Biosc 2110-Microbial Diversity

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- **Level of course**: Graduate students and advanced undergraduates
- **Approximate size of enrollment**: 5-25 students
- **Class times**: Mondays 2-3:50pm
- **Room**: Langley 219A

1 Course overview-Microbial Ecology and Evolution

The importance of microbes for ecology, health and even development has become increasingly clear. Microbes are diverse, ubiquitous and essential for biogeochemical cycles. It is calculated that microbial carbon (only prokaryotes) is 60-100% of the total carbon in plants, and that there is approximately 10 times more prokaryotic nitrogen and phosphorus than that contained in all plants. Microbes are often found in complex multi-species communities interacting through metabolites and other secretions, modifying their environments and constantly changing. This class explores central concepts in ecology and evolution, their applications for microbial communities and the ways in which microbes might provide novel insight into ecological and evolutionary thinking. This class is meant graduate students and—using microbes as an entry point—it should provide important skills for graduate school like: basic experimental design, clear communication skills and efficient comprehension of scientific papers, and making connections between different bodies of literature.

2 About this syllabus

This syllabus is meant to be a roadmap of this course. It is not only a way to communicate expectations, describe course and assignments and explain grading policies, but it is a document that provides explanations for the different assignments and what is their role in knowledge, how do assignments build of each other and relate to the outcomes of the class. It also should set the tone for what you can expect from me and what are my expectations with respect to the class dynamics. For me students are not passive receptacles of knowledge, but collaborators and active knowledge producers. Thus, this syllabus should be a tool for reflection about the class, and our learning.

3 Outcomes

In this class, I expect that you: - Are able to make connections between classical and more current papers. - Are able to apply the concepts learned here to your own questions and systems. - Will learn some of the central ideas in ecology and evolution as they apply to microbes. - Are able to apply some of the experimental design and methodologies to write a short but effective proposal.

4 Context for the class

This class is meant to be collaborative and a space for community learning. It covers some of the interests of graduate students in the biology department at the University of Pittsburgh (e.g. community ecology, evolution of genetic regulation, host-parasite interactions, molecular evolution) and serves as an interdisciplinary space to integrate ideas from across the biological sciences (e.g. developmental biology, ecology and evolution) as well as different scales (from genes to ecosystems). Lastly, this class is meant for graduate students to develop some skills that I have found particularly useful as a PhD student: efficient reading and processing of scientific papers, writing effective proposals and designing informative experiments. I hope that this class will help to bridge collaborations among students and postdocs in Ecology and Evolution as well as between them and other students within the biology department or other programs (e.g. microbiology and molecular genetics) at the University.

5 Course goals

In this course we will apply main ideas of evolution and ecology to the understanding of microbes and microbial communities. We are still uncovering much of the microbial diversity and its implications, therefore many current papers focus on describing microbial communities and patterns of diversity. This course, however, will be centered in the questions and the processes shaping those patterns. It is a class meant to practice questioning our world, generating testable hypotheses and designing informative experiments to test those hypotheses.

5.1 Learn central ideas in ecology and evolution

Microbes have often been utilized to test and generate hypotheses in ecology and evolution and many of these studies provide a good illustration of complex concepts like species coexistence, niche divergence, pleiotropy and epistasis. In addition, many technical advances have been made in recent years allowing us to investigate many ecological and evolutionary processes in complex communities and in the field. This class highlights the importance of ecological and evolutionary theory in the application of novel methods to generate questions and understand processes involved in shaping microbial communities and the interactions of microbes with other organisms.

5.2 Apply ecological and evolutionary theory to microbes and their microbial communities

Every week we will read two or three papers for discussion. One of the papers will always be a classical paper in ecology or evolution in general, or a paper that uses microbes to test a concept or a long-standing hypothesis in the field. The other paper(s) will tend to be more recent and exemplify the application of these concepts to microbes.

5.3 Introduce R and experimental design for ecology and evolution

This class has a theoretical and a practical component. Each week we will spend the first hour discussing the general concepts and main results of the papers. The second hour we will focus on methods used in the field and a basic introduction to experimental design. We will do a few hands-on sessions using R. I will introduce this language and its main structures in the first two weeks of the class. Because class time alone is not enough practice in R, I will assign three problem sets to work on. I will not grade the problems, but I will discuss the answers the following week. Students are encouraged to work in groups to solve the problems assigned.

5.4 Practice writing a proposal

The main assignment of this class is a scientific proposal with a clear motivation leading to clear questions and hypotheses and a feasible experimental design. Students are expected to make clear connections between the motivation, the questions, their aims and hypotheses and the experiments to address such hypotheses. The writing of this proposal will come in multiple steps: First, I will personally meet with each student to discuss their interests and narrow down a research question about which to write their proposal. Students will write a first draft to be reviewed by their peers in a mock NSF panel format. Students will then use the peer-review comments to revise and submit their final proposal.

5.5 Improve effective reading of scientific literature

Each week students have to read 2 to 3 papers, summarize the main point of the paper in a paragraph or less and make connections between the different readings. This will help to develop the skills of reading quickly and effectively,and build habits of keeping up with the literature on a topic.

6 Proposed assignments and grading

Proposal peer review report (15%)
Proposal (35%)
Participation including reading summaries and R exercises (50%)

7 Schedule

- Population biology
  - (W1) Microbial growth-Intro to R (classes, structures and indexing)
    - Monod. (1949)
    - Bachmann et al. (2013)
  - (W2) Mutation-Logic statements
    - Frenkel et al. (2014)
    - Bjedov et al. (2003)
  - (W3) Population sampling (drift) - On populations, samples and distributions. (*First R problem set*).
  - (W4) Natural selection and adaptation - Evolutionary simulations.
- Microbial interactions
  - (W5) Host-microbe interactions. Experimental design 1.
  - (W6) Social life of microbes. Experimental design 2 (*Second R problem set*)
  - (W7) Predator-prey interactions. Statistical testing
  - (W8) Biotic interactions and evolutionary dynamics. Linear models 1 (*First draft of proposal due*)
- Communities and Metacommunities
  - (W9) Succession and community assembly. Assumptions and null models.
  - (W10) Ecological interactions and evolutionary dynamics (*Peer review comments due*). Linear models 2.
  - (W11) Diseases, dispersal and metacommunities. General mixed models (*Third R problem set*).
  - (W12) Metagenomics- Intro to multivariate data and multiple testing problems.
- Ecosystem ecology
  - (W13) Impact of microbes at ecosystem level
  - (W14) Final proposals due