BIOE 147 (BIOE 247) - PRINCIPLES OF SYNTHETIC BIOLOGY (4 UNITS)

COURSE OVERVIEW

SUMMARY

BioE 147/247 is cotaught by Prof. Adam Arkin at Berkeley and Prof. Ron Weiss at MIT. The students would interact with the MIT side via BlueJeans calls. There was a good mixture of undergraduate and graduate students with various backgrounds (BioE, ChemBio, MicroBio, EECS, MechE, etc.)

Most of the course materials (problem sets, exams, previous year lecture videos and previous year lecture notes) are on MITx.

(From syllabus)The lectures give a good exposure of means to “understanding and manipulating our physical world for desired purposes”. The SynBio field and “its natural scientific and engineering basis” are introduced. This includes but not limited to 1) the basics of SynBio such as quantitative cellular network characterization and modeling, 2) the principles of discovery and genetic factoring of useful cellular activities into reusable functions for design, 3) the principles of biomolecular system design and diagnosis of designed systems, and 4) cutting-edge SynBio applications and their corresponding anaylizing and design tools. Relevant topics include but not limited to are: “cellular and molecular biology and biophysics, dynamical and engineering systems, and design and operation of natural and synthetic circuits”.

The biweekly online problem sets could involve high-level concept understanding, various applications in literature-based or hypothetical situations, biological logic circuit design, MATLAB modeling or different kinds of mathematical calculations.

The individual term-project is to “design and analyze a novel biological system or to analyze an existing biological system (synthetic or natural) in depth in a novel way”. Creativity is highly encouraged.

PREREQUISITES

MATH 53 (math53.html) and MATH 54 (math54.html); BIOE 103 (bioe103.html) or equivalent or consent of instructor

Additional Notes

TOPICS COVERED

- About Synthetic Biology
- Quick review of relevant cellular processes
- Metabolism and Metabolic Engineering 1
- Metabolism and Metabolic Engineering 2
- Welcome MIT and Scope of the Course
- Top Down Design and Applications: TKB and Tissue Homeostasis
- Modeling Biology: Useful abstractions for design and gene expression
- DNA Assembly, genome editing and whole genome engineering
- Parts and composition I: What are parts and how do they connect?
- Parts and Composition II: Gene expression and regulation, composition into cascades
- Device Characterization, device matching, predictions, longer cascades and noise
- Basic Logic Gates: NOR, NAND, AND and OR and the Boolean Logic
- Scaling Up: logic minimization and Cello
- Recombinases and DNA-based memory
- Logic design and minimization I
- Logic design and minimization II
- Combination Logic/ Feed-forward motifs
- Toggle Switch I
- Toggle Switch II/ Oscillators I
- Scalable protein TFs: NOR gates, TetR family, ZFs, TALER, CRISPR

- Oscillators II
- RNA Devices
- RNA Devices and Circuits: MiRNA and RBPs, rCas9
- Protein-Protein Circuits
- DIPS, TIPS, and Gene Drives
- Synthetic Morphogenesis
- Biocompiler and Analog Circuits; Summary
- Summary and Perspective

WORKLOAD

COURSEWORK

- MITx problem sets (~ 5 – 6 in total, each could range from 2 sections to 7 sections with various numbers of subsections)
- Term project
  - Individual
  - Check points
    - Project description
  - Model description

- Final submission
  - 10-minute video
  - 6-page write up
- One midterm on MITx
- Final exam on MITx

TIME COMMITMENT

3 hours of lecture and 1 hour of discussion per week

The problem sets, project, and studying for exams can take a significant amount of time

CHOOSING THE COURSE

WHEN TO TAKE

Fall only.

This course fulfills the Chem/Chembio allied subject requirement and the ChemE engineering elective requirement.

WHAT NEXT?

- BIOE 148 - Bioenergy and Sustainable Chemical Synthesis: Metabolic Engineering and Synthetic Biology Approaches (bioe148.html)
- BIOE 135 - Frontiers in Microbial Systems Biology (bioe135.html)
- CBE 274 - Biomolecular Engineering (cbe274.html)

ADDITIONAL COMMENTS AND TIPS

The course covers an amazingly broad topics with an incredible amount of information with really passionate lectures who are distinct in the SynBio field.

Personally, I found the course both exciting and overwhelming. Those who with more EE/circuit design experience, and/or MechE/dynamic control exposure, and/or a holistic MCB/bio background/intuition might be better prepared for some parts of the course. I also found it could be hard to synthesize the high-level information into more application based questions.

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