Spring 2-1-2019

BIOM 415.01: Microbial Diversity Ecology & Evolution

Matthew Church
University of Montana, Missoula, matt.church@umontana.edu

BIOM 415: Microbial Diversity, Ecology, and Evolution
Spring 2019

When: Tuesday and Thursday 9:30-10:50 AM
Where: Liberal Arts (LA) Classroom 103B
3 credits
Course prerequisites: BIOB 260, 272, BIOM 360-361, or by consent of instructors

Instructor:

Matthew Church, Flathead Lake Biological Station, (406) 982-3301; matt.church@umontana.edu; Office hours by appointment on campus (HS 416A), Tuesday 11:00-14:00

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 Chemistry classroom 102. 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. The collective metabolisms of these organisms play major roles in planetary habitability.

The study of microbial ecology has been revolutionized in recent years by advances in technology, notably including genomic methodologies 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)

- Kirchman DL (2008) Microbial Ecology of the Oceans (Wiley).
- Madsen EL (2008) Environmental Microbiology - from genomes to biogeochemistry (Blackwell).

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 (5%)
2) Performance on mid-term and final in-class exams (35% each)
3) Participation in student-led paper discussions (5%)
4) Quality of oral and written presentation of literature review summarizing microbially-relevant research (20%)

Required Assignments:

In-class paper discussions: Every week there will be one paper assigned from the primary literature as required reading. Students are expected to have read the required paper prior to attending class that day. Students should come to class with 2-3 questions suitable for the in-class discussion. We will spend time during the class period discussing these papers and will use these questions as the basis for these classroom discussions.
Exam Review Sessions: These class periods will be used to promote discussion among students and the instructor, while also trying to answer questions related to course material. These sessions will occur in the classes immediately prior to the mid-term and final exams, providing opportunity to use these sessions to review any questions or clarify concepts or topics that may appear on the exams.
Literature Review Student Presentations and Papers: Near the end of the semester (**April 18 and April 23**), each student will present a 10-minute summary of a literature-based survey on a topic relevant to course material (i.e. related to microbial ecology,

diversity, and/or evolution). My hope is that you will identify a topic of interest, perhaps one deriving from a lecture or in-class paper discussion, and want to investigate further. You will need to search the primary literature, read a few papers, and put together a brief presentation summarizing the topic (why it is important, what advances have been made, what remains to be known). In addition, each student will submit a 4-page paper summarizing your findings from this literature review. These papers should include: 1) An introduction of the research topic that provides the motivation for why you wanted to investigate the topic and its importance. In addition, provide an explanation of how the papers you read contribute to the research topic - what are the take-home points from the papers. 2) A description of the approaches the authors took – what experimental design and methods were used (summarized, not detailed!) – and do you think they were appropriate? Are there other methods you think might have been useful or better? 3) Discussion of findings, including major results and brief discussion of why the results are important and what information they provide to help better understand the topic. 4) Present the next experiment or analysis that you think should be performed (your original idea) to follow the papers. These papers should include citation of sources and a complete bibliography
Prior to Spring Break, each student will need to discuss the selected topic with the instructor.

Presentations will be graded using the following metrics:

Excellent	**Satisfactory**	**Needs improvement**
Engaging eye contact, proper enunciation of words, ingenuitive features (such as interactive elements and/or visual imagery). Topic has a clear focus and contains at least two scholarly sources. Finishes precisely on time.	Decent eye contact, most words are properly enunciated. Has basic requirements of a visual presentation. Topic is rather clear, and contains one scholarly source. Stays within reasonable time limit.	Lacking eye contact, many words were not properly enunciated. Presentation lacks visual flair, and may have errors. Topic is not clear, and contains no scholarly sources. Presentation time was either too long or too short.

Papers will be graded using the following metrics:

Excellent	**Satisfactory**	**Needs improvement**
Well-written, introduction clearly motivates the rationale for selection of the topic, excellent use of references to support statements, concise summary of what is currently known about the topic, succinct summary of methodologies used to investigate the topic.	Well-written; topic is clearly introduced, including good use of references to support statements; clear summary of methodologies and results.	Not clearly written; poor use of references to support statements; inaccurate or too brief summary of methodologies; no clear motivation for investigating the topic.

Exams:

- Mid-term Exam – February 28, 2019
- Final Exam – April 30, 2019

Remote Lectures:

Lectures for the course may need to be conducted remotely, using PolyCom, Sykpe, Zoom, or some equivalent system. 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.

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 instructor 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. 10-April 30, 2019)
Classes meet 9:30-10:50 AM in LA103B

Date	Topic	Required Reading
Thursday Jan. 10	**Lecture 1:** Introduction to BIOM 415: Microbial Ecology, Diversity, and Evolution	
Tuesday Jan. 15	**Lecture 2:** The evolution of life on Earth and the role of microorganisms and bioenergetics	
Thursday Jan. 17	**Lecture 3 and paper discussion:** Microbial energetics and metabolism	**Paper discussion:** Judson (2017): The energy expansions of evolution. *Nature Ecology and Evolution* 1: 1-9
Tuesday Jan. 22	**Lecture 4:** The microbial tree of life	
Thursday Jan. 24	**Lecture 5 and paper discussion:** Mechanisms of microbial evolution	**Paper discussion:** Doolittle (2000): Uprooting the tree of life. *Scientific American*, 90-95.
Tuesday Jan. 29	**Lecture 6:** Methods of characterizing microbial communities: Cultivation & PCR (part 1)	
Thursday Jan. 31	**Lecture 7 and paper discussion:** Methods of characterizing microbial communities: Genomics & metagenomics (part 2)	**Paper Discussion:** Handelsman (2004) Metagenomics: Application of Genomics to Uncultured Microorganisms. *Microbiology and Molecular Biology Reviews*, 68: 669–685
Tuesday Feb. 5	**Lecture 8:** Cellular growth and metabolism	
Thursday Feb. 7	**Lecture 9 and paper discussion:** Microbial phototrophy	**Paper discussion:** Delong and Beja (2010). The light-driven proton pump proteorhodopsin enhances bacterial survival during tough times. *PLoS Biol.* 8: e1000359.
Tuesday Feb. 12	**Lecture 10:** Photosynthetic microbes and the cyanobacteria	
Thursday Feb. 14	**Lecture 11:** Definitions and measurements of primary production	**Paper Discussion:** Biller et al. (2015). *Prochlorococcus*: The structure and function of collective diversity. *Nature Reviews Microbiology* 13: 13-27

Tuesday Feb. 19	**Lecture 12:** Measurements and distributions of microbial biomass	
Thursday Feb. 21	**Lecture 13:** Viral ecology	**Paper Discussion:** Li et al. (2005). Bats Are Natural Reservoirs of SARS-Like Coronaviruses. *Science*, 301: 676-679.
Tuesday Feb. 26	Exam Review	
Thursday Feb. 28	MID-TERM EXAM	
Tuesday Mar. 5	**Lecture 14:** Nitrogen cycling	
Thursday Mar. 7	**Lecture 15 and paper discussion:** Phosphorus and sulfur cycling	**Paper discussion:** Kuypers et al. (2018). The microbial nitrogen-cycling network. *Nature Reviews Microbiology*, 16: 263-276.
Tuesday Mar. 12	**Lecture 16:** Methanogensis and methanotrophy	
Thursday Mar. 14	**Lecture 17 and paper discussion:** Microbial ecology of terrestrial ecosystems (soil, forests, tundra)	**Paper Discussion:** Delgado-Baquerizo et al. (2017) A global atlas of the dominant bacteria found in soil. *Science*, 359: 320-325.
Tuesday Mar. 19	**Lecture 18:** Microbial ecology of aquatic ecosystems	
Thursday Mar. 21	**Lecture 19 and paper discussion:** Marine ecosystems	**Paper discussion:** Sunagawa et al. (2015). Structure and function of the global ocean microbiome. *Science*, 348: 1261359.
Tuesday Mar. 26	**Spring Break**	
Thursday Mar. 28	**Spring Break**	
Tuesday Apr. 2	**Lecture 20:** Extreme ecosystems (hot springs, deep subsurface, mine drainage)	
Thursday Apr. 4	**Lecture 21**: Microbial interactions: Symbioses, allelopathy, syntrophy, quorum sensing	**Paper Discussion:** McFall-Ngai et al. (2013). Animals in a bacterial world, a new imperative for the life sciences. PNAS 110: 3229–3236.
Tuesday Apr. 9	**Lecture 22:** The human microbiome (part I)	

Thursday Apr. 11	**Lecture 23:** The human microbiome (part II)	**Paper discussion:** Dominguez-Bello et al. (2010). Delivery mode shapes the acquisition and structure of the initial microbiota across multiple body habitats in newborns. *Proceedings of the National Academy of Sciences*, USA, 107: 11971–11975
Tuesday Apr. 16	**Lecture 24:** TBD (likely to be used to catch up)	
Thursday Apr. 18	Student presentations (6)	
Tuesday Apr. 23	Student Presentations (5)	
Thursday Apr. 25	Exam Review	
Tuesday Apr. 30	FINAL EXAM 08:00-10:00 AM	