

10.521: DESIGN PRINCIPLES IN MAMMALIAN SYSTEMS & SYNTHETIC BIOLOGY

Fall 2022

Instructor:	Katie Galloway	Time:	TR 13:00 – 14:30
Email:	katiegal@mit.edu	Place:	24-110.

Course Description: This course focuses on the layers of design, from molecular parts to large transcriptional networks in mammalian biology. The course formally introduces concepts in the emerging fields of mammalian systems and synthetic biology, including engineering principles in neurobiology and stem cell biology. One aim is to expose students from quantitative backgrounds to problem-solving opportunities at the interface of molecular biology and engineering.

Course Pages:

1. [Canvas](#)

Office Hours: After class, or by appointment.

Main References:

- Uri Alon, *An Introduction to Systems Biology - Second Edition*, CRC Press, 2019.

Objectives: This course is primarily designed for graduate students and advanced undergraduates looking to dive into topics in mammalian synthetic and systems biology.

Prerequisites: An undergraduate-level understanding of molecular cell biology, kinetics, thermodynamics, and ordinary differential equations is assumed.

Tentative Course Outline:

- Week 1: Introduction to Course and Policies
- Week 2: Intro to Synthetic Biology: Tools, Parts, & Systems
- Week 3: Introduction to Principles in Molecular Systems Biology
- Week 4: Network Motifs + Negative feedback
- Week 5: Feedforward motifs + promoter engineering dynamics
- Week 6: Positive feedback and bistability
- Week 7: Engineering Cell Fate: Stem Cells and Reprogramming
- Week 8: Systems-level Principles of Cell-fate Transitions
- Week 9: MAPK Pathways in Cell-fate Decision-Making
- Week 10: Challenges in Engineering Mammalian Cells
- Week 11: AIChE; No Class
- Week 12: Thanksgiving; No Class
- Week 13: Nuclear Architecture
- Week 14: Engineering Chromatin

Grading Policy:

Journal club presentation	30%
Written topic summaries	20%
Modeling project	30%
Science + Society project	20%

Important Dates:

Lecture	Tuesdays
Journal club presentations	Thursdays
Topic summary 1	September 30, 2022
Modeling project presentation	November 10, 2022
Modeling project report	November 17, 2022
Topic summary 2	December 2, 2022
Final project presentation	December 8, 2022
Final project written documents	December 13, 2022

Class Policy:

- Regular attendance is essential and expected.

Journal Club: For each weekly topic, relevant papers will be posted. You will sign-up for one to provide the class with a quick summary. You will also select a paper not on the list to compare with the pre-selected paper. Each paper should be summarized in a single slide and no more than 5 minutes. Over the course of the semester you should present approximately 6 times on a total of 12 papers. Slides will be submitted following the presentation. Each one is worth 5% of your total grade.

Topic Summary: To integrate the material into an understanding, you will complete two topic summaries which represents a summary of the content and synthesis of the ideas. These topics can follow on of the weekly topics or be on a topic of your choosing. Please verify approval of your topic 2 weeks before the deadline. A questionnaire will be provided to guide the narrative response. Two topic summaries of the 10 topics should be completed over the course of class. For more detail, see [Guidelines for Topic Summaries](#). Each one is worth 10% of your total grade.

Modeling Project: Each student will select a model, compose and explore that model. Each student will summarize how changes in parameters affected the desired properties of the system and what mitigating strategies could be employed to restore or enhance functionality. For details, see [modeling guidelines](#). The report and presentation are worth 30% of your total grade.

Science + Society Project: Art powerfully engages society in science, inspiring young scientists and illuminating ideas. In this project the goal is to develop ideas, stories, pictures that illuminate the power and potential of synthetic biology, systems biology, and/or stem cell biology and spark awe and wonder in the audience. For details, see [10.521 Science + Society Project](#). The report and presentation are worth 20% of your total grade.