CIVE/CBE 540
Advanced Biological Wastewater Processing

Instructor:
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Office hours: M, W 11:00 am – 12:30 pm

Instructional Assistant (IA):
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Communications:
Campus Students: The best way to reach me outside of class is by attending office hours. I get behind on e-mails and struggle to respond to all of them. The Instructional Assistant (IA) is only for the distance students. Please do not e-mail him with questions.

Distance Students: Send an e-mail to the IA as a first line of communication. The IA will forward e-mails and questions to me as needed.

Course description:
The purpose of this course is to educate students in biological process engineering. Students will be introduced to fundamentals of biotechnology and design and operation of biological processes. Fundamental biotechnology concepts will include basic environmental microbiology and microbial ecology; microbial metabolism, energetics and kinetics; applications of molecular biology; and an introduction to bioreactor design. Biological wastewater process engineering will also be introduced. Both aerobic and anaerobic biological waste treatment will be covered.

Course objective
To gain a fundamental understanding of microbial processes necessary for the design and optimization of biological processing unit operations.

Learning Objectives
By the end of CIVE students will:
1. Have a basic understanding of microbial processes governing environmental systems.
2. Understand relationships between stoichiometry and bacterial energetics.
3. Understand the fundamentals of bacterial kinetics.
4. Be able to conceptualize and mathematically express biological mass balances in environmental systems based on the above concepts.
5. Design an Activated Sludge treatment plant appropriate to the influent wastewater conditions.
6. Design Attached Growth bioreactors appropriate to the treatment conditions.
7. Design processes for specialized treatment, such as removal of nitrogen and phospohorus.
8. Design an anaerobic digester
9. Consider alternative treatment approaches based on appropriate criteria.

Prerequisites:
CIVE 437 (also acceptable as co-req); A course in general microbiology is recommended. The course

involves quantitative analysis of microbial systems and thus familiarity with differential equations is assumed.

Textbook and Course Materials

Required text: Rittmann, B.E., and P.L. McCarty, Environmental Biotechnology: Principles and Applications, McGraw-Hill, 2001.

Supplemental materials (journal articles and instructors' notes) will be distributed in class or on Canvas

Grading:

Homework 20%
Exam I 25%
Exam II 25%
Design Project 30%

Term grades will be assigned as follows:

A	90% or better
B	80-89%
C	70-79%
D	60-69%
F	59% or below

However, a curve may be applied depending on the overall performance of the class as a whole. Term grades for this course will use the +/- grading system as described in the CSU catalog.

Late Submissions:

All assignments must be submitted at the start of class on the due date. Homeworks received on the due date after the start of class will receive a 25% reduction. No assignments will be accepted after the due date. While discussion is encouraged on assignments, your submission must reflect your own individual work.

Additional course information available on RamCT.

Course Schedule [approximate number of lecture hours]

1. **Introduction [1]**
2. **Basics of Environmental Microbiology [2]**
   a. Taxonomy and phylogeny
      i. Eukaryotes and prokaryotes (bacteria and archaea), viruses
      ii. Morphology
      iii. Trophic classifications
   b. Physiology of the cell
   c. Microbial replication and growth
3. **Biochemistry and Metabolism [4]**
   a. Anabolism/catabolism
   b. Central metabolism: glycolysis and the TCA cycle
   c. Metabolic pathways of contaminant biodegradation
   d. Metabolic regulation

4. **Microbial Ecology [1]**
   a. Types of microbial communities and interactions
   b. Enrichment cultures and other selection procedures
   c. Horizontal gene transfer

5. **Detection, Enumeration, and Characterization of Microorganisms in the Environment Methods for detection and enumeration [1]**
    a. Methods for characterization of microbial communities
        i. Traditional
        ii. Molecular microbial ecology

Exam I [1]

6. **Stoichiometry and Bacterial Energetics [4]**
    a. Mass balances
    b. Redox reactions: electron donor/electron acceptor
    c. Redox half-reactions
    d. Energy balances (ΔG)
        i. Growth
        ii. Substrate Partitioning and theoretical yield
        iii. Electron acceptors, fermentation
    e. Nitrogen source
    f. BOD/COD

7. **Enzyme and Microbial Kinetics [4]**
    a. Michaelis-Menten kinetics
    b. Monod kinetics
    c. Inhibition kinetics
    d. Alternate Rate Expressions
    e. Growth on multiple substrates
    f. Cometabolism
    g. Mixed culture kinetics

8. **Bioremediation [2]**

9. **Wastewater Treatment [6]**
    a. Wastewater Treatment Plant Configuration
    b. Reactor Types
    c. Activated Sludge

Exam II [1]
Field Trips [2]

10. **The Activated Sludge Process (Chapters 5 & 6) [6]**
    a. Aeration
    b. Analysis and design of settling
        i. Type I, II, III "zone settling" (M&E chapter 6)
        ii. Loading criteria
        iii. Basics of flux theory
        iv. Sludge-settling problems (bulking, foaming, etc.)

11. **Nutrient Removal** (Chapters 9 "Nitrification," 10 "Denitrification," and 11 "Phosphorus Removal") **[9]**
    a. Nitrification
        i. Biochem and physiology of nitrifying bacteria
        ii. Activated Sludge versus Biofilm nitrification
        iii. Role of BOD_L : TKN ratio
    b. Denitrification
        i. Physiology of denitrifying bacteria

   ii. Tertiary denitrification
   iii. One-Sludge Denitrification
c. Phosphorous Removal
   i. Phosphate uptake (normal and luxury uptake)
   ii. Precipitation by metal-salts addition
   iii. Enhanced biological P removal, and Barden-Pho process

12. Anaerobic Treatment (Chapter 13) – [3]

a. Applications of anaerobic treatment
b. Reactor configurations
c. Chemistry and microbiology
d. Kinetics of methanogenesis
e. Factors for design consideration