MICROBIAL ECOLOGY & EVOLUTION

MICROBIO 440 **FALL 2018, 3 credits – Class Nr. 80720**

Schedule: MWF 11:15 am – 12:05 pm in 444 Morrill Sci. Ctr. I

Instructors:
Dr. Klaus **Nüsslein**
Office N110A Morrill I (nusslein@microbio.umass.edu)
Office hours: by appointment and Mondays 1:30-2:30pm

Dr. Kristen **DeAngelis**
Office N435 LSL (deangelis@microbio.umass.edu)
Office hours: by appointment and Mondays 2:30-3:30pm

Prerequisites: MICROBIO 310 or permission from instructor

COURSE GOALS

At the conclusion of this course, students should be able to:

1. Define the processes and outcomes of microbial evolution.
2. Describe microbial ecology, and understand how and why microbial ecology is an integral part of the science of microbiology.
3. Compare and contrast the processes of ecology and evolution in shaping microbial community structure and function.
4. Identify and defend bioinformatics and molecular methods which can be applied to answer questions about the ecology and evolution of microbes in natural environments.
5. Identify best practices in research, and apply this understanding to the critical reading of a scientific paper and the analysis of bioinformatics data sets.

COURSE DESCRIPTION

This lecture-based course is designed to introduce students of microbiology to the dynamic nature of microbes on Earth. Course topics are structured to demonstrate the linkages between microbial ecology, diversity, and evolution. During this course, we will cover the following topics:

- Role of microbial life in the evolution and ecology of the biosphere.
- Application of classical ecological concepts to microbial populations and communities.
- Underlying principles that drive microbial population structure in the environment.
- Community function and dynamics at both the molecular and the organismal level.
- Abiotic and biotic interactions within microbial communities.
- Ecophysiology and thermodynamic constraints on microbial community structure.
- Molecular and genomic tools for understanding the physiology and ecology of microbial communities.
- Microbial metabolism and biogeochemical cycling.
- Woesian revolution.
- Microbial system resiliency, functional redundancy, and dormancy.

Emphasis will be on relating environmental influences to community structure and function. Limits of system requirements will be explored by discussions of a core genome, core communities, or limits of functional diversity.

Topics are presented in fifteen parts, one part per week. Each part includes a lecture presented in 2-3 sections, followed by a case study from seminal research publications, combined with an interactive discussion of current issues debated within the discipline. Instruction will be primarily through lectures and discussions based upon material in texts, as well as, current primary research literature or topics in the news.

GRADING AND COURSE REQUIREMENTS

Assessment:	**Percent**
Paper	20 %
Quizzes	40 %
Final exam	20 %
Participation	20 %

Each student will write a scientific review **paper** on a topic of their choosing related to class. A maximum of 1000 words, the paper must include a Box with definitions of technical terms. Due dates are:

- Oct 24: present topic to instructors (2.5 points)
- Nov 07: present outline to instructors (2.5 points)
- Dec 12: research paper due (15 points)

Quizzes will be administered every week at the beginning of class on Fridays. The best 11 of 13 **quizzes** will be counted towards your grade. Quizzes will have 7-10 questions, including multiple choice, fill in the blank, and short answer. The cumulative **final exam** will have 50-60 questions in the same form as the quizzes.

Part of your grade will include **participation**. Credit for participation will be counted when students attend class; ask questions and participate in class-wide, small group, and paired discussions; lead the discussion on a table, figure, or other aspect of a paper we are discussing; and provide peer review through grading quizzes, and evaluating topics and outlines for papers.

Grades are calculated to the nearest percent. The grade cut-offs may be lowered on the basis of the point distribution. No re-grading will be done after one week. All materials will be discarded 30 days after the end of the semester.

ATTENDANCE AND PARTICIPATION

Attendance at all scheduled classes is expected except in cases of emergency (death in family), the advent of religious holidays (the observance of which requires restriction of daily activity) or when participating in official College functions (e.g., field trips and athletic events). The instructors may require such evidence as seems fit.

All students are expected to adhere to the Code of Conduct as described by the UMass Dean's office to create a respectful atmosphere for learning and sharing. If you would like to request accommodation because of a documented disability, please discuss your situation and possible needs with the instructor within the first week of class. The instructor is available and willing to answer any questions and to give individual help on any portion of the course during class or outside of class by appointment. If you have any questions or need help, please ask.

S C H E D U L E MICROBIO 440 FALL 2018

MONDAYS	will be mostly lecture, with a preliminary discussion of this week's paper. *Please read the week's paper before class on Monday*.
WEDNESDAYS	will continue the lecture, with most time reserved for paper discussion.
FRIDAYS	will begin by taking the quiz, followed by in-class grading of the quiz, followed by discussion of the topic and learning goals.

WK	DATE	Prof	TOPIC
1	Sept 5	(K2)	Lecture #1: Introduction to microbial ecology and evolution
	Sept 7	(K2)	Paper #1: How To Read A Scientific [Journal] Article Quiz #1

Required reading:
- How To Read A Scientific [Journal] Article (choose 1 of 3 options)

Additional optional reading:
- Chapter 1, Introduction, and Chapter 3, Physical-chemical environment of microbes. In, Processes in Microbial Ecology by David Kirchman (2012) 1-18, 35-54
- Chapter 1, Genes, Genetic codes, and Mutation. In, Molecular Evolution, by Wen-Hsiung Li (2000) 5-38

2	Sep 10	(KD)	Lecture #2: The Woesian Revolution and Tree-Thinking
	Sep 12	(KD)	Paper #2: Woese et al. PNAS 1990
	Sep 14	(KD)	Quiz #2

Required reading:
- Woese, C., Kandler, O., & Wheelis, M. (1990). Towards A Natural System Of Organisms - Proposal For The Domains Archaea, Bacteria, And Eucarya. *Proceedings of the National Academy of Sciences of the United States of America*, *87*(12), 4576–4579

Additional optional reading:
- Chapter 17, Origins and Evolution. In, Microbiology: an Evolving Science, by Slonczewski & Foster (2011) W. W. Norton & Company, New York NY. 623-667
- Oliverio, Angela M. and Laura A. Katz. (2014) The Dynamic Nature of Genomes across the Tree of Life. Genome Biol. Evol. 6(3):482–488

3	Sep 17	(KN)	Lecture #3: Dynamics of Genes in Populations
	Sep 19	(KN)	Paper #3: Morris et al., 2012
	Sep 21	(KN)	Quiz #3

Required reading:
- Gullberg et al 2011 Selection of Resistant Bacteria at Very Low Antibiotic Concentrations

Additional optional reading:
- Chapter 11, DNA Repair and Mutagenesis. In, Molecular Genetics of Bacteria, by Snyder and Champness (2007) American Society for Microbiology Press, Washington DC. 434-471
- Blazquez et al 2012. Antimicrobials as promoters of genetic variation. Current Opinion in Microbiology 15: 561-569

4	Sep 24	(KD)	Lecture #4: Rates of evolution
	Sep 26	(KD)	Paper #4: Tenalion et al., 2016
	Sep 28	(KD)	Quiz #4

Required reading:

- Ford et al 2013 *Mycobacterium tuberculosis* mutation rate estimates from different lineages predict substantial differences in the emergence of drug-resistant tuberculosis http://www.nature.com/ng/journal/v45/n7/full/ng.2656.html

Additional optional reading:

- Chapter 3, Bacterial Genetic Analysis: Fundamentals and Current Approaches. In, Molecular Genetics of Bacteria, by Snyder and Champness (2007) ASM Press, Washington DC. 125-182

5	Oct 1	(KN)	Lecture #5: Microbial Primary Production and Phototrophy
	Oct 3	(KN)	Paper #5: Beja et al., 2000
	Oct 5	(KN)	Quiz #5

Required reading:

- Beja, O. et al. (2000). Bacterial Rhodopsin: Evidence for a New Type of Phototrophy in the Sea. Science, 289(5486), 1902–1906. doi:10.1126/science.289.5486.1902

Additional optional reading:

- Chapter 4, Microbial primary production and phototrophy, and Chapter 10, Genomes and metagenomes of microbes and viruses. In, Processes in Microbial Ecology by David Kirchman (2012) 55-78, 177-194

6	Oct 9[a]	(KD)	Lecture #6: Degradation of Organic Material
	Oct 10	(KD)	Paper #6: Bernard et al., 2012
	Oct 12	(KD)	Quiz #6

[a] Monday class schedule to be followed on Tuesday due to Columbus Day holiday

Required reading:

- Bernard, L., L. Chapuis-Lardy, T. Razafimbelo, M. Razafindrakoto, A.-L. Pablo, E. Legname, J. Poulain, T. Bruls, M. O'donohue et al. 2012. Endogeic earthworms shape bacterial functional communities and affect organic matter mineralization in a tropical soil. ISME J. 6: 213-222

Additional optional reading:

- Chapter 5, Degradation of Organic Matter. In, Processes in Microbial Ecology by David Kirchman (2012) 79-98

7	Oct 15	(KD)	Lecture #7: Controls on Microbial Growth and Biomass
	Oct 17	(KD)	Paper #7: Kerr et al., 2002
	Oct 19	(KD)	Quiz #7

Required reading:

- Kerr, Benjamin, Margaret A. Riley, Marcus W. Feldman, Brendan JM Bohannan. "Local dispersal promotes biodiversity in a real-life game of rock–paper–scissors" Nature 418, (2002): 171-174

Additional optional reading:

- Chapter 6, Microbial growth, biomass production, and controls. In, Processes in Microbial Ecology by David Kirchman (2012) 99-116

8	Oct 22	(KN)	Lecture #8: Food webs, Predation and Protists
	Oct 24	(KN)	Paper #8: Kardol …
	Oct 26	(KN)	Quiz #8

Required reading:
- Choose one of the papers in this special SBB issue on food webs: http://www.sciencedirect.com/science/journal/00380717/102/supp/C

Additional optional reading:
- Chapter 7, Predation and Protists, and Chapter 8, Ecology of Viruses. In, Processes in Microbial Ecology by David Kirchman (2012) 117-155

9	Oct 29	(KD)	Lecture #9: Community Structure in Natl. Environments
	Oct 31	(KD)	Paper #9: Peay et al., 2007
	Nov 2	(KD)	Quiz #9

Required reading:
- Peay et al. 2007 Ecol Letters "A strong species–area relationship for eukaryotic soil microbes: island size matters for ectomycorrhizal fungi"

Additional optional reading:
- Chapter 9, Community structure of microbes in natural environments. In, Processes in Microbial Ecology by David Kirchman (2012) 157-176

10	Nov 5	(KN)	Lecture #10: Evolution and adaptive immunity
	Nov 7	(KN)	Paper #10: Childs et al., 2014
	Nov 9	(KN)	Quiz #10

Required reading:
- Childs LM, England WE, Young MJ, Weitz JS, Whitaker RJ (2014) CRISPR-Induced Distributed Immunity in Microbial Populations. PLoS ONE 9(7): e101710. doi:10.1371/journal.pone.0101710

Additional optional reading:
- Chapter 7, Bacteriophages: Lytic Development, Genetics, and Generalized Transduction. In, Molecular Genetics of Bacteria, by Snyder and Champness (2007) ASM Press, Washington DC. 270-323

11	Nov 14[b]	(KN)	Lecture #11: Group work
	Nov 16	(KN)	Paper #11: Abstract of your article
			Quiz #11

[b] No class on Monday Nov 12 due to Veterans' Day holiday

Required reading:
- The recent (or transformative) research article that will be the focus of your article.

Additional optional reading:
- At least one other article that relates to the main article, e.g., a corroboration, the same findings in a different system, a contradictory result, a similar question in some way.

12	Nov 19-23	Thanksgiving – NO CLASS THIS WEEK

13	Nov 26	(KN)	Lecture #12: The Pan-Genome
	Nov 28	(KN)	Paper #12: Tetteline et al., 2005
	Nov 30	(KN)	Quiz #12

Required reading:

- H. Tettelin, et al. (2005) Genome analysis of multiple pathogenic isolates of *Streptococcus agalactiae*: Implications for the microbial ,"pan-genome". Proceedings of the National Academy of Sciences. 102(39). 13950-13955

Additional optional reading:

- Chapter?
- Fullmer, Matthew S., Shannon Margaret Soucy, and Johann Peter Gogarten. "The pan-genome as a shared genomic resource: mutual cheating, cooperation and the black queen hypothesis." *Frontiers in microbiology* 6 (2015): 728.
- The Konstantinidis (?) and Tiedje (?) E. coli pan-genome paper Konstantinidis, K.T. and Tiedje, J.M., 2005. Genomic insights that advance the species definition for prokaryotes. *Proceedings of the National Academy of Sciences*, *102*(7), pp.2567-2572.

14	Dec 3	(KD)	Lecture #13: Experimental evolution and adaptation
	Dec 5	(KD)	Paper # 13: Lenski 2017
	Dec 7	(KD)	Quiz #13

Required reading:

- Richard E Lenski. (2017) Experimental evolution and the dynamics of adaptation and genome evolution in microbial populations. The ISME Journal. 11: 2181-2194

Additional optional reading:

- Chapter 13, Global Regulation: Regulons and Stimulons. In, Molecular Genetics of Bacteria, by Snyder and Champness (2007) ASM Press, Washington DC. 270-323
- Morris JJ, Lenski RE, Zinser ER. (2012) The Black Queen Hypothesis: evolution of dependencies through adaptive gene loss. mBio 3(2):e00036-12. doi:10.1128/ mBio.00036-12.
- Tenaillon, Olivier, Jeffrey E. Barrick, Noah Ribeck, Daniel E. Deatherage, et al. "Tempo and mode of genome evolution in a 50,000-generation experiment." *Nature* 536, no. 7615 (2016): 165

15	Dec 10	(guest)	Play Phyllo the game (https://phylogame.org/) ?
	Dec 12	(KN)	???

Required reading:

-

Additional optional reading:

- Chapter?
-

...