TO: The Engineering Faculty

FROM: The Faculty of the School of Agricultural and Biological Engineering

RE: New graduate course – ABE 58500 Soil Microbiology (3 credit hours)

The Faculty of the Department of Agricultural and Biological Engineering has approved the following experimental course for a permanent number. This action is now submitted to the Engineering Faculty with a recommendation for approval.

FROM:

ABE 59100 Soil Microbiology Sem. 2, Class 3 Cr. 3.

Temporary course number. Course was taught Spring 2019, cross-listed with AGRY 58000.

TO:

ABE 58500 Soil Microbiology Sem. 2, Class 3 Cr. 3. Restrictions: Classification 4 or higher.
Prerequisites: Graduate Standing OR
(BIOL 22100 and (AGRY 25500 or NRES 25500))
and
BCHM 30700 or CHM 33300

The soil microbial population and its role in the soil ecosystem; microbial transformations of inorganic and organic compounds; decomposition of residues; and dynamics of soil organic matter. Typically offered Spring. 3.000 Credit hours

BACKGROUND:
Soil Microbiology focuses on the microorganisms found in the environmental landscape (soil and water) and their relationship to land management, agricultural production, and environmental processes. This course is taught to graduate students in several disciplines of environmental sciences and agricultural engineering. The course meets three times each week; 2 of the meetings are lecture-based with active learning by the instructors and guest lectures for applied topics; the final class period each week is discussion-based where students lead small and large group discussions on synthesis and application of primary literature. The course includes a final project and 2 exams. The attached syllabus has additional details on learning objectives, topics covered, course schedule, and grading policies.

REASON:
The course has been successfully taught in the Department of Agronomy as AGRY 58000 since Fall 2008. In the Spring 2019, the course was co-taught by faculty in ABE, cross-listed as an

ABE 59100 experimental course and is now being submitted for a permanent course number. This offering of the course had 18 students enrolled. Moving this course is requested because it will continue to be co-taught by ABE faculty and is of relevance to students in the ABE graduate and undergraduate programs.

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Head of ABE

Soil Microbiology
AGRY 58000 / ABE 59100

Leonardo Da Vinci said (five hundred years ago):
"We know more about the movement of celestial bodies than about the soil underfoot."

Instructors:

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Office Hours: Send an email to setup a time.

Class Location and Hours: Lilly Hall of Life Sciences G-458, MWF 9:30-10:20

Text: Soil Microbiology, Ecology and Biochemistry, Fourth Edition 4th Edition
Edited by Eldor Paul (available on line at the Purdue Library)

> ***Our Goal****: is to provide a setting in which you can fully develop an understanding of the role and significance of microorganisms in the environment (soil, water air).*
>
> ***Student's Goal:*** *to acquire a knowledge and appreciation for how microbiology and microbial processes influence and control the environment.*

Defined: Soil Microbiology is a branch of science concerned with the microorganisms found in the landscape (soil and water) and their relationship to land management, agricultural production, and environmental processes.

Microbial - Soil System: Because of the size and direct interaction of the microbes with the mineral and organic phase in soil, the study of soil microorganisms is complex needing special tools and techniques. Consequently, soil microbiology *tends* to be a methods-driven discipline and knowledge of the procedures is mandatory if you are going to understand the system. We will develop a full understanding of the tools of Soil Microbiology. Soil scientists have divided the soil ecosystem into a series of manageable physical segments: air, liquid, and solids (organic and mineral) – microbiology affects all aspects of the system.

As the microorganisms control the flow of energy (electrons) which will affect the systems functions, microorganisms are the major *biochemical driving force* in soil. The flow of electrons controls most of the important soil reactions, including the stability of mineral phases, organic matter turnover and the fate of introduced xenobiotic materials. As microorganism control electrons flowing in the system, it can be suggested that microorganism control soil. Therefore, if you want to understand soil you need to understand the soil's microbiology.

Learning Outcomes

By the end of the semester, you should be able to:

1. Interrelate the importance of soil microorganisms, and the biological processes they mediate, to soil properties and ecosystem functions.
2. Be knowledgeable of the importance of soil as a habitat for organisms and critical biogeochemical processes they control.
3. Be knowledgeable of the morphology, physiology, and ecology of the major groups of soil microorganisms.
4. Be able to relate soil microbiology to your own area of research interest and be able to articulate correctly a response on questions related to microbiology or microbial functions in the environment.

Topics

We are interested in defining how microorganisms grow, reproduce, and function in the soil environment we are interested in the soil microbiome. We are also interested in how these actions influence other organisms and the environment (e.g., air, water) as whole. To understand the wild soil microorganisms, we will focus on a number of topics:

1) General microbiology;
2) Water systems
3) Microbes found in soil;
4) The soil as a microbial habitat;
5) Microbes and environmental stress;
6) The microbiome in concept and reality.
7) Interactions between microbes;
8) Mycorrhizal relationships;
9) Formation of soil organic matter;
10) Nutrient cycling (N, P, S, C);
11) Response to metals;
12) Engineering for optimal functions: (Composting, biopiles, bioremediation; two-stage ditches)
13) How humans impact microbes in soil;
14) Sustainability of the soil system;

Assignments and assessments

What to expect: This is a graduate level course and you are going have a variety of things to do both in and out of class. We are flipping things around and will include more in class assignments but that requires that you are prepared for the event (this is particularly important for Fridays). SO, pre-class reading, note reviews, and attendance are critical. You should expect to read the equivalent of 2-3 research papers each week.

The book and other readings. Lecture materials will come from the book, *Soil Microbiology, Ecology and Biochemistry 4th ed., by E.A. Paul.* This book is a well-written and up-to-date coverage of soil microbial processes – making time to read the chapters is critical. Peer reviewed papers (available on blackboard) will provide more detail and contextualize concepts on the functioning of soil. Combined, the readings will provide you with the information you need to discuss the points in class and to answer written questions about the readings.

Homework/Problem sets: There will be 8-10 homework assignments throughout the course. You will typically be due one week after they are assigned and will vary in format. There will also be a variety of knowledge assessments in class to ensure you are (1) keeping up with the reading and (2) understanding/retaining/processing the material.

Final Project: This course will allow you to explore an area of soil microbiology that supports your thesis/dissertation work but is independent from it. The goal is for you to use this opportunity to broaden your understanding of controls, drivers, and contexts so that you are able to think more expansively about the environmental issues affecting soil function and the microbial communities that are at the heart of it. The intent is also to acquaint you with the process of critically reading and writing. The project will be a written paper and rubrics will include detailed instructions and requirements. All project topics must be pre-approved by the instructors.

Exams: All exams will be take-home and return. Expect an essay style with an emphasis on data interpretation and problem solving.

- First exam is in late February; concepts from the first half of the class
- Second exam is during exam week; concepts from the second half of the class

In Class Discussions: Active participation in discussions during class is a key part of your grade in this course. To facilitate that, we will have structured group discussions on most Fridays. We will break the class up into groups of 3-4 students. Each group will be assigned a paper to read before class, and develop a 1-page summary (example format is available on Blackboard). The groups will all have different papers on the same topic. One person (which will rotate) from each group will then present the key findings of their paper to the rest of the class.

Abstracting Assignments: The most fundamentally difficult things to do is write is an abstract. However, because of the internet and electronic searching tools, the abstract is even more important as many more people will encounter your work through the abstract and make a decision about the work based on what they see in just the abstract. To gain a better understanding of this process, you will be given a paper that lacks its abstract and write an abstract. Guidelines and rubric will be provided on Blackboard.

Grading: Grades will be earned by a weighted average according to the following formula:

- Assignments (homework, paper summaries, abstracting assignments) = 35%
- Final project = 15%
- In-class participation = 10%
- Exams (2 x 20%) = 40%

Course grades will be determined as follows:

Score	≥ 97	92-96.9	88-91.9	82-87.9	77-81.9	72-76.9	67-71.9	62-66.9	60-61.9	< 60
Grade	A+	A	A- / B+	B	B- / C+	C	C- / D+	D	D-	F

If you fall into one of the "gray areas" (A- or B+, B- or C+, C- or D+) your grade will be based on two main criteria: (1) whether your performance has improved or gotten worse and (2) your participation in making the classroom a positive learning environment for everyone.

Soil Microbiology
AGRY 58000 / ABE 59100

A general outline for the semester – Changes are possible and *likely*

Page References are for: **Soil Microbiology, Ecology and Biochemistry, Fourth Edition 4th Edition.** *Edited by Eldor Paul* (Sections will also have additional material added on the Blackboard site – you are responsible for all readings.)

Chapter 1: pp. 1-13. General information about microorganism, soil and ecology. What makes a microorganism function?

Chapter 2: pp. 15-39. The Soil Habitat: how do water, soil structure, pH, redox, and temperature affect the microorganism.

Chapter 9: pp. 245-272. Microbial Physiology and Growth: how do microorganism make a living and what do they eat? Enzymes, transformations, and the how to use electrons.

Chapter 3: pp. 41-73. Bacteria and Archaea and then (pp. 77-100), Fungi: what are the typical forms of microbial life in soil? What are their functions in soil?

Chapter 6: pp. 151-180. Molecular methods for soil biota.

Chapter 7: pp. 188-218. Methods for the measurement of the microbe in soil:

Chapter 5: pp. 111-149. Soil Fauna: occurrence, diversity, and major roles in soil.

Chapter 8: pp. 223-241. Microbial Distribution in soil; Handouts: The Soil Microbiome (THIS is the future.) http://www.earthmicrobiome.org/

Chapter 10: pp. 272-303. Ecology of the soil Microorganism: where do they live and how do they interact?

Chapter 12: pp. 339-382. Carbon Cycle: Carbon utilization, energy production and the microbe in soil. Growth linked biodegradation, assimilation of carbon and acclimation. Extracellular enzymes; enzyme

Chapter 15: pp. 447-468. The Nitrogen Cycle Inputs

Chapter 14: pp. 421-443. The Nitrogen Cycle Transformations activity in soils use of soil enzymes as a measure of soil stability.

Chapter 16: pp. 471-497. Other nutrient cycles: Sulfur cycle and the Phosphorus semi-cycle

Chapter 18: pp. 505-537. Management of soils processes

Additional References:
Water Relations in Soil Microbiology; Any general Soil Science textbook (Brady, Fotch etc.),
The Rhizosphere and spermosphere. (Unique environments?)
Methods of soil analysis: Microbial and biochemical properties. R. Weaver et al. (ed.) Soil Science Society America. Madison WI;
Methods in Applied Soil Microbiology and Biochemistry eds. Alef and Nannipieri Academic Press