

Independent Research to satisfy the MCDB BS Major Senior Requirement

Summary: MCDB 485 and 486 are one-credit research courses taken consecutively during the senior year (2-credits total). Students receive a grade of Satisfactory or Unsatisfactory for their effort in the fall term for MCDB 485. At the end of the spring term a Satisfactory grade in MCDB 485 is reassigned as a letter grade on your transcripts, and MCDB 486 is also given a letter grade that will be on your senior year transcripts. In rare instances where students receive a grade of Unsatisfactory in MCDB 485, they will not be permitted to continue to MCDB 486.

MCDB 485 is taken in the fall term followed by MCDB 486 in the spring term. The research project must fall within the disciplines of molecular, cellular and developmental biology. Students are strongly encouraged to seek out a supportive faculty member within the Department of MCDB during their junior year (or in the summer preceding the start of their senior year) to secure a laboratory position for a full year of senior research. Pursuing a research project in a laboratory outside the Department of MCDB is acceptable, as long as the project meets criteria outlined below. Research within a laboratory at the YSM is common, as long as the student is involved in experimental design and the project is not solely based on analysis of data from work of others. Computational analysis, molecular modelling and simulations are acceptable as long as the student proposes to model data they had a hand in generating. If a student is interested in research that does not have a substantial biomedical focus, or if the proposed research involves only analysis of data collected by others, this project may not be suitable for MCDB 485/486 credit. If your project is not typically considered to be within the disciplines of molecular, cellular and developmental biology, please contact the course instructors via the office of the MCDB DUS (crystal.adamchek@yale.edu) prior to making any firm commitments to work in a lab.

MCDB 485/486 research courses are for students committed to a full year of consecutive research during their senior year. If you are unsure about how things will work in a new laboratory, or if you can't commit to a full senior year of uninterrupted research, please consider enrolling in MCDB 475 independent research. MCDB 475 is a one credit independent research class for seniors that can be taken in the fall and/or spring terms. Any senior who completes only one term of research will be credited with enrollment in MCDB 475. For example, students who have completed MCDB 485 but are unable to enroll or successfully complete MCDB 486 will have their course transcripts changed to reflect enrollment in one term of MCDB 475.

Do not enroll in MCDB 485/486 unless you are sincere about a full year of senior research. If you have any doubt about your ability to work in a lab for a full year, enroll in MCDB 475.

MCDB 485/486 cannot be used as a substitute to fulfill the laboratory course research requirements (MCDB 201Lb – MCDB 345Lb) necessary to complete the BA or BS degrees in the MCDB major.

Sequence of enrollment: Students enroll in MCDB 485 in the fall term of their senior year followed by enrollment of MCDB 486 in the spring term of their senior year. In cases where students have taken a leave of absence and their degree sequence is delayed by one term (this is often due to COVID safety concerns) it is possible to enroll in MCDB 485 in the spring of their penultimate term followed by enrollment in MCDB 486 in the fall of their final term at Yale. In these rare instances, students enrolled out-of-sequence in MCDB 485/486 must still submit a poster summarizing their senior research due on the last day of classes in the spring term. Students who graduate in December may submit posters electronically for the presentation in April. Accordingly, students who graduate in December do not need to be physically present to present the final MCDB 485/486 poster session in April.

Students enrolled out-of-sequence must also present to a peer cohort a formal 15- minute seminar in their final term (while completing MCDB 486). For most students enrolled in the typically MCDB 485 (fall) MCDB 486 (spring) sequence, the peer-group seminar will be in December of your senior year.

Students enrolled in MCDB 485/486 are expected to meet with their faculty principal investigator (and mentor if possible) to draft a 1-2-page research proposal that is due at 5 PM on the last day of the add/drop. Ideally you can meet prior to the start of your senior year, but if this is not the case, students must meet (this can be via Zoom) during the first week of classes to finalize a research proposal that is mutually satisfactory. The 2-page limit proposal include specific aims, background, rationale and limited references. The 2-page limit does not include the title page (see details below).

To complete MCDB 485, students must submit a 5-page (double-spaced) grant proposal due on the last day of classes in the fall term. For MCDB 486, students submit a 12-15 (double-spaced) research summary due on the last day of classes. Students also give a 15-minute formal seminar to a cohort of peers (late April) and also present a poster at the senior research poster session (last day of spring term).

A final written report that summarizes your research effort (12-15 pages double spaced) is required to be uploaded to MCDB 474 Canvas Assignments by 5 PM on the last day of classes each term. The 15-page limit is firm and includes: all data, appendices and references. The title page does not count toward the 15-page limit.

Students enrolled in MCDB 485/486 are expected to read and sign a binding contract (see below) that indicates your willingness to meet essential criteria for a year of research in a chosen laboratory. The contract signed by you and your principal investigator (or mentor) is required to be uploaded to MCDB 485/486 Canvas Assignments folder by 5 PM on the last day of add/drop period for MCDB 485.

MCDB 485/486 Student Contract:

In the Department of MCDB at Yale University, our mission is to foster creative independent research opportunities for undergraduates while also providing students with exposure to a broad range of pertinent topics in the life sciences. For those students who elect to participate in year-long independent research for Yale College course credit and to fulfill the Senior requirement for the MCDB BS, a research agreement signed by both the student and faculty mentor (i.e., the Principal Investigator of the laboratory in which you propose to perform research) is required. This signed contract is due in the Office of the MCDB DUS by the end of Add/Drop period.

As a MCDB major planning on year-long research (fall and spring terms), I agree to the following:

- 1) I am expected to devote an average of 10-12 hrs/week in the lab to this research.
- 2) I am aware that failure to do so will result in my withdrawal from the course.
- 3) I will make every effort to attend my principal investigator's laboratory meetings, and present my research at least once each term to my colleagues. The student lab meeting presentation may be satisfied by remote video conferencing if COVID prevents in-person meetings.
- 4) Students will give a 12-minute formal seminar (MCDB 485/486 oral presentation requirement) in April of 2022. This oral presentation may be similar in content to the seminar presented at your laboratory meeting (see #3), but is different in that it is presented to a cohort of peers enrolled in the MCDB 485/486 research program.
- 5) I will attend at least 2 of the MCDB 485/486 oral presentation sessions and will present my research at one of them. These presentations are scheduled to be in-person, but pending university and CDC recommendations for COVID-19 safety, these presentations may be via ZOOM.
- 6) I will make every effort to schedule my MCDB Oral Presentations at the time that fits with my mentor's schedule so that my mentor and laboratory colleagues can attend my talk.
- 7) I will present a poster of my final data in April of 2022. This poster session will likely be on the last day of classes in the spring term and pending health guidelines will be in-person.

Name: _____ (Please Print)

Signature: _____

Phone: _____

Class: _____

Email Address: _____

Research Mentor: _____

Title of Research Project: _____

MCDB 485 Research Mentor Contract (Principal Investigator of Laboratory):

I acknowledge that any MCDB 485/486 student in my laboratory is expected to complete an average of at least 10-12 hours of effort per week in the lab for each term. If my undergraduate MCDB student is not able to meet this laboratory requirement, by mid semester of the term I will notify the student and the MCDB 485/486 course instructors/Office of the DUS (Joseph.Wolenski@yale.edu, m.odonnell@yale.edu, crystal.adamchek@yale.edu) that an increase in effort is expected. I am aware that failure of my student(s) to meet this expectation may result in withdrawal from the course. I expect MCDB 485/486 students in my laboratory to attend our laboratory meetings and present their research at least once each term to provide guidance, constructive feedback, evaluate their progress and assess their final grade.

If in-person lab meetings are not possible due to the COVID-19 safety guidelines, students may satisfy this requirement by attending virtual lab meetings as well as presenting their data using video conferencing or webinars.

As a PI mentoring this undergraduate student, I will make every effort to attend my student's MCDB Oral Presentation in April. 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 Assignments section of Canvas. (crystal.adamchek@yale.edu)

Due dates:

Fall term of 2021:

Wednesday: 15 September, 2021 by 5 PM to the Canvas Assignments MCDB 485/486 folder. Student and Mentor Contract; 1–2-page research proposal with 1-3 specific research aims, background, proposed goals and pertinent references. Proposal 2-page limit does not include title page.

Friday: 10 December, 2021 by 5 PM to the Canvas Assignments MCDB 485 folder. 5-page (double spaced) grant proposal outlining your research proposal.

MCDB 486 fall: Final report: (12-15 pages double spaced). Due last day of classes (December 5). 15-page limit does not include title page.

MCDB 486 Fall: Student Seminar for peer cohort: Scheduled for early December of 2021.

If you finish MCDB 486 in December of 2021, you submit a poster electronically for presentation in April of 2022.

Spring term of 2022 for students enrolled in MCDB 486.

MCDB 486 final report: (12-15 pages double spaced). Due last day of classes in April. 15-page limit does not include title page.

Oral Presentations typically meet in person in a conference room in YSB. Pending the COVID-19 health guidelines in the spring term, we will likely hold multiple in-person sessions over the course of one week in late April. The dates and times of these meetings will be posted in January of 2022 on the MCDB 485/486 Canvas sites.

Poster Symposium: The last day of classes in April. Pending health guidelines, the poster session will be in-person in YSB or remote via Zoom. April 23, 2022

MCDB 485/486 – Senior Requirement MCDB BS Major

Independent Research to satisfy the MCDB BS Major Senior Requirement

Summary: MCDB 485 and MCDB 486 are one-credit research courses taken consecutively during the senior year (2-credits total). The main purpose of this two-term research program is to enable undergraduates to learn how to design biological research experiments and obtain extensive hands-on laboratory research training as part of your education at Yale. MCDB 485/486 entails a full year of senior experimental research with a minimum time expectation of 10-12 hours per week at the lab bench. To be productive in this lab environment, students often find they need to dedicate more time at the bench than initially anticipated. Successful students often work much more than 12 hours per week in the lab, with some students averaging closer to 20 hours per week when time permits. If you are unsure about your ability to make research progress in a new laboratory, or if you can't commit to a full senior year of uninterrupted intensive research, consider enrolling in MCDB 475 independent research. MCDB 475 is a one credit independent research class for seniors that can be taken in the fall or spring terms for the BA degree only.

Students enrolled in MCDB 485/486 independent research must be involved in the design of their proposed experiments as well as the development of specific aims that guide your research. The proposed research must test a hypothesis, and it is imperative that students find a suitable principal investigator who can provide regular feedback and support for the entire year. The area of research can be broad but must be relevant to topics of interest to the Department of Molecular, Cellular and Developmental Biology. Students are encouraged to pursue research in the laboratory of a faculty member within the Department of MCDB, or they may pursue a scientific problem in other departments (including at the YSM) as long as the research meets certain criteria (described below), or with permission from the course instructors. Computational analysis, molecular modelling and simulations are acceptable as long as the student proposes to develop models based on experimental data they had a hand in generating. If a student is interested in research that does not have a substantial biomedical focus, or if the proposed research involves only analysis of data collected by others, this project may not be suitable for MCDB 485/486 credit. If your project is not typically considered to be within the disciplines of molecular, cellular and developmental biology, please contact the course instructors via the office of the MCDB DUS (crystal.adamchek@yale.edu) prior to making any firm commitments to work in a particular lab.

Only MCDB seniors may take this course, and only to fulfill the Senior Requirement for the MCDB BS degree. MCDB 485/486 cannot be used as a substitute to fulfill the laboratory course research requirements (MCDB 201Lb – MCDB 345Lb) necessary to complete the BA or BS degrees in the MCDB major.

Sequence of enrollment: Students enroll in MCDB 485 in the fall term of their senior year followed by enrollment of MCDB 486 in the spring term of their senior year. In cases where students have taken a leave of absence and their degree sequence is delayed by one term (this is often due to COVID safety concerns) it is possible to enroll in MCDB 485 in the spring of their penultimate term followed by enrollment in MCDB 486 in the fall of their final term at Yale. We do not anticipate this to be an issue for the academic year given that the university is expecting all students to return for in-person instruction starting in the fall of 2021. In rare instances where a student chooses to enroll in MCDB 485/486 out of sequence they must still submit a poster summarizing their senior research due on the last day of classes in the spring term. Students who graduate in December may submit posters electronically for the presentation in April. Accordingly, students who graduate in December do not need to be physically on campus to present the final MCDB 485/486 poster session in April. Students who are enrolled out-of-sequence must also present to a peer cohort a formal 15-minute seminar in the fall term.

Deadlines for assignments: Fall Term MCDB 485: Students submit a research Proposal at the start of the fall term. Students enrolled in MCDB 485/486 are expected to meet with their faculty principal investigator (and mentor if possible) to draft a 1-2-page research proposal that is due at 5 PM on the last day of the add/drop (Wednesday 15 September, 2021). Ideally you can meet prior to the start of your senior year, but if this is not the case, students must meet (this can be via Zoom) during the first week of classes to finalize a research proposal that is mutually satisfactory. The 2-page limit proposal include specific aims, background, rationale and limited references. The 2-page limit does not include the title page (see details below).

Fall Term 2021 MCDB 485:

Students submit a **grant proposal** at the end of the fall term. To receive credit for MCDB 485, students must submit a 5-page (double-spaced) grant proposal due on the last day of classes in the fall term (Friday 10 December, 2021).

Spring Term 2022 MCDB 486:

If you completed MCDB 495 in the fall term of your senior year and are starting MCDB 486 without any gaps in your enrollment, *you do not need to write another proposal for MCDB 486 in the spring term.*

Students give a **12-minute formal seminar** to a peer cohort in April. This seminar is limited to 15 minutes to allow for a few questions from the audience.

Students submit a **12-15 (double-spaced) research summary** due on the last day of classes in April. This written report should summarize your research effort. The 15-page limit is firm and includes: all data, appendices and references. The title page does not count toward the 15-page limit.

Students make a **poster** to present at the MCDB Senior Poster Session held in YSB on the last day of spring term classes in April.

Submission and Formatting Instructions for all written work: All papers should be uploaded to the *Assignments* folder in Yale Canvas for MCDB 485/486. 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
- (d) PI Name.

(e) Include a header on pages 2 through end with: Student Name, course & Term and page number.

Save papers as a pdf using the following nomenclature:

StudentLastName_FirstName_MCDBCourse_Term&Year.pdf. Send a copy to your PI!

Safety Requirements: You will need to fulfill certain safety requirements prior to starting research that vary 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. If your proposed research involves animal use your professor must have approval for the protocol from the Yale Institutional Animal Care & Use Committee (IACUC). Your professor must send a new form to IACUC to include you in the protocol once your project has been approved. If you have not already done so, you may need to complete an IACUC course before research can begin.

Students enrolled in MCDB 485/486 are expected to read and sign a binding contract (see below) that indicates your willingness to meet essential criteria for a year of research in a chosen laboratory. The contract signed by you and your principal investigator (or mentor) is required to be uploaded to MCDB 485/486 Canvas Assignments folder by 5 PM on the last day of add/drop period for MCDB 485/486.

Course Requirements:

Student and Research Mentor Contracts: Due date: (end of Add/Drop period). These should be uploaded to the Assignments section of Canvas. Contracts are attached to these guidelines. Summary Proposal: Due date: (end of shopping period). A 1–2-page double-spaced summary of your research (written in collaboration with your research mentor) is due for each term of research and must be uploaded by the end of Add/Drop period. This should include a short (no more than 1 page) overview/background of the project and a section describing the general objectives and most importantly, the specific aims of your project. In most cases, students will outline research strategies for one or two specific aims in 2 pages of text. You should also add references. The Background, Specific Aims and Methods section of your proposal should not exceed two pages double spaced. You do not need to include Results/Figures in your research proposal. For

guidance, ask your mentor to see a Specific Aims section of one of her/his NIH or NSF grants. The title page does not count toward the 2-page limit.

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. If you are considering a project that may fall into one of the categories above, please discuss this with the instructor(s) 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 (MCDB 485) – Grant Proposal: Due date: (last day of classes in December). 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 485/486 students.

Each student will give an oral presentation on their research to a small group of students enrolled in MCDB 485/486. These sessions will also be open to faculty mentors and lab colleagues. Following the 12-minute presentation, students are expected to answer 2-3 questions from the peer group and faculty. Questions from peers are strongly encouraged and a portion of your course grade will be based in part on participation in these sessions. There will be 6-7 students presenting at each of the sessions, which generally run for about 2 hours. Students must present at one session and attend one additional small group session as a member of the audience. 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.

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 YSB or pending the health guidelines, will be held remotely. 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 Canvas by Crystal Adamchek. All students should try to find a mutually agreeable time with their Research Mentors for their MCDB Oral Presentations. Each student must have a verified time slot for his/her presentation (using the CANVAS sign-up schedule).

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 acronyms. You should assume that the audience does not know the terminology or background of your field.

Give a practice talk to your lab members before you give it to the MCDB 485/486 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: Last day of classes in spring term.

The purpose of the MCDB 485/486 poster symposium is to share information and more specifically to highlight undergraduate research at Yale. This symposium will be held in YSB or remotely pending health requirements due to COVID-19. The symposium will be open to anyone wishing to attend, so please encourage friends, colleagues and other students to attend. 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 for you to mount your poster. 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. Please do not wait until the 11th hour to print your poster since local printers may not be able to meet your deadline. 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, and your research course. 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 if you were 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 the 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 if you are outsourcing the print job, plan on several days for the project to be completed. Bring it to the session ready to assemble. Please keep in mind that content should take precedence over form. It is most important that your poster be clear, informative, and include meaningful data. 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 (MCDB 486): Due date: Last Day of Classes in April

A 12–15-page double-spaced paper is due on the last day of classes (12-15 pages includes results and literature cited). 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 the Office of the DUS (Crystal.adamchek@yale.edu) 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 (*Journal of Cell Biology*) 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 and Figure Legends: Describe what you have done. Include bar graphs, sketches, diagrams, tables, photographs etc. -- whatever is needed to represent your data. Figure Legends include captions that describe the contents of each figure.
- Discussion: If your project was successful, describe the significance of the results. If your project did not work, describe what you think went wrong, and what your expectations were. Regardless of outcome, describe what you would try next if you were to continue the project.
- References: (literature cited) 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.

The preferred format style is detailed in the following paper: *How to Write your First Research Paper*. Elena D. Kallestinova. *Yale Journal of Biology and Medicine* 84 (2011), pp 181-190. Yale Graduate School, Graduate Writing Center.

https://poorvucenter.yale.edu/sites/default/files/files/how_to_write_your_first_research_paper_2011.pdf

If you would like more detailed information, please read some of the guidelines outlined by the *Journal of Cell Biology*.

https://poorvucenter.yale.edu/sites/default/files/files/how_to_write_your_first_research_paper_2011.pdf

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, your seminars, oral presentation to the peer cohort, poster and the quality of the final research reports. The MCDB research coordinators 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.

Addendum:

Molecular, Cellular & Developmental Biology

The Senior Requirement

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

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

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

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

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

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

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

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

The Combined BS/MS Degree Program

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

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

We hope that seniors will be able to complete their senior research as originally outlined above. However, should it not be possible to complete the research requirements, we are making the following substitutions possible to count towards senior requirements. If it becomes necessary to move away from in-person research during fall 2021 or spring 2022 semesters, those enrolled in senior research courses will be transitioned to MCDB 470/471-style tutorials or other arrangements made with their lab with permission of the DUS, while remaining enrolled in the original course number.

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

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

The BS Degree [2 (MCDB 485 & 486) or 2 (MCDB 475 & 475) or 2 (MCDB 350+/MCDB 470/471) credits]

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

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

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

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

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MCDB 470 – Tutorial in MCDB

Offered fall 2021 and spring 2022. Individual or small-group study for qualified students who wish to investigate an area of experimental biology not presently covered by regular courses. A student must secure the sponsorship of a Yale faculty member, who sets the specific requirements. The course will include one or more written works and is expected to meet at least once per week. ***It will require the submission of a brief course description, a syllabus, and a reading list to and permission from the DUS at the beginning of the term.***

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

MCDB 471 – Senior Seminar in Biology

Offered fall 2021 and spring 2022. This course instructs students in developing effective writing and speaking skills required for preparation of scientific manuscripts and presentations and communicating in the scientific world. Students will be required to prepare and present oral presentations and to submit a literature review and written grant proposal by the end of the semester. This course may be taken only by seniors and can be used only to satisfy the Senior Requirement in MCDB.