

BIOE 526/498: Advances in Biotechnology

Meeting time: Mondays and Wednesdays: 12:30 pm - 1:50 pm

Location: Everitt Laboratory 3217

Credit hours: 3 or 4

Semester: Fall 2026

Course website: <https://canvas.illinois.edu/courses/74670>

Course email: gaj@illinois.edu

Instructor Information

Name	Thomas Gaj, Ph.D.
Office Hours	By appointment (Office: Everitt 2252)

Course Description

From protein design to genetic engineering and regenerative medicine to all things omics, Advances in Biotechnology will expose students to many of the cutting-edge technologies that are revolutionizing how we engineer, measure, and control biological systems, as well as how we detect, understand, and treat disease. This course will emphasize how these advances are creating new capabilities for interrogating biological systems, manipulating their function, and enabling new therapeutic approaches.

Course Objectives

During this course, students will:

1. Gain familiarity with contemporary research domains within cellular and molecular engineering and biotechnology, with an emphasis on how technological advances create new capabilities to measure, engineer, and control biological systems.
2. Develop the ability to conduct critical, evidence-based assessments of scientific literature and evaluate the experimental rationale, methodology, data, and conclusions presented in primary research.
3. Cultivate effective science communication skills through written reviews, figure-based discussions, and oral presentations.
4. Acquire insights into the development and communication of original research ideas, including the rationale, experimental strategy, significance, and organization of a scientific research proposal.
5. Develop an understanding of how emerging biotechnologies progress from fundamental discoveries to potentially translatable technologies.

Grading

Homework Assignments: 20%
Weekly Discussion and Class Participation: 20%
Research Proposal: 30%
Proposal Presentation: 20%
Research Proposal Letter of Intent: 10%

Final grade scale for course (%):

A : 90 – 100 **B** : 80 – 89 **C** : 70 – 79 **D** : 61 – 69 **F** : < 60

Homework Assignments

Students will complete a peer review-style evaluation of the assigned pre-print (see *Course Schedule* below) before the start of class on Wednesday. Each summary should consist of five parts (with each part consisting of three to four sentences):

- **Summary:** Describe the motivation of the work and the key findings from the study.
- **Impact:** Are the results in the study important? Do they advance the field? What major limitation did the study overcome? Summarize what you perceive to be the overall impact of the work and the new capability or biological insight enabled by the study.

- **Weaknesses:** What are the major limitations of the work? For example, are the conclusions supported by the results? Do the authors present enough evidence to convince you of the importance of their study? *Every manuscript has its limitations and it's your job as a reviewer to identify them and articulate them.* (This will require researching the literature in the field)
- **Suggested Revisions:** Are additional experiments needed to support the conclusions of the study? Did the authors overlook any key controls? It's your job as a reviewer to identify concerns and then provide recommendations for how they can be addressed by the authors.
- **Decision** (one sentence only): What is your decision? Accept (as is), Major Revisions, Minor Revisions, and Reject. There is no right answer, but your decision should be supported by the evidence laid out in your review.

Links to each research paper are below in the *Course Schedule*. Each homework assignment is worth 10 points and will be graded based on each student's ability to follow the above rubric. *Because new manuscripts are always deposited on bioRxiv, the assigned papers could change! I will notify the class in the event that I decide to change an assigned manuscript to new one.*

The use of AI is not permitted in this class. This is a writing- and critical-thinking intensive course that requires full engagement. Assignments suspected of being substantially generated or written by AI will receive an automatic 0. Your grade is not based on prose but on the quality of your scientific reasoning, critical analysis, and interpretation of evidence.

For weeks with a discussion, summaries are due on Canvas by 12:30 pm on the day of a discussion.

Weekly Discussion/Presentation

Each Wednesday, we will discuss, as a class, an assigned research article. One student will provide a 10-15 min overview on the background, which includes a description of prior advances, the current state of the field, and the key limitations or gaps that motivate the study, as well as the rationale for the work and the advance(s) described in the study.

We will then engage in a round table discussion where each student will summarize the results from a pre-assigned figure. Each student must read the ENTIRE paper and supporting materials and provide a clear and accurate presentation of their assigned figure. During the discussion, each student will:

- Explain the rationale for the experiments in their assigned figure. Remember, it's about the story! Your job as a presenter is to tell the story on behalf of the authors and explain why these experiments were necessary.
- Describe the experimental methods used in the figure and the relevance of the experiments to the underlying goal of the study.
- Walk the class through the results and your interpretation of them. Are you convinced by the findings? Do you have questions or concerns about the experimental design? Do the results support the authors' conclusions?
- Explain the significance and implications of the results and how they advance the field.
- Identify and discuss inconsistencies or problems with the results in the figure.
- Summarize the conclusions of the figure and distinguish between what the data demonstrate and what the authors infer from the data.

Students will be given their discussion assignments typically one week before the discussion date. *Your job is to describe the assigned figure in sufficient detail so that someone who has not read the paper can understand the experimental question, approach, results, and conclusions.* We will only discuss the scientific content of the figures, NOT their aesthetics. Student's participation grades will be based in part on their ability to execute the above instructions and to engage constructively with the interpretations and critiques raised by their classmates.

Research Proposal

Students will be expected to complete a four-page (undergraduates) or six-page (graduate students) proposal describing an original research project addressing a biological or biotechnological question related to a topic discussed in the course. Proposal topics cannot be related to the student's research.

Proposals are due **December 17, 2026**. Proposals will NOT be evaluated primarily on innovativeness or feasibility. Instead, they will be scored on the strength and significance of the rationale, the logic and rigor of the experimental design, the alignment between the proposed experiments and the stated objectives, organization, and clarity. These elements will be discussed in class on **November 2, 2026**, with a detailed grading rubric provided at a later date.

Letter of Intent

Students will be expected to submit a letter of intent (LOI) that describes the motivation, significance, and central objective of the research proposal. The LOI should identify the biological or technological problem to be addressed, explain why the problem is important, and briefly describe the proposed approach.

LOIs, which can be submitted by email to gaj@illinois.edu or uploaded to Canvas, are due by **November 4, 2026** and should not exceed 500 words. LOIs must be approved before a student can begin the proposal and may require revision(s) before receiving instructor approval.

Proposal Presentations

During the final four weeks of the course, each student will give a 30-35 min presentation that lays out the vision for their original research proposal. Each student will:

- Give sufficient background to understand the biological or technological problem and its significance.
- Provide an outline of the research strategy and the methods that will be used to address the central question or advance the proposed objective.
- Explain the significance of the research plan and the biological or technological insight that would result if the proposed work were successful.
- Identify potential limitations and alternative approaches where appropriate.

These presentations are an opportunity for the class to provide feedback for each project. Students should use this opportunity to identify weaknesses in their experimental logic, clarify their rationale, and strengthen their proposals before submission. Make the most of it for the goal of receiving as much constructive feedback as possible! Student's participation grades will be based in part on their ability to engage constructively and substantively during these presentations.

Attendance

Attendance is required at **ALL** class meetings. One *excused* absence will be permitted, but it must be cleared with the instructor ahead of time or evidence of an emergency must be provided. Any student with an excused absence must make every effort to attend the other class session that week or contact the instructor for a make-up assignment. **Unexcused absences will result in a 0 for that week's discussion and homework assignment.**

Note

The instructor reserves the right to modify the syllabus and schedule in response to class needs.

Course Schedule

Week	Monday	Wednesday
1	Course Overview and Review (8/24/26)	Reading Biology: From Sanger Sequencing to Multi-Omics (8/26/26)
2	Integrative spatial profiling of 3D genome organization and gene expression in tissue doi: https://doi.org/10.64898/2026.07.28.741242 (8/31/26)	Editing Biology: From Recombinant DNA to CRISPR (9/2/25)
3	NO CLASS: LABOR DAY (9/7/26)	Structure-guided discovery and engineering of miniature CRISPR-Cas12m for epigenome editing doi: https://doi.org/10.64898/2026.03.26.714355 (9/9/26)

4	Engineering Proteins: From Directed Evolution to AI (9/14/26)	Learning protein function through autonomous experimental interaction doi: https://doi.org/10.64898/2026.08.14.744985 (9/16/26)
5	Understanding Function: From Gene Knockouts to Perturbation Screens (9/21/26)	Genome-scale functional mapping of the mammalian whole brain with in vivo Perturb-seq doi: https://doi.org/10.64898/2026.03.16.711480 (9/23/26)
6	Building Biology: From Synthetic Biology to Synthetic Genomes (9/28/26)	A Chemically Defined Synthetic Cell Capable Of Growth And Replication doi: https://doi.org/10.64898/2026.07.01.735724 (9/30/26)
7	Delivering Biology: From Drug Delivery to Programmable Therapeutics (10/5/26)	In vitro–reconstituted Drosophila Arc capsids deliver gene editors to dystrophic muscle doi: https://doi.org/10.64898/2026.05.25.727180 (10/7/26)
8	Engineering Cells: From Stem Cells to Cellular Therapeutics (10/12/26)	Synthetic Hybrid Receptors for Safer and Programmable T Cell Therapy doi: https://doi.org/10.64898/2026.01.22.701150 (10/14/26)
9	NO CLASS: BMES (10/19/26)	NO CLASS: BMES (10/21/26)
10	Automation and Biotechnology at Scale (10/26/26)	A platform for automated training of mammalian cell physiology doi: https://doi.org/10.64898/2026.08.13.744473 (10/28/26)
11	Formulating a Research Plan and Writing a Proposal (11/2/26)	NO CLASS: Letter of Intent Due (11/4/26)
12	NO CLASS (11/9/26)	Proposal Presentations (11/11/26)
13	Proposal Presentations (11/16/26)	Proposal Presentations (11/18/26)
14	NO CLASS: Fall Break (11/23/26)	NO CLASS: Fall Break (11/25/26)
15	Proposal Presentations (11/30/26)	Proposal Presentations (12/2/26)

16	Proposal Presentations (12/7/26)	Proposal Presentations (12/9/26)
		Research Proposal due 12/17/26 (by 5 pm)

Disability Related Accommodations

To obtain disability-related adjustments and/or auxiliary aids, students with disabilities should contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may visit 1207 S. Oak St. Champaign, call 217-333-4603, email disability@illinois.edu or go to the DRES website.

Emergency response recommendations can be found at the following website:

<https://police.illinois.edu/wp-content/uploads/ERG.pdf>. You are encouraged to review this website and the campus building floor plans website within the first 10 days of class. <https://police.illinois.edu/em/building-emergency-action-plans/>

Laptops and mobile devices

Mobile devices should be on silent and out of sight during class. Laptops or other assistive devices may be used for course-related tasks, e.g., to take notes or investigate relevant topics during lectures and activities. If you choose to use class time to do anything that may be disruptive, distracting, or disrespectful to other students or the instructors, please reconsider your priorities as a student at the University of Illinois and expect to be asked to leave the classroom.

Academic Integrity

We will follow Articles 1-401 through 1-406 of the Student Code (beginning at <https://studentcode.illinois.edu/article1/part4/1-401/>). This rule defines infractions of academic integrity, which include but are not limited to cheating, fabrication, and plagiarism. You are responsible for following these guidelines. If you have any questions about whether something would be an infraction, consult with the instructor.

Inclusion Statement

The intent is to raise student and instructor awareness of the ongoing threat of bias and racism and of the need to take personal responsibility in creating an inclusive learning environment.

The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The College recognizes that we are learning together in the midst of the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community.

The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to the Bias Assessment and Response Team (BART) (<https://diversity.illinois.edu/diversity-campus-culture/belonging-resources/>). Based on your report, BART members will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

Family Educational Rights and Privacy Act

Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See <http://registrar.illinois.edu/ferpa> for more information on FERPA.

Religious Observances

The Religious Observance Accommodation Request form is available at <https://www.odos.illinois.edu/community-of-care/resources/faculty/religious-observances/>. Submit the form to the instructor and to the Office of the Dean of Students (helpdean@illinois.edu) by the end of the second week of the course; in the case of exams or assignments scheduled after this period, students should submit the form to the instructor and to the Office of the Dean of Students as soon as possible.

Sexual Misconduct Reporting Obligation

The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX and Disability Office. In turn, an individual with the Title IX and Disability Office will provide information about rights and options, including accommodations, support services the campus disciplinary process, and law enforcement options.

A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here:

wecare.illinois.edu/resources/students/#confidential.

Other information about resources and reporting is available here: <https://wecare.illinois.edu/>.

Community of Care

As members of the Illinois community, we each have a responsibility to express care and concern for one another. If you come across a classmate whose behavior concerns you, whether in regards to their well-being or yours, we encourage you to refer this behavior to the Student Assistance Center (217-333-0050 or <https://odos.illinois.edu/community-of-care/student-assistance-center/>). Based on your report, the staff in the Student Assistance Center reaches out to students to make sure they have the support they need to be healthy and safe.

Further, we understand the impact that struggles with mental health can have on your experience at Illinois. Significant stress, strained relationships, anxiety, excessive worry, alcohol/drug problems, a loss of motivation, or problems with eating and/or sleeping can all interfere with optimal academic performance. We encourage all students to reach out to talk with someone, and we want to make sure you are aware that you can access mental health support at the Counseling Center (<https://counselingcenter.illinois.edu/>) or McKinley Health Center (<https://mckinley.illinois.edu/>).

Mental Health

Significant stress, mood changes, excessive worry, substance/alcohol misuse or interferences in eating or sleep can have an impact on academic performance, social development, and emotional wellbeing. The University of Illinois Urbana-Champaign offers a variety of confidential services including individual and group counseling, crisis intervention, psychiatric services and specialized screenings which are covered through the Student Health Fee. If you or someone you know experiences any of the above mental health concerns, it is strongly encouraged to contact or visit any of the University's resources provided below. Getting help is a smart and courageous thing to do for yourself and for those who care about you.

- Counseling Center: 217-333-3704
- McKinley Health Center: 217-333-2700
- National Suicide Prevention Lifeline: 800-273-8255
- Rosecrance Crisis Line: 217-359-4141 (available 24/7, 365 days a year)