BIOE 410/510: Synthetic Biology (4 cr.)
Winter 2022

Instructor and contact info: Prof. Calin Plesa, calin@uoregon.edu

Meeting Times
This course will meet for 1.5 hours twice a week.
Mondays and Wednesdays, 10:15-11:45 am, March 30 – June 4, 2022

Course description
This course will focus on the application of engineering principles to design and build biological systems with predictable behaviors. It will teach students to design, build, and model simple biological circuits and systems. It will cover topics including basic biological components and their standardization, methods for analysis, modeling tools, engineering principles in biology, DNA assembly, genome engineering, and ethics. Examples of practical applications in multiple areas will be explored. Students will discuss relevant literature and develop their own synthetic biology idea into a project.

Target audience
Graduate or undergraduate students in bioengineering, biology, biochemistry, or physics. Students interested in integrating synthetic biology into their current or future research or seeking to taking part in the iGEM/iDEC competitions.

Prerequisites
Bi214 (General Biology IV: Mechanisms) or equivalent
This course assumes you are familiar with basic cellular and molecular biology and basic differential equations. You should have taken a course that discussed the *lac* operon.

Course Materials
There will be no required text. Required readings (listed in the schedule below) will be posted to Canvas in advance of course sessions.

Learning outcomes
After completing this course, students will be able to:

- Design biological circuits
- Derive ordinary differential equations to model a biological circuit
- Simulate the expected behavior of biological circuits
- Assemble and clone DNA fragments using modern methods (e.g. Gibson assembly, Golden Gate, etc…)
- Identify and describe common biological parts and their function
- Critique current literature in the field of synthetic biology
- Explain/describe synthetic biology methods and applications
- Evaluate ethical issues which arise in synthetic biology work

Tentative schedule of topics

Week 1	Introduction to synthetic biology	
	Fantastic parts and where to find them: promoters, RBSs, CDSs, terminators, insulators, backbones, reporters, senders and receivers, sensors	
Week 2	Biological circuits I: logic gates, oscillators, toggle switches	*Reading*: Elowitz MB et al. *Synthetic oscillatory network of transcriptional regulators*. Nature (2000)
	Modeling I: ODEs and Hill functions	
Week 3	Modeling II: stability and sensitivity	Assignment 1 due
Week 4	Modeling III: stochastic simulations, tools, databases	
	Biological circuits II: design considerations and troubleshooting	Reading: Moon et al. *Genetic programs constructed from layered logic gates in single cells*. Nature (2012)
Week 5	Cloning strategies and DNA assembly techniques: hosts vs. cell-free, Golden Gate, Gibson, gene synthesis	
	Measurement and characterization: traditional and high-throughput approaches	Project proposals due
Week 6	Genome engineering: zinc-finger, TALEN, recombineering, CRISPR, transposon, MAGE	Reading: Vo et al. CRISPR RNA-guided integrases for high-efficiency and multiplexed bacterial genome engineering. Nat Biotechnol. (2020)
	Directed and continuous evolution	*Reading*: Ravikumar et al. *Scalable, Continuous Evolution of Genes at Mutation Rates above Genomic Error Thresholds*. Cell (2018) Assignment 2 due
Week 7	Metabolic engineering	*Reading*: Galanie et al. *Complete biosynthesis of opioids in yeast*. Science (2015)
	Biosafety, security, and ethics: gene drives, biocontainment	Reading: Mandell et al. *Biocontainment of genetically*

		modified organisms by synthetic protein design. Nature (2015)
Week 8	Applications I: pharmaceuticals, drug delivery	*Reading*: Din et al. *Synchronized cycles of bacterial lysis for in vivo delivery*. Nature (2016)
	Applications II: materials, food, energy, bioremediation	Reading: Chen et al. *Synthesis and patterning of tunable multiscale materials with engineered cells*. Nature Materials (2014)
Week 9	Entrepreneurship and innovation: case studies and opportunities	
	Xenobiology: XNAs, ncAAs, mirror life	Reading: Pinheiro et al. *Synthetic genetic polymers capable of heredity and evolution*. Science (2012)
Week 10	Synthetic Genomes: JCVI-1.0, JCVI-3.0, Sc. 2.0, GP-Write	*Reading*: Hutchison et al. *Design and synthesis of a minimal bacterial genome.* Science (2016)
	Project presentations I	Project deliverables due

Tentative Grading Scheme

Participation in paper discussions	10%
Paper presentation(s)	15%
Project proposal	15%
Project presentation and deliverables	30%
Peer review of projects	10%
Assignments	20%
Total	100%

Students will lead the presentation of one paper during the quarter and participate in paper discussions in each class. Two assignments will prepare students for working with sequences and modeling circuits. Finally, each student will propose a small synthetic biology project. They will design, model, create a cloning strategy, and present their work to the rest of the class. Each student will also evaluate at least one other student's project. Homework is due by end of the day on the due date.