Spring 2-1-2022

BIOM 415.01: Microbial Diversity Ecology & Evolution

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BIOM 415: Microbial Diversity, Ecology, and Evolution
Spring 2022

When: Wednesday 11:00 am - 1:50 PM
Where: Liberal Arts 337
Zoom (if needed):
https://umontana.zoom.us/j/96219037018?pwd=SUtacnhMMDEwODFDVS9Ea0JkSDFDQT09
3 credits
Course prerequisites: BIOB 260, 272, BIOM 360-361, or by consent of instructor

Instructor:

Matthew Church, Flathead Lake Biological Station, (406) 872-4506;
matt.church@umontana.edu; Office hours by appointment - contact the instructor to set up a time to meet.

Health and Safety:
We will meet in person for this class. Mask use is required within the classroom.
In the event that the spread of COVID leads to disruption of UM activities it may be necessary for us to switch to remote classes. If this becomes necessary, I will communicate with you with additional information, but you should assume we will continue to meet each week on Zoom. This will require that all of you have access to a computer (with a microphone and audio capabilities), the internet, and Zoom. By now I'm sure all of you are well equipped for this situation should we need to move to remote classes. If you are required to isolate or quarantine, you will receive support in the class to ensure continued academic progress - I will record lectures and post the recordings to the class Moodle site; in addition, all class activities (papers and problem sets) will be posted to Moodle.

- If you feel sick and/or are exhibiting COVID symptoms, please don't come to class and contact the Curry Health Center at (406) 243-4330.

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 once each week (Wed) from 11:00AM -1:50PM. The course covers fundamental concepts in microbial ecology and evolution, including emphasis on globally important biogeochemical processes mediated by microbial consortia. This course highlights the excitement and importance of contemporary research in microbial ecology.

Although tiny, microorganisms are ubiquitous on Earth, collectively forming some of the largest pools of living biomass on the planet. 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 a suite of genomic approaches, which are providing new insights into the diversity, evolution, and metabolic capabilities of these organisms. Material covered during this class includes description of 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, each week there will be assigned reading from the primary literature. Students will need to read material prior to class, participate in class-wide discussion about the reading, and submit in writing answers to a few brief questions specific to each paper.

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 learn 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 five criteria:
1) Regular participation in required reading assignments and discussions; submission of written "2-minute papers" in class (10%)

2) Participation and presentation of in-class problem sets (5%)
3) Performance on 2 in-class exams (20% each)
4) Quality of 5-minute microtalk and presentation (15%)
5) Quality of 2-page written proposal on disease ecology or evolution (15%)
7) Participation *in* and quality *of* group-led oral presentations on an adopted microorganism (15%)

Required Reading Assignments and "2 Minute Papers":

Each week we will read and discuss a paper from the primary literature with a focus on critically evaluating published, peer-reviewed work. This will require that each student spend time outside of class reading the assigned papers, including carefully studying the figures and tables, and identifying the major questions or hypotheses motivating the work. Our job in reading and discussing these papers is to: 1) Focus on understanding both *why* and *how* each part of the study was done, 2) Examine the hypotheses underlying each aspect of the study, and 3) Analyze/discuss the data represented in each figure and table. We will spend time (typically ~40 minutes) during the class period discussing the papers, with an emphasis on the following questions:

1) What do the author(s) want to know (motivation)?
2) What did they do (approach/methods)?
3) Why was it done that way (context within the field)?
4) What do the results show (figures and data tables)?
5) How did the author(s) interpret the results (interpretation/discussion)?
6) What should be done next? (Regarding this last question, the author(s) may provide some suggestions in the discussion, but the key is to ask yourself what you think should come next.)

At some point during most classes, I will ask you to write a "2 minute paper" that will be submitted at the end of class. For these 2 minute papers I will ask you to answer a couple of specific questions, often related to the paper we read for that week. You will be given 2 minutes to write the paper. These written responses will be submitted before the end of class and you will earn points for submitting the papers (I will not grade them). You are allowed to not submit 2 of these papers over the semester (in the event that you are sick or absent for example) with no consequence to the total points earned for these assignments.

In-class problem sets

On several occasions throughout the semester I will distribute short problem sets (typically 2-3 questions) for students to work on during class. You can work on these problems in groups or individually. I will be available to assist with questions that arise as you work through these problem sets. These activities are intended to provide examples of how concepts or methods discussed during lectures might be applied.

Some problem sets will require plotting data, so please make sure you have a computer and software capable of graphing data (e.g., Excel). Students will be given approximately 20 minutes to work on these problems and then we will reconvene as a group and students will present answers to each question. You do not need to submit answers to these problem sets.

Individual and Group Projects:

5 minute microtalks and microtalk sessions: On **Wednesday Feb 23** (no later than 5PM) each student will submit a 5-minute "microtalk" video summarizing a topic of their choosing specific to microbial ecology. These videos will be uploaded to Moodle so everyone can view. Then over the course of 2 weeks, beginning Mar 2, we will devote ~60 minutes in each class for students to be available to answer questions about their microtalks. Microtalk topics will need to be selected early in the semester and these topics will need to be approved before Feb 16 by the instructor. Topics should be specific to microbial ecology, including topics related to microbial diversity, evolution, physiology, or any topic we cover in class that you find interesting and want to learn more about. The focus must be on microorganisms - you are welcome to explore topics on human-microbe interactions, but the focus should be on the microbes, not human health. We will have two sessions: **Mar 2 and Mar 9** where students will be available to answer questions about their topics. These sessions are intended to allow discussion and to ask each other questions about the topic and material covered in the microtalks. Each student will be given a 10-minute block of time – for these sessions, when it's your turn to present you should come prepared to present 1-2 slides (2-3 minutes max) summarizing the main elements of your topic. The remaining time will be available for discussion and to answer questions.

The recorded microtalks should consist of no more than 5 slides and each microtalk should include the following elements:

1. Title
2. Introduction to the topic of the poster: Motivate why this topic was of interest to you
3. Research question(s): What question did you ask and then investigate
4. Describe methodological approaches used for addressing this question
5. Findings: What did you learn about this topic
6. Conclusions and future directions: Summarize the major conclusions you're your research. What questions did your research leave you wanting to know more about?

You will need to submit a 5-minute video which will be posted to Moodle (or maybe Box) for everyone in class to view. Thus, microtalks should include slides (powerpoint or equivalent) in addition to you describing to viewers the material. Everyone is required to watch these short videos prior to attending the in-class presentations so that

we are all familiar with the topics and can formulate questions for the in-class presentations. There are many ways to record short videos, including using your phone, recording via Zoom, or a program like ScreenCastify (available via Chrome). All videos are due to the instructor on **Feb 23** for posting.

Written Proposal: Each student will submit a 2-page (double spaced, excluding references, figures, tables) written proposal describing a research project specific to disease ecology or evolution. **Proposals are due by 5PM on Wednesday Apr 6**. The proposal should include the following required proposal elements: 1) Title, 2) a 4-5 sentence Abstract with a concise summary of the proposed work, 3) Background information introducing the topic, 4) Research question(s), 5) Hypothesis to be tested, 6) Description of the experimental design and specific methods you will use to test the hypothesis, and 7) Timeline for completing project milestones. The proposal can be on any topic for your choosing that focuses on the ecology or evolution of diseases. You are not limited to human pathogens.

Some ideas of possible proposal topics:

1. What is the role of parasites in generating and maintaining host species diversity?
2. In what ecological settings are parasites key regulators of population dynamics?
3. How does the host microbiome influence infection and pathogenicity?
4. How is climate change (e.g., warming temperatures, increased/decreased moisture, etc.) influencing the distribution and/or transmission of diseases?

Proposals will be graded using the following metrics:

Excellent	**Satisfactory**	**Needs improvement**
Well-written, all required proposal elements are included, 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, clearly articulated question and hypothesis, succinct summary of methodologies used to investigate the topic, timeline is realistic.	Well-written, most required proposal elements are included, topic is clearly introduced, good use of references to support statements, clear summary of methodologies.	Not clearly written, missing required proposal elements, no clear motivation for investigating the topic, poor use of references to support statements, inaccurate or too brief summary of methodologies, unrealistic timeline.

Adopt a microorganism Group Project: You will be assigned to breakout groups (3-4 students per group) and each group will be assigned a microorganism that you adopt. Your job is to learn as much about the microorganism as you can, focused specifically on its ecology and evolution. During the semester you will be given opportunities to

work together as a group to learn about your adopted microbe. At the end of the semester (Apr 27 and May 4), each group will give a presentation to the class about their microbe. The following information should be included in that presentation:

1. Taxonomically and morphologically classify the microorganism
2. Characterize the metabolism of the microorganism
3. Describe where this microorganism is found and its optimal growth conditions
4. What are some of the defining characteristics contained within the genome of this microorganism?
5. What microorganisms is it most closely related too?
6. How does this microorganism interact with and modify its environment?
7. What are some of the major areas of research into this microorganism?

The total time for each presentation should be 25 minutes, with 5 minutes after for questions (30 minutes total).

The group presentations can be in many different forms; for example, a mix of a video that you and your group record, together with presentation of more traditional Powerpoint slides, and maybe something more creative (an animation, a poem, a song, drawing/painting, etc.). **Be creative!** The important thing is to communicate key findings about your microorganism in a way that is informative and educational. Presentations will be evaluated based on the following metrics:

Excellent	**Satisfactory**	**Needs improvement**
Engaging, clear, and creative features (e.g., interactive elements and/or visual imagery). All of the 7 required elements (see above) are included and described. Sources used to gather information are cited. Finishes precisely on time.	Mostly clear and engaging. Includes basic visual presentation (e.g., Powerpoint slides). Describes the 7 required elements but some are not clear or lacking. Stays mostly within the time limit.	Lacks clarity and little effort to make the presentation engaging. Presentation does not cover the 7 required elements. Presentation lacks visual flair, and may have errors. No sources of information are cited. Presentation time was either too long or too short.

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 two exams, providing opportunity to use these sessions to review any questions or clarify concepts or topics that may appear on the exams.

Exams:

- Exam #1: Wednesday March 16, 2022 from 11:00-1:00PM
- Exam #2: Wednesday May 13, 2022 from 10:10-12:10

Absences:

Students are expected to attend all classes and actively participate in discussions and ask questions. If you need to miss class, you should contact the instructor to find out what you will miss.

Accessibility Statement:

The University of Montana assures equal access to instruction through collaboration between students with disabilities, instructors, and the Office for Disability Equity (ODE). If you anticipate or experience barriers based on disability, please contact the ODE at: (406) 243-2243, ode@umontana.edu, or visit www.umt.edu/disabilityfor more information. Retroactive accommodation requests will not be honored, so please, do not delay. As your instructor, I will work with you and the ODE to implement an effective accommodation, and you are welcome to contact me privately if you wish.

BIOM 415 Course Schedule (Jan. 19-May 4, 2022)
Class meets 11:00AM-1:50 PM

Date	Activities and topics	Required reading for in class discussions and written summaries	Assignments due
Wed Jan. 19	A) Lecture: Introduction, microbial bioenergetics B) In-class problem set		GalleryWalk for Dayton water
Wed Jan. 26	A) Lecture: Microbial tree of life, mechanisms of microbial evolution B) Paper discussion C) In class problem set	**Paper discussion:** Lenski, R.E. 2017. Experimental evolution and the dynamics of adaptation and genome evolution in microbial populations. *The ISME Journal* 11: 2181–2194	2 minute paper
Wed Feb. 2	A) Lecture: Measurements and distributions of microbial biomass B) Paper discussion C) In class problem set	**Paper Discussion:** Bar-On, Y.M., Phillips, R., Milo, R. 2018. The biomass distribution on Earth. *PNAS USA* 115: 6506-6511; doi: 10.1073/pnas.1711842115	2 minute paper
Wed Feb. 9	A) Lecture: Phototrophy B) Paper discussion C) 5 min microtalk discussion	**Paper Discussion:** Gómez-Consarnau et al. (2007). Light stimulates growth of proteorhodopsin-containing marine Flavobacteria. *Nature* 445: 210–213.	2 minute paper
Wed Feb. 16	A) Lecture: Chemotrophy B) Paper discussion C) In class problem set	**Paper Discussion:** Ji et al. (2017). Atmospheric trace gases support primary production in Antarctic desert surface soil. *Nature* 552: 400-403.	2 minute paper
Wed Feb. 23	A. Lecture: Tools for characterizing microbial communities B. Paper discussion C) In class problem set	**Paper Discussion:** Hug et al. 2016. A new view of the tree of life. *Nature Microbiology*. doi: 10.1038/NMICROBIOL.2016.48	5-minute microtalks due 2 minute paper
Wed Mar. 2	A) Lecture: Primary production and respiration B) Paper discussion C) Microtalk presentation session	**Paper discussion:** Bernhardt et al. (2018). The metabolic regimes of flowing waters. *Limnology and Oceanography* 63, 2018, S99–S118.	Microtalk session #1 2 minute paper
Wed Mar. 9	A) Exam Review B) Paper discussion C) Microtalk presentation session	**Paper Discussion:** Biller et al. (2014). Bacterial vesicles in marine ecosystems. *Science,* 343, 183-186. doi:10.1126/science.1243457	Microtalk session #2 2 minute paper

Wed Mar. 16	A) Exam #1 B) In class problem set		
Wed Mar. 23	SPRING BREAK	SPRING BREAK	SPRING BREAK
Wed Mar. 30	A) Lecture: The microbial nitrogen cycle B) Paper discussion C) Time to work on proposal	**Paper Discussion:** Schindler et al. (2008). Eutrophication of lakes cannot be controlled by reducing nitrogen input: Results of a 37-year whole-ecosystem experiment. *PNAS USA* 105: 11254–11258	2 minute paper
Wed Apr. 6	A) Lecture: Microbial carbon cycling B) Adopt a microbe breakout groups		2-page proposal on disease ecology due
Wed Apr. 13	A) Lecture: Microbiome research B) Paper discussion C) Adopt a microbe breakout groups	**Paper Discussion:** Dominguez-Bello et al. (2010). Delivery mode shapes the acquisition and structure of the initial microbiota across multiple body habitats in newborns. *PNAS USA*, 107: 11971–11975	2 minute paper
Wed Apr. 20	A) Lecture: Microbial interactions: Symbioses and mutual metabolisms B) Paper discussion C) Adopt a microbe breakout groups	**Paper Discussion:** Husnik, P., McCutcheon, J.P. 2017. Functional horizontal gene transfer from bacteria to eukaryotes. *Nature Reviews Microbiology*. doi:10.1038/nrmicro.2017.137	2 minute paper
Wed Apr. 27	A) Lecture: Microbial oceanography B) Adopt a microbe group presentations		"Adopt a microbe" group project presentations
Wed May 4	A) Exam Review B) Adopt a microbe group presentations		"Adopt a microbe" group project presentations
Friday May 13 10:10-12:10	**Exam #2**		