

BIOLOGY BY THE NUMBERS

MICRBIO 5130

AUTUMN 2025

Course days/times: MWF 10:20-11:15 am

Course location: Jennings 160

Credit hours: 3

Format of instruction: In-person lecture, 3 contact hours/week

Prerequisites: Biology 1113, 1114; Chemistry 1210, 1220; Statistics 1450, 2450, or 2480; or by permission of instructor.

INSTRUCTOR

Instructor: Dr. Karna Gowda

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Phone: (614) 688-3830

Office hours: TBD

Office location: Riffe Building R900

COURSE DESCRIPTION

Beneath the surface of every diagram or fundamental concept in a biology textbook is an essential set of numbers: counts, concentrations, rates, sizes, and energies. What are these numbers, and what can we learn from them?

The goal of this course is to introduce students to quantitative reasoning about biological systems through a survey of the important quantities relevant to a range of biological processes, from the central dogma all the way to the Earth's biosphere. While knowing these numbers at an approximate level (e.g., typical rates of transcription and translation) is an important goal of the course, equally important is learning to quantitatively reason using these numbers (e.g., learning to formulate problems such as: "How do diffusion and active transport rates constrain cell sizes?").

This course is ideal for students who have taken the introductory biology sequence and have mathematical experience through precalculus and/or introductory statistics. Mathematical knowledge required in this course will be mainly simple arithmetic – the emphasis will be placed on learning how to formulate "order-of-magnitude" estimation problems, identify relevant quantities from scientific literature and other resources, and critically assess the quality of these estimates. The course will culminate in an open-ended group project, wherein students will take on an ambitious estimation problem from any area of biology and carry out a rigorous quantitative analysis.

LEARNING GOALS

Successful students will be able to:

1. Identify important scales and quantities in biological systems (e.g., typical concentrations of key biomolecules, time scales of translation, sizes of genomes, etc.)
2. Translate biological processes into quantitative formulations
3. Extract relevant quantities for performing analyses using either quantitative or visual data from literature
4. Analyze data to make order of magnitude estimates of biological quantities and processes
5. Critique the assumptions, generality, potential failures, and margins of error for quantitative analyses
6. Communicate quantitative reasoning, both verbally and visually

COURSE MATERIALS

The textbook for the course will be “Cell biology by the numbers” by Milo and Phillips, 1ed, Garland Science, 2015. An online version of the textbook is freely available: <https://book.bionumbers.org/>. A hard copy of the textbook will also be made available for purchase in the campus bookstore.

The following publications will also supplement the course and will be made available on CarmenCanvas:

1. Bar-On, Y. M., Phillips, R., & Milo, R. (2018). The biomass distribution on Earth. *Proceedings of the National Academy of Sciences of the United States of America*, 115(25), 6506–6511. <https://doi.org/10.1073/pnas.1711842115>
2. Whitman, W. B., Coleman, D. C., & Wiebe, W. J. (1998). Prokaryotes: The unseen majority. *Proceedings of the National Academy of Sciences of the United States of America*, 95(12), 6578–6583. <https://doi.org/10.1073/pnas.95.12.6578>
3. Chure, G., Banks, R. A., Flamholz, A. I., Sarai, N. S., Kamb, M., Lopez-Gomez, I., Bar-On, Y., Milo, R., & Phillips, R. (2023). Anthroponumbers.org: A quantitative database of human impacts on Planet Earth. *Patterns*, 3(9), 100552. <https://doi.org/10.1016/j.patter.2022.100552>

SOFTWARE

This course emphasizes arithmetic and analysis that can be done with pen and paper. Familiarity with specific software is not expected or required. However, tools such as Microsoft Excel, Python or R may be helpful for group projects, especially for

organizing data or performing algebraic manipulations on large datasets. Students who are familiar with these tools are encouraged to use them, but doing so is neither required nor expected.

ASSIGNMENT INFORMATION AND GRADING

The breakdown of final grades is as follows:

- Homework – 200 points (20%)
- Midterm exam – 200 points (20%)
- Final exam – 300 points (30%)
- Group project – 300 points (30%)

Homework assignments (40 points each) will be assigned for each major topic in the course. You will need to work through homework problems on your own in a timely manner to perform well in the class. **Late assignments will not be accepted without prior permission from me.** When advance notice is not possible, I will determine on a case-by-case basis whether a late assignment will be accepted.

There will be a midterm (200 points) and a final exam (300 points). The emphasis in exams will be on reasoning and not memorization of quantities. Relevant numbers will be provided. All exams will be administered in-person during the scheduled class time.

Group projects (300 points) will be performed by teams of 2-3 students. Topics for group projects must be approved by me by the date indicated on the course schedule. The final products of these projects will be a 6-page report explaining the topic, formulating a quantitative problem, identifying relevant quantities, performing estimations, and critiquing these estimates.

Letter grades will be assigned based on the following percentages:

Grade	Percentage
A	93–100%
A–	90–92%
B+	87–89%
B	83–86%
B–	80–82%
C+	77–79%
C	73–76%
C–	70–72%
D+	67–69%
D	60–66%
E	0–59%

CLASS ATTENDANCE POLICY

In-person attendance for lecture is expected and necessary for success. Students are responsible for any notes, activities, discussions, and announcements given during lecture. Asynchronous materials for excused absences will be available on CarmenCanvas or by request. If you have a situation that might cause you to miss an entire week of lecture, discuss it with me as soon as possible. When advance notice is not possible, I will determine on a case-by-case basis whether an absence is excused. **Attendance is required** at in-person proctored exams.

MAKE UP EXAM POLICY

Students must notify me in advance if they are unable to attend a scheduled exam. Make-up exams must be scheduled within one week of the original exam date unless special circumstances prevent it. In cases of emergencies where advance notice is not possible, students should contact me as soon as possible. In such cases, exceptions to the make-up exam scheduling requirement will be made at my discretion.

ACADEMIC MISCONDUCT

Academic integrity is essential to maintaining an environment that fosters excellence in teaching, research, and other educational and scholarly activities. Thus, The Ohio State University and the Committee on Academic Misconduct (COAM) expect that all students have read and understand the University's Code of Student Conduct, and that all students will complete all academic and scholarly assignments with fairness and honesty. Students must recognize that failure to follow the rules and guidelines established in the University's Code of Student Conduct and this syllabus may constitute Academic Misconduct.

The Ohio State University's Code of Student Conduct (Section 3335-23-04) defines academic misconduct as: Any activity that tends to compromise the academic integrity of the University or subvert the educational process. Examples of academic misconduct include (but are not limited to) plagiarism, collusion (unauthorized collaboration), copying the work of another student, and possession of unauthorized materials during an examination. Ignorance of the University's Code of Student Conduct is never considered an excuse for academic misconduct, so I recommend that you review the Code of Student Conduct and, specifically, the sections dealing with academic misconduct.

If I suspect that a student has committed academic misconduct in this course, I am obligated by University Rules to report my suspicions to the Committee on Academic Misconduct. If COAM determines that you have violated the University's Code of Student Conduct (i.e., committed academic misconduct), the sanctions for the

misconduct could include a failing grade in this course and suspension or dismissal from the University.

If you have any questions about the above policy or what constitutes academic misconduct in this course, please contact me.

GENERATIVE AI

GenAI can be a helpful resource for performing quantitative analyses of scientific problems in real world situations. However, it is important to recognize that the goal of this course is develop the ability to reason quantitatively and to critique this reasoning. Moreover, you will not be permitted to use GenAI tools in in-person exams, which account for 50% of your final grade. Thus, it is critical for this course that you develop quantitative reasoning skills that do not strictly rely on GenAI tools.

That said, I am supportive of students learning to use GenAI tools for assignments and/or projects **when accompanied by critical thinking**. If you use GenAI, please include the following statement with each assignment:

1. Application used: Specify the GenAI application or tool you used (e.g., Copilot, ChatGPT, Claude AI, Gemini).
2. Intended purpose: Describe the purpose for which you used GenAI.
3. Quality of initial GenAI output: Evaluate the initial output generated by GenAI. For example, was it accurate, biased, coherent, and/or relevant?
4. Iteration and refinement: Explain how you revised prompts or adjusted parameters to refine the GenAI output. Did you experiment with different input prompts to improve the output?
5. Incorporation in completed assignment: Reflect on how you incorporated the GenAI-generated content into your assignment. How did you edit, adapt, or combine it with other ideas?

To give a brief example:

How many Rs are in "strawberry"?



There are **two** "R"s in "strawberry."

Source: ChatGPT-4o. Intended purpose: to illustrate a weakness of GenAI. Quality of the GenAI output: obviously incorrect. Iteration and refinement: I just decided to count the letters myself.

While GenAI can be a valuable tool, remember that academic integrity remains paramount. You are responsible for developing and articulating your own ideas, so addressing how GenAI contributed to those ideas (as you would for any sources you use) is centrally important to your learning. Attribute GenAI-generated content with

proper citations and avoid plagiarism. Additionally, consider the accuracy of information incorporated in your assignment and the ethical implications of using GenAI in educational contexts. You are responsible for ensuring that the information you submit based on a GenAI query does not contain misinformation, unethical content, or violate intellectual property laws. Submission of GenAI-generated content as your own work is considered a violation of Ohio State's [Academic Integrity](#) policy and [Code of Student Conduct](#) because the work is not your own. The use of unauthorized GenAI tools will result in referral to the [Committee on Academic Misconduct](#). If I suspect that you have used GenAI inappropriately on an assignment for this course, I will ask you to communicate with me to explain your process for completing the assignment in question.

Students should familiarize themselves with the Terms of Use for the GenAI service they use, as well as the service's expectations around data privacy and use. Students should not share private or sensitive information about themselves or others with GenAI services. As indicated in Ohio State's February 2024 Security and Privacy Statement on Artificial Intelligence, "[u]niversity community members should not enter any institutional data that is categorized above the S1 (public) level into generative AI tools, except when using the protected environment of Copilot, meaning that you logged in with your university credentials and see the green 'Protected' button in the upper right-hand corner. Even when using the protected version of Copilot, it is best practice to put only S1 or S2 (internal) institutional data into the tool. S3 (private) and S4 (restricted) data should not be entered into any AI platform."

Please contact me if you have questions regarding this course policy.

DISABILITY SERVICES

The university strives to maintain a healthy and accessible environment to support student learning in and out of the classroom. If you anticipate or experience academic barriers based on your disability (including mental health, chronic, or temporary medical conditions), please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion.

If you are ill and need to miss class, including if you are staying home and away from others while experiencing symptoms of a viral infection or fever, please let me know immediately. In cases where illness interacts with an underlying medical condition, please consult with Student Life Disability Services to request reasonable accommodations. You can connect with them at slds@osu.edu; 614-292-3307; or slds.osu.edu.

RELIGIOUS ACCOMMODATIONS

Ohio State has had a longstanding practice of making reasonable academic accommodations for students' religious beliefs and practices in accordance with applicable law. In 2023, Ohio State updated its practice to align with new state legislation. Under this new provision, students must be in early communication with their instructors regarding any known accommodation requests for religious beliefs and practices, providing notice of specific dates for which they request alternative accommodations within 14 days after the first instructional day of the course. Instructors in turn shall not question the sincerity of a student's religious or spiritual belief system in reviewing such requests and shall keep requests for accommodations confidential.

With sufficient notice, instructors will provide students with reasonable alternative accommodations with regard to examinations and other academic requirements with respect to students' sincerely held religious beliefs and practices by allowing up to three absences each semester for the student to attend or participate in religious activities. Examples of religious accommodations can include, but are not limited to, rescheduling an exam, altering the time of a student's presentation, allowing make-up assignments to substitute for missed class work, or flexibility in due dates or research responsibilities. If concerns arise about a requested accommodation, instructors are to consult their tenure initiating unit head for assistance.

A student's request for time off shall be provided if the student's sincerely held religious belief or practice severely affects the student's ability to take an exam or meet an academic requirement and the student has notified their instructor, in writing during the first 14 days after the course begins, of the date of each absence. Although students are required to provide notice within the first 14 days after a course begins, instructors are strongly encouraged to work with the student to provide a reasonable accommodation if a request is made outside the notice period. A student may not be penalized for an absence approved under this policy.

If students have questions or disputes related to academic accommodations, they should contact their course instructor, and then their department or college office. For questions or to report discrimination or harassment based on religion, individuals should contact the [Office of Institutional Equity](#). (Policy: [Religious Holidays, Holy Days and Observances](#)).

MENTAL HEALTH

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce

a student's ability to participate in daily activities. The Ohio State University offers services to assist you with addressing these and other concerns you may be experiencing. If you or someone you know are suffering from any of the aforementioned conditions, you can learn more about the broad range of confidential mental health services available on campus via the Office of Student Life's Counseling and Consultation Service (CCS) by visiting ccs.osu.edu or calling [614-292-5766](tel:614-292-5766). CCS is located on the 4th Floor of the Younkin Success Center and 10th Floor of Lincoln Tower. You can reach an on-call counselor when CCS is closed at [614-292-5766](tel:614-292-5766) and 24-hour emergency help is also available 24/7 by dialing 988 to reach the Suicide and Crisis Lifeline.

CREATING AN ENVIRONMENT FREE FROM HARASSMENT, DISCRIMINATION, AND SEXUAL MISCONDUCT

The Ohio State University is committed to building and maintaining a community to reflect diversity and to improve opportunities for all. All Buckeyes have the right to be free from harassment, discrimination, and sexual misconduct. Ohio State does not discriminate on the basis of age, ancestry, color, disability, ethnicity, gender, gender identity or expression, genetic information, HIV/AIDS status, military status, national origin, pregnancy (childbirth, false pregnancy, termination of pregnancy, or recovery therefrom), race, religion, sex, sexual orientation, or protected veteran status, or any other bases under the law, in its activities, academic programs, admission, and employment. Members of the university community also have the right to be free from all forms of sexual misconduct: sexual harassment, sexual assault, relationship violence, stalking, and sexual exploitation.

To report harassment, discrimination, sexual misconduct, or retaliation and/or seek confidential and non-confidential resources and supportive measures, contact the Office of Institutional Equity: online reporting form at equity.osu.edu, call 614-247-5838 or TTY 614-688-8605, or Email equity@osu.edu.

The university is committed to stopping sexual misconduct, preventing its recurrence, eliminating any hostile environment, and remedying its discriminatory effects. All university employees have reporting responsibilities to the Office of Institutional Equity to ensure the university can take appropriate action:

- All university employees, except those exempted by legal privilege of confidentiality or expressly identified as a confidential reporter, have an obligation to report incidents of sexual assault immediately.
- The following employees have an obligation to report all other forms of sexual misconduct as soon as practicable but at most within five workdays of becoming aware of such information: 1. Any human resource professional (HRP); 2.

Anyone who supervises faculty, staff, students, or volunteers; 3. Chair/director; and 4. Faculty member.

GRIEVANCES AND SOLVING PROBLEMS

A student who encounters a problem related to his/her educational program has a variety of avenues available to seek resolution. (Note: the procedures for grade grievances are explicitly covered in the faculty rules) Typically, a student is advised to resolve any dispute, disagreement, or grievance as directly as possible, engaging with the person or persons most closely involved. The faculty and staff of the departments and colleges are available to work with students in this regard. If this step does not produce acceptable results, the student should follow a logical stepwise progression to address the academic concerns.

According to University Policies, if you have a problem with this class, you should seek to resolve the grievance concerning a grade or academic practice by speaking first with the instructor or professor. Then, if necessary, take your case to the department chairperson, college dean or associate dean, and to the provost, in that order. Specific procedures are outlined in Faculty Rule 3335-8-23. Grievances against graduate, research, and teaching assistants should be submitted first to the supervising instructor, then to the chairperson of the assistant's department.

LYFT RIDE SMART (PREVIOUSLY SAFE RIDE)

Lyft Ride at Ohio State offers eligible students discounted rides, inside the university-designated service area ([opens in new window](#)) and has expanded service to the Short North area along High Street. Service runs from 7 p.m. to 7 a.m. Prices may be impacted by distance, traffic, time of day, special events and prime time surcharges. More information about the service and the Lyft App, and a link to get started using the Lyft Ride Smart services can be found at: <https://ttm.osu.edu/ride-smart>.

WEATHER/SHORT TERM CLOSING

Although Ohio State strives to remain open to ensure continuity of services to students and the public, extreme conditions can warrant the usage of the university's Weather or Other Short-Term Closing Policy. Please visit this webpage to learn more about preparing for potential closings and planning ahead for winter weather.