SYLLABUS
CEE361-1 ENVIRONMENTAL MICROBIOLOGY
FALL Quarter 2017

DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING
Technological Institute
Northwestern University, Evanston IL

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CLASS: M.W. 2- 3:50 PM **OFFICE HOURS:** Wednesdays 12:00 - 1:30PM

COURSE DESCRIPTION:

- Basic principles and practical applications of microbiology to current problems such as production of alternative fuels, degradation of recalcitrant pollutants in the environment, control of drug-resistant organisms, global climate change, and engineering of better systems such as waste water treatment using genetically modified microbes.

PREREQUISITES: none, but basic biochemistry and biology courses are highly recommended.

MAIN IDEAS OF THE COURSE:

1. Microorganisms drive the biogeochemical cycles that sustain all living things, can cause some of the most devastating diseases, and can be used to ameliorate environmental degradation, in food industry/ biotechnology.
2. Solving major environmental problems requires a deep understanding of the main drivers, of their relationships and feed-backs and of the scientific and engineering challenges we currently face. Learning basic principles of microbiology (cell structure and function, microbial genomics, microbial and metabolic diversity, microbial growth and growth control) and different scientific technology to interrogate and analyze complex environmental systems (microscopic, molecular and biochemical) will allow us to propose strategies to solve or ameliorate these problems.
3. Environmental Engineers have a responsibility to design solutions that protect both public and environmental health in the near and long term. To that end, they need to develop critical thinking that is interdisciplinary and integrative in order to analyze complex environmental systems and design sustainable solutions.

LEARNING OBJECTIVES

By the end of this course, students should be able to…

1. Describe the science of microbiology and its significance in everyday life:
    - Explain a specific subject in terms of its basic principles, and identify major issues and current efforts to address it. (Knowledge, Comprehension)
    - Analyze the role played by various factors (science, engineering and society) in solving major environmental problems affecting the world today. (Analysis)
2. Develop a conceptual model of a specific problem in environmental microbiology and use the model to identify causes, major players and their relationships to identify ways to solve the problem. (Synthesis, Analysis)
    - Explore the critical links in the model and discuss how interventions at the critical links could potentially solve the problem. (Analysis)
3. Propose a strategy for addressing open problems in environmental engineering. Examples of problems students will be asked to provide solutions to are: i) use of microbes for production of alternative energy fuels; ii) how microbes control global climate; iii) use of microbes to degrade

recalcitrant pollutants in the environment; iv) use of microbes for optimization of waste water treatment; v) control of drug-resistant microorganisms; and vi) design of new antibiotics for health industry.

- Identify causes, major players and their relationships. (Knowledge, Comprehension)
- Discuss current efforts to solve the problem. (Knowledge, Analysis).
- Propose a strategy for addressing the problem. (Analysis, Synthesis)
- Evaluate the benefits and limitations of the proposed strategy. (Evaluation)
- Apply the solution to broader contexts. (Application)

4. Communicate scientific information and argue specific problems using scientific evidence to support their position to an audience of peers.

TEACHING METHOD: Two (1h 50m) lecture periods per week, homework and class presentation, class participation, no laboratory.

EVALUATION METHOD: Overall course grade will be calculated from scores using the scheme below:

- Case study presentations/ discussion (40%);
- in class participation (10%);
- Quiz (20%)
- In-class Final Exam (30%).

READING: Brock Biology of Microorganisms, Madigan and Martinko

- 14th ed 2014 or 13th ed, 2010 Pearson Benjamin Cummings, San Francisco
- Peer-reviewed articles and reports for in class discussion of case studies

CASE STUDY PRESENTATIONS/ DISCUSSION

The whole class will be involved in the analysis and discussion of 7 case studies. Students will be organized in teams (2-3 students/team) and all teams will participate in the analysis and discussion of the case. At the end of each case study each team will submit their answers to the questions discussed in class. Teams will be selected randomly by the instructor.

Each team will be graded on:

- Preliminary write-up submitted prior to the discussion about the case study (Max 4 points for content) – Max 300 words/ answer with optional and always appropriately referenced visual aids (tables or figures)
- Knowledge of the subject (max 16 points) – from in-class discussion and written answers submitted by each team after each class
- Clarity and content of answered questions (max 16 points) – 4 students will be randomly assigned by lottery to answer each question. Each student in the team may get extra points for helping with answering a question out of his/her turn up to 5 points extra/ case study. If a team cannot answer a particular question the team will look it up will submit it to Canvas within 3 days.
    - There will be 5 students randomly picked that will not be assigned to any question. Their job is to complement the answers of all other students and answer any questions raised by the instructor.
- Ability to argue a point with appropriate justification (max 16 points) – each student within a team will be graded for his/ hers ability to critically analyze an issue
- Submission of 2-3 summarizing paragraphs per question (300 words max) including any answer not addressed in class (max 16 points for clarity and content of answers).

Penalties:

1) Submission of 3-4 pages of preliminary write-up will happen by 5PM of the day prior to the presentation.
2) Submission of answers to each case study should be within 3 days of the lecture by 5PM. Late submission of questions = 30% reduction in grade for the whole team
3) Not submitting an answer not answered in class within 3 days of presentation = 8 points will be removed from the final grade for the whole team

Group projects allow you to practice your analytical skills to research and identify a scientific problem and to critically present your solution explaining its advantages and shortcomings.

SCHEDULE (Dates in bold indicate milestones for group projects): There might be slight modifications, depending on class size and pace, need to review lecture material, etc.

Lecture	Date	Subjects to cover
1	Wed, 9/20/17	Intro to the course, goals, organization, discussion of term project and overview of the environmental problems which will be addressed in the course. Assessment quiz – not for grade. Introduction to microorganisms, their functions, diversity and habitats and to what defines life (13 & 14th ed, Chapter 1).
2	Mo, 9/25/17	How did life originated and evolved on Earth, how are we all related and how can we see microbes. Basic structure and function of a microorganism's cellular components (what cellular structures and functions allow microorganisms to grow in almost any habitat). (14ed, Chapter 2 & 12.I through 12.III; 13 ed, Chapter 2 & Chapter 16.1 through 16.4).
3	Wed, 9/27/17	Genetic diversity: genomes of microorganisms are very plastic and diverse. Implications for emergence of pathogens, engineering of optimal communities for detoxification of pollutants, improving crops, curing diseases. (14ed. Chapters 4, 5.I, 5.II and 5.IV, 13 ed, Chapters 12.10 through 12.13, Chapter 13.1 through 13.6 and Chapter 16.5 through 16.13)
4	Mo, 10/02/17	Introduction to microbial growth under complex gradients of environmental conditions and in the lab. Growth control and implications for antimicrobial drug resistance and drug discovery. (14ed, Chapter 5) (13 ed, Chapters 4 & 5)
--	10/03/17	Case study #1 discussion topics due
5	Wed, 10/04/17	**Case study #1** – **Antimicrobial Resistance** Bacterial competition and antimicrobial resistance Hibbing 2010 NatMicroRev Bacterial competition- surviving and thriving in the microbial jungle; Chait 2012 NatChemBiol what counters antibiotic resistance in nature; White House Fact Sheet_ US Takes Actions to Combat Antibiotic-Resistant Bacteria
6	Mo 10/09/17	Metabolic diversity: microorganisms can utilize almost any compound on Earth as energy source, and any organic compound as carbon source. Implications for geochemical cycling of elements, climate control, detoxification of pollutants, etc. (14 ed. Chapters 3 and 13, 13 ed. Chapters 4 (section II through IV) & entire Chapter 13, and Chapter 14.1 and 14.6 through 14.8).
7	Wed, 10/11/17	Methods in microbial ecology: different approaches to identifying specific microorganisms and their function in microbial communities. Culturing, DNA-based methods, microscopy, radioisotopes and microelectrodes. (14 ed. Chapters 10, 11, 18 and 6.3; 13 ed. Chapter 6 – section 11 only (for PCR reaction)/ Chapter 11 – sections 1 through 3 and section 6 (read also microbial sidebar on page 301)/ Chapter 12 – sections 12.1 through 12.9/ Chapter 22 – entire chapter).
8	Mo, 10/16/17	Quiz
--	10/17/17	Case study #2 discussion topics due
9	Wed, 10/18/17	**Case study #2: Microbial Habitats:** (additional readings will be posted with the assignment) - **Biofilms** - **associations with marine communities and higher organisms** (Brock, 14 ed., Chapters 19 and 22.II and 22.III; 13 ed., Chapters 13.14-13.15, 23.6 - 23.7, 25.3- 25.8) o Soil and plant microbial habitats and implications for use of legumes and organic farming o Animal-microbial symbiosis (ruminants). o Human Microbiome

Lecture	Date	Subjects to cover (continuation)
10	Mo, 10/23/17	Biogeochemical cycles (global geochemical cycling of elements). Freshwater and marine habitats and their link to primary productivity, CO_2 fixation and global climate. Biological pump and role of marine viruses (14 ed. Chapters 19 and 20; 13 ed Chapters 23 – entire chapter, chapter 24.1 and Suttle 2007 NatMicrobiolRev Marine viruses - major players in global ecosystem).
--	10/24/17	Case study #3- discussion topics due
11	Wed, 10/25/17	**Case Study #3- Energy production by microbes.** Examples of energy production by microbes. Cellulosic biofuels and algal biofuels, and other alternatives. Are there viable and environmentally-friendly options? Discuss energetic potential and environmental impact of energy alternatives produced by microbes. (readings will be posted with the assignment)
12	Mo, 10/30/17	Marine Microbial Habitats: Coral reefs. (Dr. Timothy Swain, CEE, NU)
--	10/31/17	Case study #4- discussion topics due
13	Wed, 11/01/17	**Case study #4 Marine Microbes and Climate Change** – part 1 Group presentations and class discussion. readings TBA
14	Mo, 11/06/17	**Case study #4 Marine Microbes and Climate Change** – part 2 Group presentations and class discussion. readings TBA
--	Wed, 11/08/17	NO CLASS
16	Mo, 11/13/17	Bioremediation part 1- Detoxification of inorganic and organic pollutants by microorganisms, and challenges of microbiological degradation of recalcitrant pollutants. (14 ed., Chapter 21.II; 13 ed., Chapter 24.7 through 24.10)
17	Wed, 11/15/17	Bioremediation part 2: 2010 Gulf of Mexico Oil Spill case study – part 1 (watching the Deep Horizon movie in class)
--	10/19/17	Case study #5 discussion topics due
18	Mo, 11/20/17	**Case study #5 - Biodegradation and Bioremediation: Deepwater Horizon, (GoM oil spill)** readings TBA
--	Wed, 11/22/17	NO CLASS
--	11/28/17	Case study #6 discussion topics due
18	Mo, 11/27/17	**Case study #6 Engineering better Waste Water Treatment – Strategies and Technologies** Group presentations and class discussion. readings TBA
--	11/28/17	Case study #7 discussion topics due
19	Wed, 11/29/17	**Case study #7 Genetically modified microorganisms and Biotechnology.** Implications for drug production, and applications of genetically modified organisms in agriculture and medicine. Readings TBA

FINAL EXAM will be on Monday, December 4, 2017 from 9 to 11 AM, same classroom.