

## BIOL 71.2 Spring 2024 – Current Topics in Cell Biology – Professor Amanda Amodeo

This course will use “back-of-the-envelope” approaches to develop an intuition for scaling problems in cell biology. We will investigate questions including the sizes relationships between genomes, subcellular organelles, eukaryotic and prokaryotic cells, organs, and organisms. We will also discuss the concentration and number of cellular “building blocks” and their consequences for cell signaling and homeostasis. The course will consist of a mix of lectures, in-class exercises designed to generate biological insights, and discussion of current primary literature. Content will be organized by a central motivating question (ex. “How many of each organelle does a cell need?”) in weeklong modules. The class will be discussion based and active participation will be essential for student success. The goal of the course is to improve students’ biological numeracy and allow them to think about a range of cell biological questions quantitatively. The course will culminate in small group presentations on quantitative questions chosen by the students and vetted by the instructor.

**Discussion and Lecture (LSC ##):** MWF 10:10-11:15AM

**Instructor:** Prof. Amanda Amodeo, Life Sciences Center Room 223,  
Email: amanda.amodeo@dartmouth.edu  
Student drop-in (office hour): Thursdays 12:15-1:00 (X-hour)

**Textbook:** Cell Biology by The Numbers, Ron Milo and Rob Phillips.

**Available:** Powerpoint slides and papers for discussion will be posted on Canvas.

**Prerequisites:** BIOL 12 or 19 (Cell Structure and Function) and BIOL 13 (Gene Expression and Inheritance) and one from among BIOL 40, BIOL 41, BIOL 43, BIOL 45, and CHEM 41.

**Class Schedule:** Topics that we will discuss are tentatively planned as below (subject to change).

<u>Date</u>	<u>Week#</u>	<u>Topic</u>	<u>Readings</u>
		<b>Introduction to thinking Quantitatively.</b>	
M Mar 25	1	Introduction; Biological Numeracy & Dimensional analysis	xxiii-xlii
W Mar 27		Sizes of key cellular components	p. 40-63
F Mar 29		The toolkit: length-scales of common cell bio techniques	
		<b>What are the concentrations of key macromolecules?</b>	
M Apr 1	2	Cellular building blocks	p. 65-67; 104-132
W Apr 3		Concentration estimates across cell types	
F Apr 5		Correlations between RNA and protein	Brion et al, 2020 (eLife)
		<b>What are the timescales of cellular processes?</b>	
M Apr 8	3	Making and degrading proteins	p 231-248
W Apr 10		Diffusion and active transport	p 209-222; 263-268
F Apr 12		Diffusion in a very large cell	Huang et at, 2022 (Nat Com)
		<b>How does noise affect our ability to draw conclusions?</b>	
M Apr 15	4	Variability in biological systems	112-114; 132-142
W Apr 17		Accounting for error in experimental design	xxxii-xxxvi
F Apr 19		<i>Group formation and brainstorming for final presentation</i>	

M	Apr 22	5	<b>How many of each organelle does a cell need?</b>	
W	Apr 24		Size of organelles	p 24-40
F	Apr 26		Energy consumption in the cell	p 199-207
			Mitochondria homeostasis	Palikaras et al, 2015 (Nature)
			<b>What determines cell growth rates?</b>	
M	Apr 29	6	Genome sizes and biosynthetic capacity	p. 283-294, 147-151
W	May 1		Concentration, amount, and reaction rates	
F	May 3		Protein scaling as a function of cell size	Lanz et al, 2022 (Mol Cell)
			<b>How could a cell measure its size?</b>	
M	May 6	7	Cell size across species	p. 9-17
W	May 8		Coordinating growth and division	p 272-281
F	May 10		Components that do not scale with size	D'Ario et al, 2021 (Science)
			<b>How can groups of cells coordinate cell fates?</b>	
M	May 13	8	Diffusible morphogens	180-181
W	May 15		Example morphogen in the fly wing	Alexandre et al, 2014 (Nature)
F	May 17		<i>Prep time for presentations (no class)</i>	
			<b>What do YOU want to estimate?</b>	
M	May 20	9	Student presentations	
W	May 22		Student presentations	
F	May 24		Student presentations	
M	May 27	10	No class (Memorial Day)	
W	May 31		Student presentations if needed and wrap-up	

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**Learning Goals:**

1. Improve quantitative reasoning skills in biology. The primary goal for this course is to improve your ability to think about cell biological questions from a quantitative perspective. We will discuss example problems that will challenge you to think critically to derive inferences from limited information. We will read, evaluate, and discuss papers from primary literature to develop an understanding of scientific rationale. At the end of the course you will be better prepared to evaluate scientific findings and design your own experimental approaches to cell biological questions.
2. Increase understanding of core cell biology concepts. In addition to developing the quantitative reasoning skills described above we will explore select scaling questions in cell biology. These questions will expose you to thinking about cell biological processes at several length-scales. We will read key recent papers and explore current techniques and findings.

**Course Mode and Attendance:**

We will meet synchronously in person for lectures and discussions on MWF at the normal meeting times for 10 timeslot. The X-hour will be used for appointments as needed.

Class participation will be graded and in class attendance is mandatory. Greater than three unexcused absences will negatively affect student participation scores. Students are expected to contact (email) the instructor prior to the class period to be excused due illness, medical reasons, or the need to isolate due to COVID-19. For the health and safety of our class

community, **please do not attend class when you are sick**, nor when you have been instructed by Student Health Services to stay home.

### **Discussion and Lectures:**

The schedule of class meetings and lecture topics are provided above. The course will be divided into modules based on questions as described above. Each week we will discuss a fundamental problem in biology including working examples in class and reading an associated paper from primary literature. The paper and its related references that will form the basis for class discussion will be posted on Canvas several days before the paper will be discussed. During class, we will discuss facts and information with the goal of learning how to think about and interpret scientific data. In class we will discuss key experiments and I will provide discussion prompts. It is essential that you read the posted paper before class. Students who come unprepared to critically discuss the assigned reading will be unable to receive full participation credit.

### **Assignments and Grading Policies:**

Grading will be based on weekly group problem sets, one presentation of a primary literature paper, one final presentation and class participation. The problem sets will contain questions for you to estimate the quantities related to topics discussed in class. Some class time will be provided to start the problem-sets which will be due at the start of class each Friday. A list of pre-approved topics will be provided for the final presentation or students may choose their own question contingent upon instructor approval.

Problem sets	20%
Paper presentation	20%
Final presentation	30%
Class participation	25%
Professionalism	5% (see <a href="#">this guide</a> by Patterson for tips on professionalism)

### **Academic Honor Principle:**

Academic honesty is essential. The following is quoted directly from the Dartmouth College Student Handbook: "Any student who submits work which is not his or her own, or commits other acts of academic dishonesty, violates the purposes of the College and is subject to disciplinary action, up to and including suspension or separation." The complete text of the Academic Honor Principle is available at <http://www.dartmouth.edu/~uja/honor/Links> to an external site. Please read it carefully; you are responsible for it. Any violations of the Honor Principle will be referred to the Undergraduate Judicial Affairs Office and can result in a hearing before the Committee on Standards and can result in your suspension for multiple terms or, in the most extreme cases, separation from the College. Honesty is the foundation of the academic pursuit of knowledge. In recognition of this, the Faculty Handbook of Dartmouth College states explicitly that College Faculty members are obligated to report potential violations of the Academic Honor Principle to the Dartmouth College Committee on Standards. Should the Committee on Standards find the student to be in violation of the Academic Honor Principle, punishments usually involve suspension for multiple terms or separation of the student from the College.

### **Use of generative AI:**

The use of generative AI on problem sets and the final presentation is allowed with proper attribution. If students use an AI resource in solving these problems, they must explicitly cite where and how the AI was used in generating the answer. Failure to properly attribute work done by artificial intelligence is an honor code violation. It is important that students evaluate the answers generated by AI for factual accuracy and logical correctness. AI is a tool like any other and can give correct or incorrect results depending on inputs. Large language models (such as ChatGPT) are prone to "hallucinations" in which they generate false "facts" and even citations. Therefore, AI models themselves are not reliable sources

for information. It is incumbent upon the student to evaluate any AI generated results before incorporating them into their own work. Incorrect or poorly reasoned arguments stemming from AI-based misinformation will be graded on the merit of the work.

### **Wellness Support for Dartmouth Students:**

We recognize that the academic environment at Dartmouth is challenging, that our terms are intensive, and that classes are not the only demanding part of your life. There are several resources available to you on campus to support your wellness, including: your undergraduate dean (<http://www.dartmouth.edu/~upperde/Links> to an external site.), Counseling and Human Development (<http://www.dartmouth.edu/~chd/Links> to an external site.), and the Student Wellness Center (<http://www.dartmouth.edu/~healthed/Links> to an external site.). I encourage you to use these resources and come speak with me to take care of yourself throughout the term.

### **Student Accessibility Services:**

Students requesting disability-related accommodations and services for this course are required to register with Student Accessibility Services (SAS; Apply for Services via their website: <https://students.dartmouth.edu/student-accessibility/> or email: [student.accessibility.services@dartmouth.edu](mailto:student.accessibility.services@dartmouth.edu); or call: 1-603-646-9900) and to request that an accommodation email be sent to Prof. Amodeo in advance of the need for an accommodation. Then, students should schedule a follow-up meeting with Prof. Amodeo 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 Holidays:**

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 Prof. Amodeo as soon as possible—before the end of the second week of the term at the latest—to discuss appropriate course adjustments.

### **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 have equal access to the educational and employment opportunities Dartmouth offers. We strive to promote an environment of sexual respect, safety, and well-being. In its policies and standards, Dartmouth demonstrates unequivocally that sexual assault, gender-based harassment, domestic violence, dating violence, and stalking are not tolerated in our community. The Sexual Respect Website ([sexual-respect.dartmouth.edu](http://sexual-respect.dartmouth.edu)) provides a wealth of information on your rights and obligations with regard to sexual respect and resources that are available to all in our community. All faculty members are obligated to share disclosures regarding conduct under Title IX with Dartmouth's Title IX Coordinator.

Should you have any questions, please feel free to contact Dartmouth's Title IX Coordinator [Kristi.Clemens@Dartmouth.edu](mailto:Kristi.Clemens@Dartmouth.edu) and deputies if appropriate.

### **Special appointments:**

If you have particular concerns, difficulties or interests that you would like to discuss individually, email Prof. Amodeo to set up an appointment.