ENGS 161- Metabolic Engineering

Winter 2020

Contact information

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Lecture timing: 12 class period, M, W, F 12:50-1:55, x-hour Tu 1:20-2:10

Course description

Metabolic engineering combines aspects of chemical engineering, systems biology and synthetic biology. This course focuses on developing a quantitative understanding of metabolic processes within the cell. Although metabolism is a complex process, it is determined by a small number of physical constraints, including enzyme activity, mass balance and thermodynamics. In this course you will learn to perform a mass balance, construct and analyze a stoichiometric network, simulate a series of kinetic reactions, and analyze isotope tracer experiments. Key genetic techniques, including CRISPR, will be presented. Computational analysis will be performed using COBRA and Equilibrator via Python and associated tools in the Python Data Science stack. These tools will be applied first to several canonical examples from the metabolic engineering literature and then to a project of your choosing.

Learning outcomes

1. Perform a material balance of a fermentation given substrates and products
2. Build a stoichiometric reaction network from individual reactions, represent in matrix form, apply constraints and identify allowable input and output fluxes, and maximum theoretical yields.
3. Calculate kinetic parameters from experimental enzyme assay data
4. Construct a multi-enzyme kinetic model and determine metabolic control coefficients
5. Understand how stable isotope labeling can be used to identify metabolic fluxes
6. Identify metabolite concentrations that would allow thermodynamic feasibility of a multi-step metabolic pathway

Prerequisites

Engineering Sciences 35/160, a non-introductory course in biochemistry or molecular biology, or permission.

Class meetings

Class will meet in (room TBD) in the 12 class period (12:50 - 1:55 pm). The assigned X-hour is 1:20 - 2:10 on Tuesday. There are no specific plans for the X-hour at this time, but it may be used for individual consultation (by appointment) and/or to keep in schedule.

Readings

The primary text for this course is Bioreaction Engineering Principles, Third Edition, Villadsen, Nielsen and Liden. Additional readings will be assigned from various sources, including the primary literature, books, and web resources. Articles will be posted on Canvas.

Assignments and grading

Homework assignments (5): 50%.
Course project: 50%. Students will complete an independent project of their choosing that applies analytical techniques learned in the course and present it to the class during exam period. Projects will be evaluated for relevance, depth of understanding, quality of analysis, original insights, and clarity of presentation.