Georgia Institute of Technology, Wallace H. Coulter Department of Biomedical Engineering
BMED-7301-A FALL 2026 *Advanced Seminar: Cellular and Biomolecular Engineering*
2:35 - 3:50 PM T/R Emory University HSRB1 N100
Karmella Haynes (Dr. Haynes) HSRB1 E-154 (Emory U), kahayne@emory.edu, 404-727-0531
Office hours: Sign up, https://calendly.com/hayneslab/dr-haynes-bmed-7301-office-hours

SECTION 1: COURSE OVERVIEW

DESCRIPTION: This advanced seminar explores how molecular mechanisms can be understood, modified, and combined to engineer cellular functions. The course is organized around directed evolution as a general framework for exploring biological design spaces to optimize function. Topics include protein-nucleic acid interactions, nucleic acid interactions, regulatory networks and circuits, and protein interactions.

- The first part of the course focuses on ***how cell engineering has been done***. Students will analyze published research and work in small teams to lead discussions of research papers.
- The second part focuses on ***how to do cell engineering*** through collaborative, in-class design activities using bioengineering software, databases, and other resources. Students will apply these skills to design engineered cellular systems and strategies for improving their function through directed evolution.

Nearly all graded work will be completed or assessed during class through discussion, problem solving, design activities, and team presentations. Therefore, it is critical to plan to attend in person.

PREPARATION: PRE- &/or CO-REQUISITES

Familiarity with molecular biology (DNA, RNA, and proteins) and basic engineering concepts is strongly recommended. Students enter this course from diverse technical backgrounds, and activities are designed to encourage students to contribute their own areas of expertise while developing greater depth in cellular and biomolecular engineering.

COURSE GOALS AND LEARNING OUTCOMES

The goal of this course is to develop the ability to analyze and design engineered biological systems by connecting molecular mechanisms with desired cellular functions. Students will practice interpreting published research, identifying tunable features of biological systems, using computational tools to develop engineering designs, and evaluating strategies for exploring biological design spaces.

Upon successful completion of this course, you should be able to:

- Relate molecular components, functions, interactions, and dynamics to abstractions commonly used in systems and synthetic biology.
- Analyze published cell and biomolecular engineering research to identify the engineered function, tunable components, experimental strategy, and critical evidence supporting the authors' conclusions.
- Use bioengineering software and databases to design components of an engineered biological system.
- Identify informative experiments and controls for evaluating the function of an engineered biological system.
- Explain how variation, screening or selection, and iterative optimization can be used to explore biological design spaces through directed evolution.
- Work effectively in a team to analyze, design, communicate, and defend cell-engineering strategies.

SECTION 2: LEARNING ASSESSMENTS AND COURSE MATERIALS

COURSE MATERIALS:

There are no required textbooks for this course. Required research articles, reviews, instructions, and other course materials will be provided through Canvas. Students will use the following resources:

- **Scientific literature:** PubMed, Web of Science, or comparable literature search tools. Emory PubMed: https://www.ncbi.nlm.nih.gov/pubmed?otool=emorylib ; Georgia Tech PubMed: https://pubmed.ncbi.nlm.nih.gov/?otool=gatechlib
- **Presentation software:** PowerPoint, Google Slides, or comparable software.
- **Benchling:** Students must register (free): https://benchling.com/signup/welcome. Additional bioengineering databases and computational tools will be introduced as needed via Canvas.
- **Laptop computer:** Students should bring a laptop to class for activities that require literature searches, sequence analysis, biological design software, or other online resources.

ASSESSMENT:

BMED 7301 is primarily an **activity-based** course. Most graded work will be completed or assessed during scheduled class meetings. Assessment emphasizes scientific reasoning, participation, teamwork, design decisions, and the ability to explain and defend those decisions.

Assessment	**Points**
Research Paper Lab: Discussion Leadership	15
Research Paper Labs: Participation	15
Design Labs	40
Final Design Challenge	30
TOTAL	100

Research Paper Lab: Discussion Leadership - 15 points

During Weeks 2 - 6, each student will serve on one Discussion Leader team. Teams will be assigned one research paper and will collectively lead both Research Paper Lab sessions for that week.

- For Paper Lab A, Discussion Leaders will introduce the research paper and explain its relevance to their research interests, expertise, or other areas of cellular and biomolecular engineering.
- For Paper Lab B, Discussion Leaders will guide the class through critical figures, experimental results, and scientific questions raised by the paper.

Discussion Leadership will be evaluated as a single 15-point assignment based on the team's work across both class meetings. Since Discussion Leadership is a major course learning activity, students must participate in their assigned team's leadership week to earn these points.

Research Paper Labs: Participation - 15 points

During weeks when a student is not serving as a Discussion Leader, points are earned through participation in Research Paper Labs.

Design Labs - 40 points

Classes 13 - 26 consist primarily of collaborative Design Labs in which students apply cellular and biomolecular engineering concepts to practical problems. Activities may involve DNA and construct design, genome targeting, regulatory system design, experimental measurement, biological design-space

construction, screening or selection strategies, and directed evolution. Design Lab work will be completed primarily during class. Specific point values and assessment criteria will be provided with each activity in Canvas.

Final Design Challenge - 30 points
During the final three class meetings, teams will integrate concepts and skills from throughout the course to design an engineered cell that produces a desired response to a specified biological state and can be optimized through directed evolution.

Teams will develop the engineered system, design an appropriate directed-evolution strategy, and present and defend their final design. Assessment will emphasize the scientific rationale, feasibility and coherence of the design, connection between the engineered function and the proposed selection or screening strategy, and the team's ability to explain and defend its decisions.

GRADING:

Your final grade will be assigned as a letter grade according to the following scale:

A B C D F	90-100% 80-90% 70-79% 60-69% 0-59%	At Georgia Tech, grades are awarded on a scale of A-F with no +/- grades permitted. See http://registrar.gatech.edu/info/grading-system for more information about the grading system at Georgia Tech.

DUE DATES AND ATTENDANCE

Because most graded activities occur during scheduled class meetings, regular attendance is important. Due dates for any work that must be submitted outside of class will be posted in Canvas. Students should contact Dr. Haynes as soon as possible regarding circumstances that prevent participation in a graded class activity.

ACADEMIC INTEGRITY

Georgia Tech strives to cultivate a community grounded in trust, academic integrity, and honor. Students are expected to uphold the highest ethical standards in all academic work and to comply with Georgia Tech's Academic Honor Code.

Collaboration is an intentional and important component of BMED 7301. Students may work together when instructed to do so and may share ideas, discuss research papers, troubleshoot designs, and develop team solutions. When individual work is requested, submitted work must represent the student's own analysis and understanding.

Figures or other material reproduced from published research must be appropriately attributed. Screenshots or output generated through databases, sequence-design software, and other computational tools may be used when requested as part of an activity.

USE OF GENERATIVE ARTIFICIAL INTELLIGENCE (AI)

Generative AI tools may be used in this course unless their use is specifically restricted for an activity. Appropriate uses may include brainstorming, information gathering, explaining unfamiliar concepts, troubleshooting, or improving communication.

AI-generated output should not be treated as authoritative scientific evidence. Students remain responsible for evaluating the accuracy and relevance of information produced by AI tools and for understanding, explaining, and defending any scientific reasoning or design decisions presented as their work. Specific activities may include additional instructions regarding permitted or required AI use.

SECTION 3: POLICIES AND GENERAL RESOURCES

ATTENDANCE, MISSED ACTIVITIES, AND MAKE-UP WORK

Most graded activities in BMED 7301 take place during scheduled class meetings and depend on interaction with classmates. Regular attendance and active participation are therefore important components of the course.

To provide flexibility for occasional illness, professional travel, emergencies, etc., **the lowest weekly Research Paper Lab participation score and the lowest Design Lab score will each be dropped** when calculating the final course grade. These dropped scores are intended to accommodate occasional missed classes or unusually low participation.

Discussion Leadership and the **Final Design Challenge** are major team-based course activities and **are not eligible for the dropped-score policy**. If you know in advance that you cannot participate in one of these activities on your assigned date, contact Dr. Haynes as early as possible so that reassignment or another appropriate arrangement can be considered.

If illness, an emergency, or another excused circumstance prevents participation in Discussion Leadership or the Final Design Challenge, contact Dr. Haynes to discuss an appropriate alternative. Any make-up arrangement will depend on the nature of the missed activity and may differ from the original activity. Missed participation cannot ordinarily be recovered through extra take-home assignments.

Statement on Mental Health and Well-Being:
Biomedical Engineering (BME) instructors and the Department are committed to supporting student mental health and well-being. While course instructors can be a point of support, students are strongly encouraged to make use of Georgia Tech's formal mental health resources. Additional information is available at: https://mentalhealth.gatech.edu/

- The Center for Mental Health Care and Resources (CMHCR) is Georgia Tech's primary hub for student mental health services. CMHCR is located in the Smithgall Student Services Building and can be reached at 404-894-2575. Normal hours of operation are Monday-Friday, 8:00 a.m.-5:00 p.m. CMHCR provides access to individual and group counseling, academic and personal support services, assessment and testing for learning disabilities, and referrals to additional mental health providers. They can assist with acute concerns, crises, or longer-term support needs.
- In addition to centralized services, the BME Department hosts a satellite counselor, Kate Silverio, located in Room 1105 of the Whitaker Building (rear of the academic office). The BME Satellite Counselor offers brief (15-minute) appointments, in person or virtual, for non-emergency concerns and for guidance on navigating campus mental health resources. Appointments can be scheduled by emailing kate.silverio@studentlife.gatech.edu.
- If you require immediate mental health support:
  - During business hours (8:00 a.m. - 5:00 p.m.): Call 404-894-2575 or visit Suite 238 in the Smithgall Student Services Building.
  - After hours: Call 404-894-2575 and select the option for the after-hours counselor.
  - In an emergency: Call Georgia Tech Campus Police at 404-894-2500 or 911.

Statement on ADA: If you are a student with learning needs that require special accommodation, contact the Office of Disability Services (404-894-2563) as soon as possible to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

CLASS SCHEDULE (Fall 2026)

Date	Class	Topic	Activities/ Assignments
PART 1 - HOW CELL ENGINEERING HAS BEEN DONE: RESEARCH PAPER LABS			
T 8/25	1	Course orientation: Cell engineering & design-space/search frameworks; form Discussion Leader teams	Read assigned directed evolution review
R 8/27	2	Directed evolution; model Research Paper Labs A/B	Review Paper Lab
T 9/01	3	Protein-nucleic acid interactions	Research Paper Lab A
R 9/03	4		Research Paper Lab B
T 9/08	5	Nucleic acid interactions	Research Paper Lab A
R 9/10	6		Research Paper Lab B
T 9/15	7	Networks & circuits	Research Paper Lab A
R 9/17	8		Research Paper Lab B
T 9/22	9	Protein interactions	Research Paper Lab A
R 9/24	10		Research Paper Lab B
T 9/29	11	Directed evolution (DE)	Research Paper Lab A
R 10/01	12		Research Paper Lab B
T 10/06	No class	Fall Break	
PART 2 - HOW TO DO CELL ENGINEERING: DESIGN LABS			
R 10/08	13	Design Lab 1: DNA Parts & Constructs	Design Lab 1A
T 10/13	14		Design Lab 1B
R 10/15	15	Design Lab 2: Build It	Design Lab 2A
T 10/20	16		Design Lab 2B
R 10/22	17	Design Lab 3: Target It	Design Lab 3A
T 10/27	18		Design Lab 3B
R 10/29	19	Design Lab 4: Engineer Regulation	Design Lab 4A
T 11/03	20		Design Lab 4B
R 11/05	21	Design Lab 5: Measure Function	Design Lab 5A
T 11/10	22		Design Lab 5B
R 11/12	23	Design Lab 6: Build a Search Space	Design Lab 6A
T 11/17	24		Design Lab 6B
R 11/19	25	Design Lab 7: Select & Iterate	Design Lab 7A
T 11/24	26		Design Lab 7B
R 11/26	No class	Holiday	
FINAL DESIGN CHALLENGE			
T 12/01	27	DESIGN - Engineer a cell that produces a desired response to a specified biological state	
R 12/03	28	EVOLVE - Design a directed-evolution strategy to optimize the engineered function	
T 12/08	29	PRESENT & DEFEND - Team presentations and design defense	
		No Final Exam	