BCHE8210
Fermentation Engineering Laboratory
(Microbial Physiology and Bioprocess Engineering)
Spring 2025
3 credit hours

Instructor:
Mark A. Eiteman, Ph.D.
112 Riverbend Research Lab South
eiteman@engr.uga.edu

Meeting Time:
Wednesday, Friday 9:10 – 10:00
Driftmier 1367
The course will be a combination of lecture, discussion and labs. We will have 3 labs toward the end of the semester. During laboratory experiences, we will have to spend multiple hours working on the particular experiment. Of course, the times will occur outside the normal lecture period.

Summary: This course will cover microbial cell physiology and bioreactor operational modes (i.e., batch, fed-batch, chemostat). How do microbes behave under different conditions? How do cells modify their behavior in response to certain example gene knockouts? How does one quantify microbial behavior? How does one perform an isotopic flux balance? The course will also assist students in designing microbial fermentation experiments and interpreting results. Although *E. coli* will be used as the principal example microbe, some discussion will be on other species. I am happy to navigate the course, to some extent, in the direction the students want. Hopefully a significant fraction of the course will be a discussion in the sense that we all together pose questions, and then between meetings try to figure out answers to those questions.

Pre-requisites and background: Students would benefit from having a decent understanding of differential equations, because pretty much everything related to the rate of microbial growth comes from differential equations. Although I will be "gentle" with math, I think not having some comfort with differential equations would be a detriment. I will show some examples using MATLAB, and will provide some introduction in how to program with MATLAB. Some familiarity with computer programming (C, Basic, Pascal, etc.) would be helpful but the lack of this background will not prove fatal.

Grading:

A few (Individual) homework Problems including 1-2 with MATLAB	20% (January-February)
Two (Individual) written article Critiques	15% (January-February)
Three Lab – Reports (Team)	25% (March-April)
Project (Team)	25% (April)
Participation/Discussion (Individual)	15% (Overall)

There will be no formal "tests"

Detailed Outline:

Part 1: Cellular Metabolism and Transport Processes

A. Introduction
B. Central Metabolic Pathways
    1. Glucose uptake
    2. Glycolysis
    3. Pentose phosphate pathway
    4. Tricarboxylic acid cycle
        a. Charging the TCA cycle
        b. The TCA cycle
        c. Anaplerotic pathways
    5. Other important pathways
    6. Balancing the electrons
        a. In the presence of O_2
        b. In the absence of O_2
    7. Summary of principal carbon flow
C. Effect of Knockouts
    1. *zwf* – glucose-6P 1-dehydrogenase
    2. *pgi* – phosphoglucose isomerase
    3. *pykF* – pyruvate kinase
D. Material Balances
    1. Material balances around metabolic nodes

Part 2: Behavior of Cells in a Bioreactor

A. Models to describe cell growth
    1. Introduction
    2. Empirical models to describe cell growth rate
B. Model to describe substrate utilization
    1. Maintenance
    2. Cell mass
    3. Products
        a. Growth associated
        b. Non-growth associated
        c. Mixed-growth associated
        d. My personal preference
    4. Summary
C. General material balances
    1. Derivation
    2. Common simplifications
D. Batch operation
    1. Introduction
    2. Incorporating growth and substrate utilization models
    3. Simulation

4. Conclusions

E. Chemostat operation
   1. Cells
   2. Substrate
   3. Biomass yield
   4. Calculation of maintenance coefficient and true biomass yield
   5. More on maintenance
   6. Product
   7. Calculating substrate concentration in a chemostat
   8. Calculating biomass concentration in chemostat
   9. Calculating Monod constant
   10. Industrial use of a chemostat
   11. Why conduct a laboratory chemostat experiment?
   12. Example calculations
   13. How much time is required to reach steady-state?
   14. Competition
   15. Other thoughts
      a. What does maximum growth rate really mean?
      b. Practical matters for conducting chemostat experiments

F. Accelerostat
   1. Motivations
   2. Simulation

G. Physiological consequences of nutrient limitation
   1. Introduction
   2. Respiratory capacity
   3. Nitrogen limitation
   4. Shift between C-limited and N-limited conditions
   5. Multiple carbon/energy sources
   6. Phosphorus limitation

H. Exponential fed-batch operation
   1. Motivations
   2. Derivation
   3. Example calculations

I. Constant feed fed-batch operation
   1. Derivation
   2. Volume
   3. Biomass
   4. Substrate
   5. Example calculations

<u>Three Lab experiences:</u>

1) Measurement of k_La
2) A batch process
3) A chemostat process