

BIOLOGICAL PRINCIPLES OF ENVIRONMENTAL ENGINEERING

Course Description

CE 573 prepares you to use fundamental biological principles to analyze important biological processes in environmental engineering. Specific applications include: the biological treatment of municipal and industrial wastes, public health microbiology, and microbial ecology of engineered and natural systems. The course will cover basic microbiology (what is a cell?), survey key microbial groups and their metabolisms (how do they make a living?), cover biodegradation/catabolism of the basic macromolecules (carbohydrates, lipids, proteins), and introduce microbial ecology concepts and molecular approaches to study microbial communities.

Instructor

Dr. Doug Call
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Course Web Address

<https://wolfware.ncsu.edu/>

Lecture Meeting Time & Location

MW 8:30 – 9:45 am
2220 Engineering Building 3

Office hours

In-person: Tuesday 11:00 am – 12:00 pm and
on-demand (email me to set up a time)

Prerequisites

Background in basic biology or microbiology will be helpful, but not required. The course will be taught as an introductory course in microbiology. It is a graduate course, so I expect you to do the required readings and pursue further readings as needed. We will cover a lot of material, and new topics build on previously discussed concepts, so it is important to stay current. A strong background in fundamental environmental engineering concepts (e.g., mass balance, unit analysis) is required.

Text

Brock Biology of Microorganisms, 16th edition, Madigan, Martinko, Dunlap and Clark (previous editions will work). This class is taking part in NC State's All-In program. Course materials are delivered electronically on my Moodle site. This is the most cost effective way for you to get the materials you need to succeed in my course (\$42 for access during the semester). You have free access to the textbook until August 30. You can purchase access using the link on the Moodle page. If you do not purchase access by August 30, you will lose access to the materials and will then have to acquire the materials through another source.

- Handouts of relevant current news, scientific literature, and websites may also be provided in class or via the website
- Additional Texts. You may also wish to purchase a good reference book in environmental microbiology:
 - Maier, R., Pepper, R. L., and C. P. Gerba, *Environmental Microbiology*, Academic Press
 - D. A. Vaccari, P. F. Strom, and J. E. Alleman. *Environmental Biology for Engineers and Scientists*, First Ed., Wiley ISBN 0-471-72239-1

Course Learning Objectives

At the end of this class, you will be able to:

1. Describe biological processes in environmental engineering.
2. Differentiate microorganisms according to their metabolism (e.g., electron acceptors, electron donors), describe the main characteristics of key or example species within each functional grouping, and describe the environmental reactions mediated by these species.
3. Explain how microorganisms catabolize the major macromolecules (carbohydrates, lipids, hydrocarbons, and proteins).
4. Describe the relationship between thermodynamics and microbial growth.
5. List common strategies employed by microorganisms to survive in natural and engineered ecosystems, and in biodegradation pathways.
6. Describe the operational concepts behind molecular biology tools in environmental microbiology and how they can be used to answer questions about process performance.
7. Evaluate scientific papers in environmental microbiology. Describe the problem, describe the operational concepts behind the methods used, and explain the main findings.

Websites. We have a Moodle class website that we will use extensively for disseminating lecture notes, homework, news, and messages and posts to everyone in the class. The website is available at <http://wolfware.ncsu.edu>. You will need your unity login name and password to enter the website. “Incomplete” lecture notes will be typically put online before the class lectures to facilitate note-taking. In addition, handouts will be placed online. Please consult this website regularly. I also encourage you to use the class forum to communicate with me and each other. Please post questions, answers, ideas, comments, etc.

Grading. A weighted average grade will be calculated as follows. Grades will not be assigned using a curve. Your course grade will depend only on how you do and not how everyone else in the class does.

Exam 1	15%	A+	97-100%	C	73-76%
Exam 2	15%	A	93-96%	C-	70-72%
Exam 3	15%	A-	90-92%	D+	67-69%
Final Exam	20%	B+	87-89%	D	63-66%
Project	20%	B	83-86%	D-	60-62%
Homework	15%	B-	80-82%	F	< 60%
		C+	77-79%		

Homework. Please read these requirements carefully.

1. Homework assignments will be completed individually.
2. Homework will be due one week from the time it was assigned, unless otherwise noted.
3. Homework will be made available on Moodle.
4. Late homework will be accepted for 50% credit until the graded homework has been returned or after any solutions have been posted. After that point, no late homework will be accepted.
5. Solutions to all homework problems will be posted on the course Moodle page.
6. Homework format: ♦ Box all final answers; ♦ Order each problem by following the order presented in the homework assignment; ♦ Make sure your name and the homework number are listed on the first page; ♦ **Handwritten solutions must be legible**; Failure to follow these guidelines will result in loss of points; ♦ I do not accept photographed or scanned homework (except for EOL students).

Project. Each student will write either a research proposal [following National Science Foundation (NSF) guidelines; www.nsf.gov] or a literature review. The project must be an original effort, not a rewrite of something you have written for another purpose or class. You can cover fundamental (e.g., mechanisms of contaminant transformation) or applied problems/topics (e.g., bioremediation of specific compounds, applications of molecular techniques, bioenergy) in environmental microbiology. No clinical or medical-related topics. Topics must be approved by the instructor. More details on the required content will be provided later, but make note of these key deadlines:

Deadlines:

Sept. 16 – Topic selected and approved by instructor

Oct. 7 – Outline

Nov. 11 – First draft

Dec. 10 – Final draft

Date	Topic	Reading
		16 th ed.
8/19	Introduction	
8/21, 8/26	Microbial History & Classification <ul style="list-style-type: none"> • brief history • hallmarks of a cell • basics of cell structure • evolutionary relationships • taxonomy & nomenclature 	Ch. 1 pages 2-20; 25-29; 32-34
8/26, 8/28, 9/4	Macromolecules <ul style="list-style-type: none"> • carbohydrates • fatty acids • proteins • nucleic acids 	Read the Chemistry of Cellular Components file on Moodle.
9/4, 9/9	Cell Biology <ul style="list-style-type: none"> • key cell components & their structure 	Ch. 2 pp. 38-66
9/11, 9/16, 9/18, 9/23	Bioenergetics & Metabolism Fundamentals <ul style="list-style-type: none"> • free energy calculations • redox, enzymes, electron transfer • glycolysis • TCA cycle • ATP production • alternative electron acceptors 	Ch. 3 pp.77-94; Ch. 14. pp. 471-472.
9/25	EXAM 1	

9/30	Catabolism of Lipids, Hydrocarbons, Proteins • catabolic pathways	
10/2, 10/7, 10/9	Molecular Biology • DNA replication • DNA translation • protein synthesis • regulation	Ch. 6 pp.172-191.
10/16	Microbial Growth • growth kinetics • growth measurements	Ch.5 pp. 138-160
10/21, 10/23, 10/28	Physiological & Molecular Methods	Ch. 19
10/30	EXAM 2	
11/4, 11/6	Metabolic Diversity • phototrophy	Ch. 3 pp. 96-99.
11/11	• chemolithotrophy	
11/13, 11/18	• anaerobic metabolism • fermentations	Ch. 21 pp. 697-698
11/20	Microbial Ecology • Epsitemology of environmental microbiology	Article on Moodle; Ch. 20 pp. 652-672. Ch. 21 pp. 694-701.
11/25 (take-home)	EXAM 3	
12/2	Public Health Microbiology • bacterial pathogens • viruses	Ch. 33 pp. 1001-1007.
12/9 8:30 – 11:00 AM	FINAL EXAM	

Attendance Policy

I do not record attendance, but I expect you to be present in each class in order to participate in the discussion and ask questions. Contributing to the discussion and providing questions through the Moodle site is acceptable for those enrolled in the online section of the course. If you need to miss an exam (exam dates listed below) due to an expected or unexpected event, you will need to submit an absence verification request here: <https://osla.dasa.ncsu.edu/absence-verification-process/>.

Academic Integrity Statement

Students are expected to adhere to the guidelines for academic integrity as outlined in the NC State University Code of Student Conduct. Cheating and plagiarism will result in loss of credit for the exam or assignment in question and/or a zero for the course. Using online resources to obtain solutions to

homework, lab, and/or exam problems will result in a zero in the course. Providing assignments to online repositories will result in a zero in the course. For more details on the NC State Code of Student Conduct see <https://studentconduct.dasa.ncsu.edu/code/>. Violations of academic integrity will be handled in accordance with the Student Discipline Procedures ([NCSU REG 11.35.02](#)).

Artificial intelligence tools (e.g., ChatGPT) should only be used to enhance learning, not replace effort. Permitted uses include: brainstorming ideas, finding preliminary information on a topic, drafting an outline to organize your ideas, and checking grammar. Non-permitted uses include: writing a draft of a writing assignment and writing entire sentences to complete class assignments. Because A.I. tools are advancing rapidly, we are still grappling with the boundaries of acceptable use. If you are not sure if an application is acceptable, please ask the instructor. You are responsible for anything that you submit based on an A.I. query (e.g., misinformation) and your use of AI tools must be disclosed in your assignment submission and properly documented. Any assignment that is found to have used generative A.I. tools in unauthorized ways will result in a zero for the assignment, at a minimum.

Statement for Students with Disabilities

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with the Disability Resource Office at Holmes Hall, Suite 304, 2751 Cates Avenue, Campus Box 7509, 919-515-7653. For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation ([NCSU REG 02.20.01](#)).

Digital Course Components

Students may be required to disclose personally identifiable information to other students in the course, via digital tools, such as email or web-postings, where relevant to the course. Examples include online discussions of class topics, and posting of student coursework. All students are expected to respect the privacy of each other by not sharing or using such information outside the course.

Supporting Fellow Students in Distress

As members of the NC State Wolfpack community, we each share a personal responsibility to express concern for one another and to ensure that this classroom and the campus as a whole remains a healthy and safe environment for learning. Occasionally, you may come across a fellow classmate whose personal behavior concerns or worries you, either for the classmate's well-being or yours. When this is the case, I would encourage you to report this behavior to the NC State's Students of Concern website: <https://prevention.dasa.ncsu.edu/nc-state-cares/about/>. Although you can report anonymously, it is preferred that you share your contact information so they can follow-up with you personally.

Additional NC State Rules and Regulations

Students are responsible for reviewing the NC State University Policies, Rules, and Regulations (PRRs) which pertain to their course rights and responsibilities, including those referenced both below and above in this syllabus:

- Equal Opportunity and Non-Discrimination Policy Statement <https://policies.ncsu.edu/policy/pol-04-25-05> with additional references at <https://oied.ncsu.edu/divweb/policies/>

Health and Well-Being Resources

These are difficult times, and academic and personal stress are natural results. Everyone is encouraged to take care of themselves and their peers. If you need additional support, there are many resources on campus to help you:

- Counseling Center ([NCSU Counseling Center](#))
- Student Health Services ([Health Services | Student](#))
- If the personal behavior of a classmate concerns or worries you, either for the classmate's well-being or yours, we encourage you to report this behavior to the NC State CARES team: ([Share a Concern](#)).
- If you or someone you know are experiencing food, housing or financial insecurity, please see the Pack Essentials Program ([Pack Essentials](#)).