

# BIOM 415: Microbial Diversity, Ecology, and Evolution

## Spring 2017

When: Tuesday and Thursday 9:30-10:50 AM

Where: HS108

3 credits

Course prerequisites: BIOB 260, 272, BIOM 360-361, or by consent of instructors

### **Instructors:**

Matthew Church, Flathead Lake Biological Station, (406) 982-3301;

[matt.church@umontana.edu](mailto:matt.church@umontana.edu); Office hours on campus (HS 416A): Tuesday and Thursday 11:00-12:30 by appointment

William Holben, Health Sciences 503b, (406) 243-6365; [bill.holben@mso.umt.edu](mailto:bill.holben@mso.umt.edu); Office hours Tuesday and Thursday 3:00 – 4:30 or by appointment.

### **Course Overview:**

Microbial Diversity, Ecology, and Evolution (BIOM 415) is one of several required courses for undergraduate Microbiology majors in the Division of Biological Sciences at the University of Montana. The course meets twice each week (T/Th) from 9:30-10:50 AM in the Social Sciences classroom 254. The course covers fundamental concepts in microbial ecology and evolution, including emphasis on globally important processes mediated by microbial consortia. Although tiny, microorganisms are ubiquitous on Earth, collectively forming one of the largest pools of living biomass on the planet. Microbes include diverse members of all three domains of life (bacteria, archaea, and single-celled eukaryotes) as well as viruses. Although largely unseen, these organisms maintain the habitability of the planet. The study of microbial ecology has been revolutionized in recent years by the application of genomic and molecular-based technologies which are providing new insights into the diversity, evolution, and metabolic capabilities of these organisms. This course seeks to highlight the excitement and importance of contemporary research in microbial ecology. Material covered in lectures includes description of the biogeographical distributions of microorganisms; methodologies for quantifying microbial diversity, biomass, growth, and metabolism; major processes and bioelemental cycling mediated by microbes; environmental controls on the growth and mortality of microorganisms; and advances in microbiome research.

There is no required textbook for this course; however, instructors will assign reading from the primary literature. Students are expected to be familiar with material in these assigned readings. For background information and review of concepts, the following textbooks are recommended:

- Madigan et al. (2011) Brock Biology of Microorganisms, 13th ed. (Pearson)

- Atlas, R.M., and R. Bartha. 1998. *Microbial Ecology: Fundamentals and Applications*. 4th ed. (Addison-Wesley)
- Barton LL & Northup DE (2011) *Microbial Ecology* (Wiley-Blackwell).
- Kirchman DL (2008) *Microbial Ecology of the Oceans* (Wiley).
- Madsen EL (2008) *Environmental Microbiology - from genomes to biogeochemistry* (Blackwell).
- Rochelle PA (2001) *Environmental molecular microbiology: protocols and applications*.

### **Student Learning Outcomes:**

- 1) *Students should gain understanding of major concepts in microbial ecology, including processes controlling distributions of microbial biomass, rates of metabolism, and mechanisms regulating diversity.*
- 2) *Students should be able to define the major forms of microbial life and describe forms of microbial metabolism.*
- 3) *Students should know how microbial biomass, activity, and diversity are quantified, including knowledge of assumptions underlying measurements of these properties.*
- 4) *Students should be able to define major microbially-mediated processes catalyzing carbon and nitrogen cycling.*
- 5) *Students will understand contemporary techniques used to analyze microbial communities and community function.*

### **Grading:**

Grading for the course will be based on four criteria:

- 1) Regular attendance and participation (10%)
- 2) Performance on mid-term and final in-class exams (35% each)
- 3) Written summaries and questions for student-led paper discussions (20%)

### **Required Assignments:**

**Written summaries of papers and in-class discussions:** Each week there will be one paper assigned from the primary literature as required reading. Students are expected to have read these required papers prior to attending class that day. Each student is also required to submit a brief written summary of the paper that includes 2-3 questions related to the ideas, results, or methodologies described in the paper. We will spend time during the class period discussing these required papers and use the questions in these paper summaries as the basis for these classroom discussions. The written summaries should be ~1 page total and are due in class the day of the paper is assigned.

**“Ask your questions” sessions:** These class periods will be used to promote discussion among students and instructors, while also trying to answer questions related to

microbial ecology. Students are expected to come to class prepared with 2 written questions; we will randomly select from among these questions (questions will be anonymous) to guide in-class discussions.

**Exams:**

Mid-term Exam - March 9, 2017

Final Exam - May 9, 2017

**Remote Lectures:**

Approximately half of the lectures for the course will be conducted remotely, using PolyCom, Sykpe, or equivalent. Students are expected to attend all lectures and in-class discussions. The use of remote technology enables dialogue between students and instructors; however, every effort will be made to have face-to-face classroom lectures/discussions weekly.

**Absences:**

Students are expected to attend all classes and actively participate in discussions and ask questions. Unexcused absences will impact the grade you receive in the course.

**Disabilities:**

Any student who feels s/he may need an accommodation based on the impact of a disability is invited to contact the course instructors privately. The University of Montana assures equal access to instruction through collaboration between students with disabilities, instructors, and Disability Services for Students. If you have a disability that adversely affects your academic performance, and you have not already registered with Disability Services, please contact Disability Services in Lommasson Center 154 or 406.243.2243. The instructors will work with you and Disability Services to provide an appropriate modification.

**BIOM 415 Course Schedule (Jan. 24-May 4, 2017)****Classes meet 9:30-10:50 AM in SS254**

| Date                | Topic  | Lecturer | Required Reading   |
|---------------------|--|----------|--|
| Tuesday<br>Jan. 24  | Introduction to the course and the evolution of life on Earth                          | Church   |  |
| Thursday<br>Jan. 26 | Microbial energetics and nutrition   | Church   | <b>Paper summary due for:</b><br>Falkowski et al. (2008) The microbial engines that drive Earth's biogeochemical cycles. <i>Science</i> 320: 1034-1039                               |
| Tuesday<br>Jan. 31  | Metabolic diversity  | Church   |  |
| Thursday<br>Feb. 2  | The microbial tree of life   | Church   | <b>Paper summary due for:</b><br>Pace et al. (2012). Phylogeny and beyond: Scientific, historical, and conceptual significance of the first tree of life. <i>PNAS</i> 109: 1011-1018 |
| Tuesday<br>Feb. 7   | Methods of characterizing microbial communities – cultivation, PCR, probes, sequencing | Holben   |  |
| Thursday<br>Feb. 9  | Microbial genomics and metagenomics  | Holben   | <b>Paper summary due for:</b><br>Tyson et al. (2004). Community structure and metabolism through reconstruction of microbial genomes from the environment. <i>Nature</i> 428: 37-43  |
| Tuesday<br>Feb. 14  | Microbial interactions: Symbioses, allelopathy, syntrophy, quorum sensing              | Holben   |  |
| Thursday<br>Feb. 16 | Viral ecology  | Holben   | <b>Paper summary due for:</b><br>Raoult and Forterre (2008). Redefining viruses: lessons from Mimivirus. <i>Nature Reviews Microbiology</i> 6: 315-319   doi:10.1038/nrmicro1858     |
| Tuesday<br>Feb. 21  | Plant-microbe interactions   | Holben   |  |

|                             |  |        |   |
|-----------------------------|--|--------|---|
| Thursday<br>Feb. 23         | Animal-microbe interactions  | Holben | <b>Paper summary due for:</b><br>Dethlefsen et al. (2007) An ecological and evolutionary perspective on human–microbe mutualism and disease. <i>Nature</i> 449: 811-818   |
| Tuesday<br>Feb. 28          | Microbial ecology of freshwater ecosystems (lakes, streams, wetlands)                          | Holben |   |
| Thursday<br>Mar. 2          | Microbial ecology of terrestrial ecosystems (soil, forests, tundra)                            | Holben | <b>Paper summary due for:</b><br>Bier, Raven L., et al. "Linking microbial community structure and microbial processes: an empirical and conceptual overview." <i>FEMS microbiology ecology</i> 91.10 (2015): fiv113. |
| Tuesday<br>Mar. 7           | <a href="#">Ask your questions session</a>   | Holben | <a href="#">Each student comes prepared with 2 questions</a>  |
| Thursday<br>Mar. 9          | <b>MID-TERM EXAM</b>   | Holben |   |
| Tuesday<br>Mar. 14          | Measurements and distributions of microbial biomass  | Church |   |
| Thursday<br>Mar. 16         | Microbial growth and cellular activity   | Church | <b>Paper summary due for:</b><br>Whitman (1998). Prokaryotes: The unseen majority. <i>PNAS</i> 95: 6578–6583  |
| <b>Tuesday<br/>Mar. 21</b>  | <b>Spring Break</b>  |        |   |
| <b>Thursday<br/>Mar. 23</b> | <b>Spring Break</b>  |        |   |
| Tuesday<br>Mar. 28          | <b>Remote lecture:</b><br>Phototrophy and photosynthesis                                       | Church |   |
| Thursday<br>Mar. 30         | <b>In class lecture and group discussion:</b><br>Photosynthetic microbes and the cyanobacteria | Church | <b>Paper summary due for:</b><br>Biller et al. (2015). <i>Prochlorococcus</i> : The structure and function of collective diversity. <i>Nature Reviews Microbiology</i> 13: 13-27                                      |
| Tuesday<br>Apr. 4           | <b>Remote lecture:</b><br>Carbon cycling   | Church |   |

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| Thursday<br>Apr. 6  | <b>In class lecture and group discussion:</b><br>Nitrogen cycling   | Church | <b>Paper summary due for:</b>  |
| Tuesday<br>Apr. 11  | <b>Remote lecture:</b><br>Sulfur and metal cycling  | Church |  |
| Thursday<br>Apr. 13 | <b>In class lecture and group discussion:</b><br>Marine ecosystems (I)  | Church | <b>Paper summary due for:</b><br>DeLong (2009). The microbial ocean from genomes to biomes. <i>Nature</i> 459, doi:10.1038/nature08059   |
| Tuesday<br>Apr. 18  | <b>Remote lecture:</b><br>Marine ecosystems (II)  | Church |  |
| Thursday<br>Apr. 20 | <b>In class lecture and group discussion:</b><br>Extreme ecosystems (hot springs, deep subsurface, mine drainage) | Church | <b>Paper summary due for:</b><br>Edwards et al. (2012). The Deep, Dark Energy Biosphere: Intraterrestrial Life on Earth. <i>Ann Rev Earth Planet Sci.</i> 40: 551-568.                               |
| Tuesday<br>Apr. 25  | <b>Remote lecture:</b><br>Biofilms  | Church |  |
| Thursday<br>Apr. 27 | <b>In class lecture and group discussion:</b><br>Microbial ecology in the Anthropocene                            | Church | <b>Paper summary due for:</b><br>Lau and Lennon (2012). Rapid responses of soil microorganisms improve plant fitness in novel environments. <i>PNAS</i> 109:14058–14062. doi:10.1073/pnas.1202319109 |
| Tuesday<br>May. 2   | <b>Topic TBD</b>  | Church |  |
| Thursday<br>May 4   | <a href="#">Ask your questions session</a>  |        | <a href="#">Each student comes prepared with 2 questions</a>   |
| Tuesday<br>May 9    | <b>FINAL EXAM</b>   |        |  |