

## Biology 76/176: Advanced Genetics

Fall 2025

Lecture M,W,F 12:50-1:55pm, x hour: Tu 1:20-2:10pm  
Life Sciences Center 205

**Professor** Prof. Emily Behrman

**Office** Life Sciences Center 335

**Office Hours** Tu 1:20-2:10pm (x-hour) or by appointment

**Email** [Emily@dartmouth.edu](mailto:Emily@dartmouth.edu)

### COURSE DESCRIPTION

This course dives into the analysis of gene inheritance and function. We will build a foundation of the approaches and tools involved in genetic analysis using the model organisms that have been the center of genetics research and discovery. We expand to how modern tools and technology broaden the research questions, systems and scope. Throughout we emphasize the importance of complementing laboratory research with natural genetic variation to obtain information relevant to important questions in biology.

### LEARNING OBJECTIVES

This capstone experience is designed to train students to develop skills that are key for future careers in science fields as well as an educated citizen. The course is designed using principles of teaching that focus on a framework hierarchy of learning stages. It builds on remembering, understanding, and applying the basic biology content of Biol 12 and Biol 13 and moves to higher levels of synthesis through application, evaluation and creation. By the end of the course, students will be able to...

#### know

- Discuss how molecular modifications to DNA, RNA and proteins can regulate gene function.
- Describe and apply fundamental approaches in modern genetic analysis.
- Explain how classical model organisms and natural genetic variation are utilized in our understanding of genetics.

#### do

- Read, interpret and critique primary literature in different fields of genetics.
- Evaluate appropriateness of methodological approaches and validity of conclusions based on the data presented.
- Identify questions, generate hypotheses, and design experiments to test those hypotheses.
- Communicate scientific ideas clearly and persuasively in different formats (written, verbal, visual).

#### appreciate

- Appreciate the value of basic science research.

### Required texts

There will be no text, but your text from earlier Genetics classes (e.g., Russell iGenetics 3e) might prove useful as a resource.

Primary literature readings will be available on the lab Canvas site.

## Canvas

Course materials for Biology 76/176 will be available in Canvas including the syllabus, announcements, reading assignments, Powerpoint class presentations, pre-class screencasts, and class recordings.

## ASSIGNMENTS

### Pre-class assignments on Canvas

There will be pre-class reading material on Canvas to be completed before each meeting. Reading in advance of class is essential for our class discussions to function. The intention of these assignments is to deliver material in advance so we can focus class time on discussions and active learning.

### In class assignments

Participation: This is a discussion-based course and relies heavily on your participation. Please complete the assigned reading before class so you are ready to actively engage during class. To get full credit for in-class participation, you need to attend a minimum of 90% of classes (you can miss a maximum of two classes, and it will not affect your grade). If you miss more than three classes, your grade will be slowly reduced.

Meet the models: We will have an activity working with the specific model organism on which we are focusing for the week. Groups will present an introduction to the model organism (each group will present 2 model organisms throughout the class). The in-class activity will be done by all groups and handed in at the end of class.

Several of the classes will involve a short trip to visit the model organism in their environment. Punctuality on these days is essential for these trips not exceeding the designated class time. Visiting the vertebrate facilities will require written consent for IACUC and EHS and there will be the option to opt-out if you have a pre-existing condition such as allergies or asthma.

Sticker Contest: Communicating science visually is an extremely important way to complement your written or verbal presentations. This assignment is to generate an image that encompasses a theme from the class. Group work with any members of the class is permitted. Dartmouth provides access to software such as BioRender and Canva that may be useful in the design process if you do not feel artistically inclined. The designs will be voted on and the winning design will be made into a sticker for everyone in the class.

### Research Grant (Individual)

The cumulative experience for this class will be to write a research proposal. The goal of this assignment is to apply the approaches and tools of genetic analysis that we have explored throughout this class to a question of interest to you in a non-model system. The ability to write concise and persuasive argument is key in many scientific careers, but this skill requires work and practice as much as other skills in science. Developing the ideas for and writing a proposal is an iterative process and therefore we will break the assignment into several components during the course of the quarter.

- Initial Grant topic (due 9/29 by end of day)

It is important to plan research early to provide the needed time to adequately develop your hypotheses and prepare your proposal. Prepare a short paragraph explaining your research question and why it is exciting to you personally. Additionally, provide an annotated bibliography of 3-5 papers that will be key in your proposal with the proper

scientific notation as well as a short description of no more than 3 sentences of how the contributions of this paper contribute to the research plan.

- Grant Proposal (due 10/21 by end of day)

Write a short grant proposal taking the principles of genetic analysis discussed in the course and apply these techniques to a question of interest to you in a non-model system. The grant proposal should address:

- (1) *Introduction*: what is the question and why is it exciting? What is known already and what are the open questions?
- (2) *System*: What is the natural history of the organism that you will use? How does the biology of the organism shape its utility in research? What genetic tools are available? What are the strengths and weakness of this organism to answer your question?
- (3) *Approach*: What steps of genetic analysis will you take to answer this question?

The final proposal should be a maximum of 3 pages, single spaced, with a minimum size of Arial size 11 including in-text citations but not included end-text reference list. See rubric for more details.

- Peer Review (due 10/29 by end of day)

Peer review is an important part of the scientific processes. Your colleagues can provide useful feedback and ideas on how to improve the rigor of your research questions. Each member of the class will be assigned two of the grant proposals and will provide feedback addressing the scientific approaches as well as clarity of communication. The Writing Assistant will also provide feedback on all initial proposals.

- Revised Grant (due 11/7 by end of day)

Incorporate all of the feedback into your final, polished proposal.

- Presentation (due week of 11/10)

Each student will present a 8 minute summary of their research proposal and answer questions from the class for 4 minutes. This provides the opportunity (1) to gain experience communicating clearly in verbal and visual format, (2) to receive feedback and ideas from additional class members that can be incorporated into your final proposal and (3) to broaden the classes exposure to exciting modern questions in genetic research.

### **Extra Credit**

This fall the Department of Biological Sciences is hosting two seminar speakers relevant to this course in the Cramer Seminar Series that is held on Fridays in Life Sciences Center 201 from 2:10-3:15pm. You can receive 1 point extra credit each talk that you attend and write a short a (no more than 1 page) description of the research. Reflections are due by end of day the Sunday after each seminar.

Please be sure to address:

- The “big picture” research question
- The organisms used to address the question and why
- The methods used and major results

- Your thoughts on the most exciting thing presented, what questions you have for next steps, and how you would address those questions.

On Friday, September 26, Dr. Jenn Coughlan (Yale University) will be presenting “*The dual role of parental conflict in speciation*”. Dr. Coughlan is a speciation biology and evolutionary geneticist whose work merges quantitative and population genomics, fieldwork, and common garden experiments to understand speciation, hybridization, and adaptation in wildflowers.

On Friday, October 3, Dr. Caiti Heil (NC State) will be presenting “*Signatures of domestication in Saccharomyces yeast*”. Dr. Heil is an evolutionary geneticist who uses genetics, genomics, and experimental evolution to study evolutionary processes including the evolution of recombination rate, hybridization, and adaptation to fermentation environments.

### ASSESSMENT OF YOUR ACADEMIC PERFORMANCE

|                                              |            |
|----------------------------------------------|------------|
| <b>Participation</b>                         | <b>25%</b> |
| Discussion participation                     | 20%        |
| Professionalism                              | 5%         |
| <b>Group assignments:</b>                    | <b>30%</b> |
| Meet the model presentations (2x)            | 8%         |
| In class activities                          | 20%        |
| Sticker contest                              | 2%         |
| <b>Research Grant Proposal: (Individual)</b> | <b>45%</b> |
| Topic proposal                               | 3%         |
| Initial Grant                                | 10%        |
| Peer review – two proposals                  | 10%        |
| Presentation                                 | 10%        |
| Revised Grant                                | 12%        |

### Late policy

The pre-class activities will close when class starts. In class activities must be turned in by the end of class the day they are assigned unless otherwise instructed. The assignments related to the research grant proposal will be penalized 25% of the earned grade per day late unless a prior arrangement is finalized in writing in advance.

### Absences

Participation—and therefore attendance—is essential for this course. You are expected to attend class in person unless you have made alternative arrangements due to illness, medical reasons. For the health and safety of our class community, please: **do not attend class when you are sick**. If you miss class for an excused reason you will be given the option to complete the in-class assignment independently from the group.

**Special appointments** If you have particular concerns, difficulties or interests that you would like to discuss individually, email to set up an individual appointment.

### Resources

**Library** Our liaison librarian, Lilly Linden ([lilly@Dartmouth.edu](mailto:lilly@Dartmouth.edu)), is available for help with getting access to books, videos, articles, etc. for your research. For more information, also see the [Biology Research Guide](#). Lilly will be joining us for two X-hours to share research and citation skills to help prepare for the grant writing.

Writing Assistant Our writing assistant, Simone Chaney ([simone.g.chaney.26@dartmouth.edu](mailto:simone.g.chaney.26@dartmouth.edu)), is a resource to help with the writing that is part of this course. Simone is available in the planning phase to help with brainstorming and outlining, can meet one-on-one or provide written feedback on drafts, and will provide written feedback for everyone during the peer review process.

## TOPICAL COURSE OVERVIEW

### 1. What is genetics?

DNA → RNA → Protein

DNA-level modifications: affect the genetic material itself or its accessibility:

- Mutations
- Epigenetic modifications
- Chromatin remodeling
- Structural changes

RNA-level modifications: regulate how much, where, when and how the transcript is used:

- RNA processing
- RNA stability & degradation
- RNA modifications
- RNA localization

Protein-level modifications: fine tune the activity, location or stability of the product

- Post-translational modifications
- Protein folding & chaperones
- Protein localization
- Protein-protein interactions

### 2. Forward Genetics: How to identify genes of interest?

Phenotype → Gene

- Mutagenesis
- Phenotypic Screening
- Genetic mapping
- Gene identification

### 3. Reverse genetics: How to confirm the function of a gene?

Gene → Phenotype

- Gene knockout/disruption
- Gene silencing (RNAi)
- Over-expression/transgenic approaches
- Site-directed mutagenesis

### CHRONOLOGICAL COURSE OVERVIEW

|                                                |   |                      |                                                                                                                                           |
|------------------------------------------------|---|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Week 1:<br>The logic of<br>genetic<br>analysis | M | 9/15                 | Introduction to advanced genetics                                                                                                         |
|                                                | T | 9/16                 | X-hour – Office hours in LSC 335                                                                                                          |
|                                                | W | 9/17                 | What are model organisms & how are they used to identify genes of interest?                                                               |
|                                                | F | 9/19                 | What is a phenotype and how do we confirm the function of a gene?                                                                         |
| Week 2:<br>Plant<br>genetics                   | M | 9/22                 | Meet the model: <i>Arabidopsis</i>                                                                                                        |
|                                                | T | 9/23                 | X hour –Library Resources I                                                                                                               |
|                                                | W | 9/24                 | How do genes act as regulators and molecular signalers in a pathway?                                                                      |
|                                                | F | 9/26                 | How do genes act as regulators and molecular signalers in a pathway?                                                                      |
|                                                |   | Extra credit         | Cramer Seminar Speaker Dr. Jenn Coughlan “The dual role of parental conflict in speciation” 2:10pm in LSC 201 on Friday, September 26     |
| Week 3:<br>Yeast<br>genetics                   | M | 9/29                 | <b>Genetic mapping recombination and QTL</b><br>What roles do regulatory elements and mobile DNA play in phenotypic diversity?            |
|                                                |   |                      | <b>Assignment: Grant topic</b>                                                                                                            |
|                                                | T | 9/30                 | X hour – Office hours in LSC 335                                                                                                          |
|                                                | W | 10/1                 | Genetic mapping: Linkage, QTL, and fine-scale mapping                                                                                     |
|                                                | F | 10/3                 | Meet the model: Yeast                                                                                                                     |
|                                                |   | Extra credit         | Cramer Seminar Speaker Dr. Caiti Heil “Signatures of domestication in <i>Saccharomyces yeast</i> ” 2:10pm in LSC 201 on Friday, October 3 |
| Week 4:<br>Evolutionary<br>genetics            | M | 10/6                 | Fieldtrip: <i>Drosophila</i> experimental evolution at Dartmouth Organic Farm                                                             |
|                                                | T | 10/7                 | X-hour – Library Resources II                                                                                                             |
|                                                | W | 10/8                 | How does natural selection shape genes?                                                                                                   |
|                                                | F | 10/10                | How do we empirically test the genetic basis of adaptation?                                                                               |
| Week 5:<br><i>C. elegans</i><br>genetics       | M | 10/13                | Meet the model: <i>C. elegans</i>                                                                                                         |
|                                                | T | 10/14                | X-hour – Office Hours LSC 335                                                                                                             |
|                                                | W | 10/15                | Where and when genes are expressed?                                                                                                       |
|                                                | F | 10/17                | How to validate gene function?                                                                                                            |
| Week 6:<br>Zebrafish<br>genetics               | M | 10/20                | Meet the model: Zebrafish                                                                                                                 |
|                                                | T | 10/21                | X-hour – Office hours in LSC 335                                                                                                          |
|                                                |   |                      | <b>Assignment: Grant</b>                                                                                                                  |
|                                                | W | 10/22                | Site directed mutagenesis                                                                                                                 |
|                                                | F | 10/24                | Fieldtrip: Zebrafish facility tour                                                                                                        |
| Week 7:<br><i>Drosophila</i><br>genetics       | M | 10/27                | Meet the model: <i>Drosophila</i>                                                                                                         |
|                                                | T | 10/28                | X-hour – Office hours in LSC 335                                                                                                          |
|                                                |   |                      | <b>Assignment: Sticker contest due</b>                                                                                                    |
|                                                | W | 10/29                | Alternative splicing                                                                                                                      |
|                                                |   |                      | <b>Assignment: Peer review</b>                                                                                                            |
|                                                | F | 10/31                | Reciprocal Hemizygosity                                                                                                                   |
| Week 8:<br>Mouse<br>genetics                   | M | 11/3                 | Meet the model: Mouse                                                                                                                     |
|                                                | T | 11/4                 | X-hour – Office hours in LSC 335                                                                                                          |
|                                                | W | 11/5                 | Mouse pigmentation: pleiotropy in the lab                                                                                                 |
|                                                | F | 11/7                 | Mouse pigmentation: natural selection in the wild                                                                                         |
|                                                |   | 11/9                 | <b>Assignment: Revised Grant</b>                                                                                                          |
| Week 9:<br>Moving<br>beyond<br>models          | M | 11/10                | <b>Assignment: Grant proposal presentations I</b>                                                                                         |
|                                                | T | 11/11                | X-hour – Office hours in LSC 335                                                                                                          |
|                                                | W | 11/12                | <b>Assignment: Grant proposal presentations II</b>                                                                                        |
|                                                | F | 11/14                | <b>Assignment: Grant proposal presentations III</b>                                                                                       |
| Week 10                                        | M | 11/17                | <b>Assignment: Grant proposal presentations IV</b>                                                                                        |
| <b>ASSIGNMENT DUE</b>                          |   | <b>X-HOUR IN USE</b> | <b>OPTIONAL EXTRA CREDIT</b>                                                                                                              |
|                                                |   |                      | <b>TRAVEL</b>                                                                                                                             |

*This is our plan for the quarter, but it is subject to change as the course progresses. Please consult the Canvas site for up-to-date material, dates, and deadlines.*

## ACADEMIC HONESTY

Honesty is the foundation of the academic pursuit of knowledge. In recognition of this, the faculty of Biology 76/176 will not overlook violations of [Dartmouth's Academic Honor Principle](#). The following is quoted directly from the Dartmouth College Student Handbook: "Students who submit work that is not their own or who commit other acts of academic dishonesty forfeit the opportunity to continue at Dartmouth."

The complete text of the [Arts and Sciences Academic Honor Policy for Undergraduates](#) is in the [Student Handbook](#). Please read it carefully. Graduate students should consult the [Guarini Graduate Student Handbook](#), with particular emphasis on [The Honor Principle](#) and [Code of Conduct](#). The Faculty Handbook of Dartmouth states explicitly that College Faculty members are obligated to report potential violations of the Academic Honor Principle to the Dartmouth's Community Standards and Accountability Office or to the Dean of Graduate Studies, respectively, and can result in a hearing before the Committee on Standards. Students found responsible for violating the honor principle can be suspended for multiple terms or, in the most extreme cases, separated from the College.

### Permitted collaboration

There are group assignments in this course. All group members are expected to work together on the group assignment and indicate their participation by signing their names on the cover page. If a student puts their name on group work that they did not contribute to, the student is considered to have misrepresented the work of another as his or her own and is in violation of the Academic Honor Principle. It is also considered a violation of the Honor Principle for the group assignment to consult with students outside of their group or with anyone else.

Awareness of the Academic Honor Principle is not intended to inhibit discussion of the class material among the students. Indeed, such discussion is worthwhile and constitutes a valuable component of the learning process and is encouraged.

### Use of Generative Artificial Intelligence (GAI)

Please do not use GAI as a substitute for your own thinking and learning. AI can generate inaccurate or outdated knowledge (including fake citations) and if used incorrectly it can diminish your learning by short-circuiting the data acquisition process.

Limitations of Use: The use of AI in this course should be limited to research and understanding of concepts. AI tools should be a starting point to clarify concepts or facilitate brainstorming questions that can be further investigated. It should not be used for drafting or completing assignments in their entirety. There are several assignments in which GAI may not be used at all: (1) in class assignments or reflection essays or (2) peer review process.

Citation and Transparency: Students must not pass off the work generated by AI as their own. If GAI is used to help outline or brainstorm, it must be cited along with a short reflection of the experience that includes what was learned, how the GAI was useful, and any limitations or challenges encountered. Please also see [this resource on proper citation of sources](#).

Student Responsibility: It's the responsibility of the student to use AI tools ethically and appropriately so that their original thoughts and perspectives remain at the forefront of their work.

## STUDENT ACCESSIBILITY

Students requesting disability-related accommodations and services for this course are required

to register with Student Accessibility Services (SAS; [Apply for Services webpage](#); [student.accessibility.services@dartmouth.edu](mailto:student.accessibility.services@dartmouth.edu); 1-603-646-9900) and to request that an accommodation email be sent to me in advance of the need for an accommodation. Then, students should schedule a follow-up meeting with me to determine relevant details such as what role SAS or its [Testing Center](#) may play in accommodation implementation. This process works best for everyone when completed as early in the quarter as possible. If students have questions about whether they are eligible for accommodations or have concerns about the implementation of their accommodations, they should contact the SAS office. All inquiries and discussions will remain confidential.

### RELIGIOUS OBSERVANCES

Dartmouth has a deep commitment to support students' religious observances and diverse faith practices. Some students may wish to take part in religious observances that occur during this academic term. If you have a religious observance that conflicts with your participation in the course, please meet with me as soon as possible—before the end of the second week of the term at the latest—to discuss appropriate course adjustments.

### MENTAL HEALTH

The academic environment at Dartmouth is challenging, our terms are intensive, and classes are not the only demanding part of your life. There are a number of resources available to you on campus to support your wellness, including your [undergraduate dean](#), [Dartmouth Student Health Service](#) and the [Student Wellness Center](#).

### SEXUAL MISCONDUCT AND TITLE IX

At Dartmouth, we value integrity, responsibility, and respect for the rights and interests of others, all central to our Principles of Community. We are dedicated to establishing and maintaining a safe and inclusive campus where all community members have equal access to Dartmouth's educational and employment opportunities. We strive to promote an environment of sexual respect, safety, and well-being. Through the Sexual and Gender-Based Misconduct Policy (SMP), Dartmouth demonstrates that sex and gender-based discrimination, sex and gender-based harassment, sexual assault, dating violence, domestic violence, stalking, etc., are not tolerated in our community. For more information regarding Title IX and to access helpful resources, visit Title IX's website ([sexual-respect.dartmouth.edu](http://sexual-respect.dartmouth.edu)). As faculty members, we are required to share disclosures of sexual or gender-based misconduct with the Title IX office. If you have any questions or want to explore support and assistance, please contact the Title IX office at 603-646-0922 or [TitleIX@dartmouth.edu](mailto:TitleIX@dartmouth.edu). Speaking to Title IX does not automatically initiate a college resolution. Instead, much of their work is around providing supportive measures to ensure you can continue to engage in Dartmouth's programs and activities.

### CLASS RECORDINGS

The classroom capture system in LSC 205 will record the class sessions. We will make these recordings available to students. By enrolling in this course,

A. I affirm my understanding that the instructors may record meetings of this course in our classroom.

B. I further affirm that the instructors own the copyright to their instructional materials, of which these recordings constitute a part, and my distribution of any of these recordings in whole or in part to any person or entity other than other members of the class without prior written consent of the instructors may be subject to discipline by Dartmouth up to and including separation from Dartmouth.

C. Right to Privacy Policy