Instructor: Warren A. Dick  
The Ohio State University / The Ohio Agricultural Research and Development Center  
Wooster, OH 44691  
Telephone: (330)263-3887; E-mail: dick.5@osu.edu

Office Hours: Anytime (just call or email)

Meeting Times: Soil and Environmental Biochemistry and Microbial Ecology (ENR 6610) meeting times will be on Tuesdays and Thursdays from 12:45 – 2:05 PM via a two-way live video link between Wooster (Williams 123) and Columbus (Kottman 333C).

Course Materials: Students are encouraged to create a folder or loose-leaf binder containing recommended readings and other course content. Most class overheads are posted on the web (http://senr.osu.edu/courses/enr-6610).

Course Philosophy and Content: Soil and Environmental Biochemistry and Microbial Ecology (ENR 6610) is a two credit semester course designed to explore the concept that soil can be considered a tissue, with many kinds of living and life-derived cells, to which biochemical and microbial ecology techniques are applicable. J. W. Quastel (In A. D. McLaren and G. H. Peterson (eds.), Soil Biochemistry, Vol. 1, Marcel Dekker, New York, 1967) adopted the conceptual theme that "the soil as a whole can be considered an organ comparable in some respects to a liver or a gland to which may be added various nutrients, pure or complex degraded plant materials, rain, and air, and in which enzymatic reactions can occur. The products of these reactions are important steps in elemental cycles."

To this we add the concept that soils teem with diverse microorganisms, many of which are still unknown but highly appreciated for the ecosystem goods and services they provide. Sometimes this unknown microbial component is called the “dark matter” of soil. In this class, we will explore recent advances in methods to study microbial ecology and how this has lead to a better understanding of who is in soil and what they are doing. At best, this is only scratching the surface of this vast, yet highly exciting discipline area.

Topics of major concern in this course will be the biochemical reactions and mechanisms involving carbon, nitrogen, phosphorus, sulfur and the trace elements in soil. Following will an emphasis on the biochemistry of xenobiotics in soil and the fate of biologically active molecules and genetic material in soil. The last part of the course will focus on methods to measure the presence of microorganisms in soil and to assess their function.

Course Objectives:

Specific course objectives are:

A. For the student to become accustomed to thinking of soil-related problems in biochemical and microbial ecology terms.

B. For the student to acquire and demonstrate understanding of the biochemical reactions and mechanisms of the carbon, nitrogen, and phosphorus cycles and of heavy metals in soils.
C. For the student to investigate the biochemical reactions and mechanisms associated with the fate of natural and man-made biologically active chemicals added to soils.

D. For the student to become exposed to molecular methods used to characterize the microbial community in soil.

E. For the student to develop skills in critically evaluating scientific findings related to soil and environmental biochemistry and microbial ecology and in preparing and presenting oral and written technical information.

The Course in Brief:

Preface and Introduction

I. Soil Biochemistry: Its Definition and Scope (Lecture 1 – January 12)

A working definition of soil biochemistry will be introduced. A description of how the physical, chemical, and biological components control biochemical reactions, will be presented. An important concept discussed as part this chapter is that of the soil microsite. Biochemical reactions in soil take place at a particular locus that can be described by the various soil components. The difference between microbial presence and microbial activity in soil will be described.

II. Soil Enzymes and Enzyme Kinetics (Lectures 1 and 2 - January 12 and 14)

Classification of enzymes, enzyme kinetics, and the regulation of enzyme reactions will be discussed. The source of enzyme activity and how this activity is stabilized in soil are important topics. Examples and illustrations will be used from the discipline of soil biochemistry.

III. The Microbial Biomass and Soil Biochemistry (Lecture 3 - January 19)

The microbial biomass plays a central role in many important biochemical transformations in soil (e.g. mineralization and immobilization of elements). Various methods of determining microbial biomass and evaluating biomass dynamics will be presented.

IV. Biochemistry of Carbon Transformations in Soil (Lectures 4-5, January 21 and 26)

Material presented will describe the major carbon-containing materials added to soils, radioactive decay and 14C-dating, the formation and characterization of humus and the biochemical reactions of humus, free radical formation and coupling of aromatics in soil, the cycling of carbon in soils (i.e. the degradation of naturally occurring organic compounds in soils and carbon turnover), and the metabolism of phenolics.

V. Biochemistry of Nitrogen Transformations in Soil (Lecture 6-7, January 28 and February 2)

A description of the N compounds found in soil and the major biochemical transformations that comprise the N cycle in soils will be discussed. Topics include mineralization, immobilization, nitrification, and gaseous losses of N through ammonia volatilization and denitrification. Attention will be focused on several specific biochemical reactions catalyzed by enzymes such as urease, the amidases, the proteases, and the deaminases. Also specific enzymatic reactions involved in the degradation of nucleotides and various amino acids will be presented.
VI. Biochemistry of Phosphorus and Sulfur Transformations in Soil (Lectures 8, February 4)
A description of P and S compounds in soil will be followed by discussion of mineralization-immobilization reactions and oxidation-reduction reactions of P and S in soils. The role of specific enzymes in degrading P- and S-containing plant and microbial residues in soil will be discussed.

VII. Biochemistry of Metal Transformations in Soil (Lecture 9, February 9)
This chapter will focus on the oxidation-reduction reactions of metals (Mn, Fe, Se, etc.) that are enzymatically catalyzed in soil. Other biochemical reactions that bring about the production of volatile forms of metals will be presented. The effects of heavy metals in the soil environment, which have been introduced by man’s activities or which are present naturally, on many soil biochemical reactions will be presented. A specific portion of this section will focus on the biologically important iron-binding compounds called siderophores.

VIII. Biochemistry of Xenobiotics in Soils (Lecture 10, February 11)
The main chemical families of xenobiotics will be surveyed. The effect of various xenobiotics on the biochemical reactions in soil will be addressed. Topics presented under the general heading of xenobiotic metabolism will include the relationship between the structure of a xenobiotic molecule and its persistence in soil, general biochemical reactions which are important in the degradation of xenobiotics, and specific pathways of breakdown of various xenobiotic chemicals.

IX. Biochemistry of Biologically Active Materials in Soil (Lecture 11, February 16 and 18)
Production and persistence of plant hormones, allelopathic responses in soil, production of antibiotics by microbes and their activity in soil, and pathogenic and viral introduction and survival in soil will be topics introduced.

X. Soils and Human Health (Lecture 12, February 23)
Soils are often ignored as an important direct causative link to human health. There are also many indirect links that are not readily recognized. These topics will be explored.

XI. First Set of Student Presentations (February 25)

MIDTERM – March 1

XI. Microbial Phylogeny and Diversity in Soil (Lectures 12 and 13, March 3 and 9)
Microbial diversity in soil ecosystems exceeds, by far, that of eukaryotic organisms. Microbial diversity describes complexity and variability at different levels of biological organization. It encompasses genetic variability within taxons (species), and the number (richness) and relative abundance (evenness) of taxons and functional groups (guilds) in communities.

XII. Interactions with the Biotic Environment: Symbiosis, Competition, Parasitism, Predation (Lecture 14, March 10)
Microorganisms engage in a variety of social interactions. The benefits and disadvantages of these types of interactions depend on the perspective being considered.
XIII. Microbial Guilds and Biogeochemical Cycles (Lecture 15, March 22)

Although there are many species in a community, a much smaller number of biological processes are necessary for the function of an ecosystem. The concept of guild is that of a group of species that exploit the same class of environmental resources in a similar way without regard for the taxonomic position of each species. The guild is the functional unit of the ecosystem.

XIV. Methods to Analyze Microbial Communities in Soil (Lecture 16-17, March 24 and 29)

In these lectures, we will introduce both biochemical and molecular methods used to explore the microbial community. These methods will be explored in more detail when we look specifically at the metagenome, metatranscriptome and the metaproteome.

XV. The Soil Metagenome (Lecture 18-19, March 31 and April 5)

The soil metagenome involves the study of genetic material recovered directly from a soil sample. It represents the sum total of the genetic diversity of the soil microbial population.

XVI. The Soil Metatranscriptome (Lecture 20, April 7)

Soil metatranscriptomics is the study of ribosomal RNA (rRNA) and messenger RNA (mRNA) of the microbial community in soil. It allows the simultaneous investigation of the gene expression (mRNA) and abundance (rRNA) of the active microorganisms.

XVII. The Soil Metaproteome (Lecture 21, April 12)

Proteins reflect actual functionality with respect to metabolic reactions and regulatory cascades and provide more direct information about microbial activities than do functional genes or even their corresponding messenger RNAs. Identification of proteins can also reveal the identities of active microorganisms via database homology to other species.

XVIII. Single Cell Analysis (Lecture 22, April 14)

Isolating and analyzing individual microbial cells from the total population have enabled us to explore the taxonomy, physiology, and activity of microbes at the single-cell level. Single cell isolation techniques that physically separate individual cells from each other and/or from matrix will be introduced.

XIX. Time for Review (April 19)

XX. Second Set of Student Presentations (April 21)
Teaching Methods and Grades:

Teaching methods that will be used in the course include lectures, assigned readings, problem solving and discussion.

Final grades for this section of ENR6610 will be calculated by weighting participation, project quality, and the midterm examination as follows:

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<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Participation</td>
<td>15%</td>
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<tr>
<td>Project (written)</td>
<td>15%</td>
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<tr>
<td>Project (oral)</td>
<td>15%</td>
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<tr>
<td>Midterm/Final Examination</td>
<td>55%</td>
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Discussion:

1) Each class, students will be expected to bring to class a question, on a separate sheet of paper, which can be discussed by the class. This must be more than a simple yes-no question because such questions do not lead to discussion. Questions can arise out of the lectures, reading, your own studies, etc. They must, however, be relevant to the topics currently being addressed in the course.

2) Each week students will also be required to submit one exam questions based on the material being covered in class. Please send these to me via e-mail. These should include multiple choice, matching questions, or questions that can be answered with one or two words. These must be submitted each week to obtain participation credit. Finally, by the end of the quarter, each student will be required to submit four longer response (two to four sentences) questions and two essay questions. These can be submitted any time during the quarter. These questions often form the basis of both the midterm and final exams.

3) Participation in “in-class” discussion will be monitored. No comment or discussion is really inappropriate in a learning environment. Participation by all is absolutely essential for a discussion format to be successful.

Project:

Objectives:

A. For the student to thoroughly assimilate, digest and understand specific topics (chosen by the student) from among the vast subject material which composes soil and environmental biochemistry and microbial ecology.

B. For the student to learn writing and oral skills required in the scientific and professional community for presentation of knowledge.

The Task:

The project will be a two-fold activity. The first activity will involve choosing a research journal paper and writing a lay interpretation of the results. Papers chosen must have as their theme a topic that is related to the subject matter of class lectures. If there is a question about the appropriateness of a paper to be used for this activity, please review the topic with me before beginning. Two samples of such types of writing can be found at:

http://senr.osu.edu/sites/senr/files/imce/files/course_materials/enr6610/Project 1A.pdf
http://senr.osu.edu/sites/senr/files/imce/files/course_materials/enr6610/Project 1B.pdf
The second activity will be a 10-15-minute oral presentation in which you will provide a quick overview and lead a discussion on the paper for which you wrote your lay interpretation. These presentations are scheduled at two different times during the semester depending on whether the presentation is more biochemically oriented (February 25) or microbial ecology oriented (April 21). The order of presentation will be determined by random draw.

Evaluation:

Evaluation will be made in two areas which will receive equal weight: (i) the organization and writing of material in a concise but readable and understandable summary and (ii) the quality of the oral presentation. This project will count for 30% of your grade for my portion of ENR 6610.

Other Items of Importance:

Availability of Special Accommodation. If special accommodations are needed because of a disability, please contact me as soon as possible. Assistance from the Office For Disability Services will be obtained to verify the need for accommodations and to develop accommodation strategies.

Academic Misconduct. The University's Code of Student Conduct defines academic misconduct as "[a]ny activity that tends to compromise the academic integrity of the University, or subvert the educational process" (http://oaa.osu.edu/coam.html). Students charged with Academic Misconduct will be referred to the University Committee on Academic Misconduct for any further action.