course #***	***Semester***	***Grade***
MCDB 200b	Molecular Biology	MCDB 290b	Microbiology			
MCDB 202a	Genetics	MCDB 310a	Physiological Systems			
MCDB 205b	Cell Biology	MCDB 320a	Neurobiology			
MCDB 210a	Developmental Biology	MCDB 430a	Biology of the Immune System			
EITHER: MCDB 300b 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 430a	Biology of the Immune System			
CPSC 475b	Comp Vision & Biol Perception	MCDB 440b	Brain Development & Plasticity			
MCDB 240b	Biololgy of Reproduction	PSYC 200b	Statistics (not if STAT 101-9 is taken)			
MCDB 315b	Biological Mech Reaction to Injury	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/MBB/ANTHRO Labs)			

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

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 101 Biochemistry and Biophysics			BIOL 101			
BIOL 102 Prin of Cell Biology & Membrane Phys			BIOL 102			
BIOL 103 Genes and Development			BIOL 103			
BIOL 104 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 *(1 term - not including Math 190)*				

CORE COURSES: *(BS & BS INT - Choose any 3)*				***Course #***	***Semester***	***Grade***
MCDB 200b	Molecular Biology	MCDB 290b	Microbiology			
MCDB 202a	Genetics	MCDB 310a	Physiological Systems			
MCDB 205b	Cell Biology	MCDB 320a	Neurobiology			
MCDB 210a	Developmental Biology	MCDB 430a	Biology of the Immune System			
EITHER: MCDB 300b Biochemistry ***OR:*** MB&B 300a Principles of Biochemistry I						

GENERAL ELECTIVES: *(2 Total)*				***Course #***	***Semester***	***Grade***
Required Track Course: MCDB 320a Neurobiology						
(Choose 1 additional elective below)						
BENG 410a	Basis of Bioimaging & Biosensing	MCDB 430a	Biology of the Immune System			
CPSC 475b	Comp Vision & Biol Perception	MCDB 440b	Brain Development & Plasticity			
MCDB 240b	Biololgy of Reproduction	PSYC 200b	Statistics (not if STAT 101-9 is taken)			
MCDB 315b	Biological Mech Reaction to Injury	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 Research)*				
MCDB 475 a or b	Independent Research MCDB			
MCDB 485/486	Senior Requirement MCDB BS Major			
**MCDB 485/486 is preferred - but 2 terms of MCDB 475 (+ summer) will satisfy this req*				
BS INT: *(2 terms of Intensive Research)*				
MCDB 495/496	Senior Requirement 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 101 Biochemistry and Biophysics			BIOL 101			
BIOL 102 Prin of Cell Biology & Membrane Phys			BIOL 102			
BIOL 103 Genes and Development			BIOL 103			
BIOL 104 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 *(1 term - not including Math 190)*				

CORE COURSES: *(BA - Choose any 2)*				Course #	Semester	Grade
MCDB 200b	Molecular Biology	MCDB 290b	Microbiology			
MCDB 202a	Genetics	MCDB 310a	Physiological Systems			
MCDB 205b	Cell Biology	MCDB 320a	Neurobiology			
MCDB 210a	Developmental Biology	MCDB 430a	Biology of the Immune System			
EITHER: MCDB 300b Biochemistry ***OR:*** MB&B 300a Principles of Biochemistry I						

GENERAL ELECTIVES: *(2 Total)*				Course #	Semester	Grade
Required Track Course: MCDB 261b Intro Dynamical Systems in Biology						
(Choose 1 additional elective below)						
MCDB 320a	Neurobiology	MATH 251b	Stochastic Processes			
MCDB 361a	*Dynamical Systems in Biology	MBB 302b	Principles of Biophysics			
BENG 467b	Systems Biology Cell Signaling	MBB 435a	Mathematical Methods Biophysics			
CENG 320a	Immunoengineering	MBB 452a	Bioinformatics: Mining & Simulation			
CPSC 440b	Numerical Computation	MBB 523b	Biological Physics			
CPSC 475a	Comp Vision & Bio Perception	PHYS 402b	Advanced Classical Physics			
MATH 246a	Ordinary Differential Equations					
** Prreferred Track Elective*						

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/MBB/ANTHRO Labs)			

SENIOR REQUIREMENT	Course #	Semester	Grade
BA: (Senior Essay or 1 term of 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 101 Biochemistry and Biophysics			BIOL 101			
BIOL 102 Prin of Cell Biology & Membrane Phys			BIOL 102			
BIOL 103 Genes and Development			BIOL 103			
BIOL 104 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 *(1 term - not including Math 190)*				

CORE COURSES: *(BS & BS INT - Choose any 3)*				*Course #*	*Semester*	*Grade*
MCDB 200b	Molecular Biology	MCDB 290b	Microbiology			
MCDB 202a	Genetics	MCDB 310a	Physiological Systems			
MCDB 205b	Cell Biology	MCDB 320a	Neurobiology			
MCDB 210a	Developmental Biology	MCDB 430a	Biology of the Immune System			
EITHER: MCDB 300b Biochemistry ***OR:*** MB&B 300a Principles of Biochemistry I						

GENERAL ELECTIVES: *(2 Total)*				*Course #*	*Semester*	*Grade*
Required Track Course: MCDB 261b Intro Dynamical Systems in Biology						
(Choose 1 additional elective below)						
MCDB 320a	Neurobiology	MATH 251b	Stochastic Processes			
MCDB 361a	*Dynamical Systems in Biology	MBB 302b	Principles of Biophysics			
BENG 467b	Systems Biology Cell Signaling	MBB 435a	Mathematical Methods Biophysics			
CENG 320a	Immunoengineering	MBB 452a	Bioinformatics: Mining & Simulation			
CPSC 440b	Numerical Computation	MBB 523b	Biological Physics			
CPSC 475a	Comp Vision & Bio Perception	PHYS 402b	Advanced Classical Physics			
MATH 246a	Ordinary Differential Equations					
* Prreferred Track Elective						

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

BS / MS Worksheet

20___ | *MCDB* | *BS /MS*

SID _____ **Research Lab Mentor:** _____

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

BIOL Prerequisites:	**Placement Exam Score**	***Course #***	***Semester***	***Grade***	***Place Out***
BIOL 101 Biochemistry and Biophysics					
BIOL 102 Prin of Cell Biology & Membrane Phys					
BIOL 103 Genes and Development					
BIOL 104 Prin of Ecology & Evolutionary Biology					

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:	***Course #***	***Semester***	***Grade***
Organic Chemistry (1 term - 174a; or 175b; or 220a)			
Organic Chemistry Lab (1 term 222L; or 223L; or 226L)			
(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 (2 terms - 170/171; or 180/181; or 200/201; or 260/261)				

MATH Prerequisites:	***Course #***	***Semester***	***Grade***	***Place Out***
Math 115 or higher (1 term - not including Math 190)				

CORE COURSES: *(Choose any 3)*				***Course #***	***Semester***	***Grade***
MCDB 200b	Molecular Biology	MCDB 290b	Microbiology			
MCDB 202a	Genetics	MCDB 310a	Physiological Systems			
MCDB 205b	Cell Biology	MCDB 320a	Neurobiology			
MCDB 210a	Developmental Biology	MCDB 430a	Biology of the Immune System			
EITHER: MCDB 300b Biochemistry OR: MB&B 300a Principles of Biochemistry I						

ELECTIVES:	***Course #***	***Semester***	***Grade***	
Graduate Level Electives (one must be a seminar course)				Grad 1
				Grad 2
				Grad 3
				Grad 4 (Seminar)

LABS:	***Course #***	***Semester***	***Grade***
(Choose 2 labs from MCDB)			

Senior Requirement:	***Course #***	***Semester***	***Grade***	
MCDB 585b Research in MCDB for BS/MS Candidates (Spring of Junior year)				Grad 5
MCDB 595a Intensive Research in MCDB for BS/MS Candidates				Grad 6
MCDB 595b Intensive Research in MCDB for BS/MS Candidates				Grad 7

6 Courses outside the Major must be taken in the last 2 years (includes 2 Undergraduate courses in the last 2 terms)		***Course #***	***Semester***	***Grade***	
Thesis Mentor:					Non Major 1
Committee Member (MCDB)					Non Major 2
Committee Member (MCDB)					Non Major 3
Committee Member					Non Major 4
					Non Major 5 "U"
					Non Major 6 "U"

Independent Research Forms and Guidelines

Senior Essay

MCDB 475

MCDB 485/486

MCDB 495/496

MCDB 585

MCDB 595

MCDB – Senior Essay Topic Approval Form

*Students must attach thesis paragraph describing topic and submit to:
office of Director of Undergraduate Studies (1220B KBT).

Electronic submission is acceptable and preferred to the office of the Director of Undergraduate Studies:
crystal.adamchek@yale.edu.

Form and topic paragraph due ***at least*** one month before the end of classes in term of expected graduation

Senior Essay Due by first week of December for Fall Graduation
Senior Essay Due by first week of April for Spring Graduation

Student's Name: _____(please print)

College: _____ Phone No. _____

Topic for Senior Paper: _____

_____

_____

To the Senior Essay Faculty Member:
By signing this form, I approve the choice of the above topic and submitted paragraph for a senior essay. I also agree to read and grade the final paper and report the grade to the DUS Office (crystal.adamchek@yale.edu).

_____
Faculty Member Signature Date

_____
Faculty Member Printed Name Department

_____
Student's Signature Date

_____
Director Undergraduate Studies Signature Date

MCDB SENIOR ESSAY

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

The senior essay should be a critical evaluation of some portion of the current, primary biological literature. The topic may be anything within the realm of biology or it may explore the relationships of biology to other fields. Each student must obtain approval of the paper topic from a faculty member of the MCDB department to assure that the subject is a promising one. A **form** for this is attached and must be returned to the office of the Director of Undergraduate Studies (1220B KBT) ***at least one month before the paper is due***. Students should attach a thesis paragraph describing the chosen topic.

The paper is to be *15-20 double-spaced pages, including bibliography.* It is the student's obligation to procure a faculty advisor to read and grade each paper. If a student needs assistance in this area, the office of the DUS is available for assistance. Papers are to be submitted to the office of the Director of Undergraduate Studies (1220B KBT). Electronic submission is acceptable and preferred to the office of the director of undergraduate studies: crystal.adamchek@yale.edu. Normally, a grade of "Satisfactory" is reported to the registrar by the Director of Undergraduate Studies. However, honor candidates must achieve a grade of A, which is of course reported.

If the essay is "Unsatisfactory", the student may make arrangements with the Director of Undergraduate Studies to submit another paper. Papers received late may not be processed before Commencement.

Hints for finding a faculty member to advise on senior essay

In choosing a faculty member to advise on your senior essay, first decide on the general area you would like to explore in your senior essay. Then determine which faculty member might have interest or expertise in that area. The best source is the MCDB Department booklet, available from the office of the Director of Undergraduate Studies, under the section "Faculty and Research Interests". Second, if a faculty member discussed the topic in a course, he/she would be a good choice or source for suggestions. Otherwise, the Yale College Program of Study (Blue Book) provides a list of faculty member and courses that may include your prospective topic.

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

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

MCDB 475 – Independent Research MCDB

FOR PASS / FAIL

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.

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.

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 Classes V2 drop box. (crystal.adamchek@yale.edu)

Due dates: Student and Mentor Contract; 1 Page Summary:
Fall: 1 week after start of classes
Spring: 1 week after start of classes

Final Report Due:
Fall: Last day of classes
Spring: Last day of classes

MCDB 475 – Independent Research MCDB

FOR PASS / FAIL

To: Prospective MCDB 475a or b Students
From: Independent Research Courses Coordinator: Staff

This is intended to give you an introduction and guidelines to the MCDB 475 (a and b) course. Students should always check the Classes V2 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 drop box in Classes V2 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 Classes V2 dropbox. 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. 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 – Independent Research MCDB

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 Classes V2 drop box. (crystal.adamchek@yale.edu)

Due dates: Student and Mentor Contract; 1 Page Summary:

Fall: 1 week after start of classes

Spring: 1 week after start of classes

Final Report Due:

Fall: Last day of classes

Spring: Last day of classes

MCDB 475 – Independent Research MCDB

To: Prospective MCDB 475a or b Students
From: Independent Research Courses Coordinator: Staff

This is intended to give you an introduction and guidelines to the MCDB 475 (a and b) course. Students should always check the Classes V2 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 drop box in Classes V2 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:

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These should be uploaded to the Classes V2 dropbox. Contracts are attached to these guidelines.

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

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 – 5:30 pm or 6:30 -8 pm over several evenings in mid-late November and early December.

All students taking MCDB 475 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 Classes V2 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 Classes V2. 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+). All presentations will be held in KBT 1202; typically from 4 – 5:30 pm or 6:30 -8 pm over several evenings in mid-late November and early December.

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.

MCDB 485 – Senior Requirement MCDB BS Major

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 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 Classes V2 drop box.

(crystal.adamchek@yale.edu)

Due dates: Student Contract, Mentor Contract, Summary: 1 week after start of classes
Oral Presentations meet in KBT 1202 typically from 4 – 5:30 pm or 6:30 -8 pm over several evenings in mid-late March and early April
Oral Presentations Spring: (To be determined)
Final Report Due:
Fall / Spring: Last day of classes
Poster Symposium: Mid April (2-4pm) (Location TBD)

MCDB 485 – Senior Requirement MCDB BS Major

To: Prospective MCDB 485 students

From: Independent Research Courses Coordinator: John Carlson

This is intended to give you an introduction and guidelines to the MCDB 485 course. Students should always check the Classes V2 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 drop box in Classes V2 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 Classes V2 dropbox. 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

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 – 5:30 pm or 6:30 -8 pm over several evenings in mid-late November and early December.

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 Classes V2 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 Classes V2. 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+). All presentations will be held in KBT 1202; typically from 4 – 5:30 pm or 6:30 -8 pm over several evenings in mid-late March and early April. 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. 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 495 – Senior Requirement MCDB BS INT Major

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 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:

One of the provisions for agreeing to accept a student into your laboratory for course credit in MCDB 485 is that you agree to the following:

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 Classes V2 drop box (crystal.adamchek@yale.edu)

Due dates: Student Contract, Mentor Contract, Summary: 1 week after start of classes
MCDB Oral Presentations meet at 6pm in KBT 1214 on:
Fall / Spring: (To be determined)
Final Report Due:
Fall / Spring: Last day of classes
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: John Carlson

Below is an introduction and guidelines to the MCDB 495 course. Students should always check the Classes V2 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 drop box in Classes V2 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 Classes V2 dropbox. 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 475/85 (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 your 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

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 – 5:30 pm or 6:30 -8 pm over several evenings in mid-late November and early December.

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 Classes V2 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 Classes V2. 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+). All presentations will be held in KBT 1202; typically from 4 – 5:30 pm or 6:30 -8 pm over several evenings in mid-late November and early December. 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. 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 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: April 17th 2-4pm (Location TBD) [Optional for MCDB 585 students]
Proposal with Research Plan to Committee & Office of DUS:
(before February 2, 2015)
MCDB Oral Presentations sessions:
Spring – Date/Location TBD
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 **expected 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 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: _____

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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
Poster: Mid April 2-4pm (Location 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:

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

2) **MCDB Oral Presentations - FALL only for MCDB 595 students**
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 – 5:30 pm or 6:30 -8 pm over several evenings in mid-late November and early December.
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 Classes V2 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 Classes V2. 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+). All presentations will be held in KBT 1202; typically from 4 – 5:30 pm or 6:30 -8 pm over several evenings in mid-late November and early December. 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.

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

4) 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.

5) 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.

6) Written Thesis:
    a) One chapter should be Introduction/Review of the field. Subsequent chapter(s) will discuss the student's research and a thorough discussion of it.
    b) The length of the thesis should be 40-100 pages.
    c) Each committee member should receive a copy of the thesis at least one week prior to meeting with the committee.
    d) 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 Cover

MCDB 221La – Model Organisms in Biological Research. This class offers students the opportunity to survey the utility of several model organisms that are used in biological research, ranging from *E. coli* to zebrafish. The laboratory classroom is equipped with iPad enabled microscopy equipment which allows students to share and record images of species being studied. The top cover picture shows student Benjamin Meyer (JE '16) an MCDB major using the Zeiss Stemi 200 directing microscope. [Photo credit: Maria Moreno]

Fabian Fernandez (DC '15) a Medical Anthropology and Pre-Medicine major observing *C. elegans* using the Leica DM750 compound microscope. [Photo credit: Maria Moreno]

Fabian Fernandez''s specimens of *C. elegans* at different stages of the life cycle using the compound microscope.

[Photo credit: Maria Moreno

MCDB 344 Laboratory students Margaret Zhang, Gianna Fote perform subcellular fractionations of HeLa cells for biochemical and light microscopy observations. [Photo credit: Joseph Wolenski]

Legend: Back Cover

Upper Left: Kline Biology Tower

Upper Right: Osborn Memorial Laboratory

Bottom: Kline Biology Tower Lobby [Photo credit: Joseph Wolenski]