Microbiology 8161: *Microbiome informatics*

Conceptual Instructor: Prof. Matthew B. Sullivan, sullivan.948@osu.edu, 914 Riffe Bldg.

Practical instructors: Dr. Ahmed Zayed, Zayed.10@osu.edu / Dr. Ben Bolduc, bolduc.10@osu.edu, 932 Riffe Bldg. / Dr. Mike Sovic, sovic.1@osu.edu / Dr. Dean Vik, vik.1@osu.edu

Teaching assistants: Dr. Marion Urvoy, urvoy.1@osu.ed / Dr. Ricardo Pavan, pavan.4@osu.edu

[Please **email us through Carmen**. Office hours are by emailed appointment.]

Lecture time and location: T 9:55-10:50, R 9:55-11:40, BioSci 684. 3 cr. hours, lecture-based.

Rationale: There are more microbial cells in our bodies than human cells, and the 'human microbiome' is now credited with impacting food cravings and digestion, our behavior, and our susceptibility to disease. Microbes were once thought to be insignificant in the Earth System, but with the advent of molecular biological techniques it is now recognized that microbes are major players across diverse ecosystems including soils, the oceans, and extreme environments. Low-cost sequencing and computational advances have flooded the life sciences with new windows into the life and impacts of these hidden movers and shakers. Students in this course will leverage an archived international 'Microbiome Informatics Webinar Series' for hands-on practical guidance that will be applied through a semester-long team research project, that will introduce the student to modern approaches for interpreting sequence datasets to improve understanding of microbes and their viruses in complex communities.

Course learning objectives: This course seeks to inspire creativity and innovation for answering fundamental microbiological questions using sequence data. Specific learning objectives include the following:

1. Gain exposure to approaches for studying the function, structure and evolutionary history of genes observed in sequence datasets.
2. Learn approaches for organizing sequence datasets into organismal units using marker genes (e.g., 16S) and shotgun metagenomics data.
3. Learn ecological statistical approaches to discern community structure and ecological drivers from large-scale metagenomic datasets.
4. Introduction to other sequence-based datasets including viral metagenomes, as well as metatranscriptomics, metaproteomics, metabolomics, etc.
5. Design, implement and interpret an informatics group project to further biological understanding of microbes.

We feel strongly that your education must be facilitated by **you**, through readings, pre-class materials, solo and group activities, and classroom engagement. During this class, we will focus on critical analyses skills, engaging other scientists (from different backgrounds), and expressing ideas purposefully on paper and verbally. At the end of this course students will be able to evaluate environmental microbiology literature and understand the inherent assumptions and limitations. It is our hope that this class fosters teamwork, leads to investment in the material, and encourages you to think a bit differently than you did previously about the microbial world in, on and around you.

Pre-requisite: None, a student can enter the course as a beginner, intermediate or advanced microbiome scientist / analyst.

Text: No text is required as 'Microbiome Informatics' tools change far too quickly for textbooks to keep pace, and ample resources are available on the web. Students with no background in studying microbial communities may choose to take M5155 (*Environmental Microbiology,* for broad conceptual introduction) or M6155 (Topics in Microbiome Science, for more detailed graduate-level microbiome science conceptual understanding). Students with no informatics background may choose to take M5161 (Bioinformatics and Molecular Microbiology). Students will also benefit from basic knowledge of using the Ohio Supercomputer (OSC) and working at the command line, experience with R, and engagement in the Center of Microbiome Science Working Group training or Data Sciences Club or independent self-training. Several resources that are fundamental to the course will be basic knowledge of the high-performance computing environment, so students should come to this course having reviewed training materials for UNIX/Linux (see online tutorials available at XSEDE, which may require free xsede portal account set up, see here more specifically here) and the OSC (see here for how to get started and review batch limit rules of owens and pitzer for how to request resources you need correctly). Additionally, many analyses will be most easily performed and/or visualized using R, which this video and this document are good for learning some basics of R. For more advanced R tutorials, see Code Club's tidyverse microbiome-related tutorials.

Semester-long project: The bulk of the course will be devoted to helping students choose and then pursue a project focus for a semester-long research experience where ***the goal is to produce, as a team, a genome-resolved microbiome science manuscript for submission to a peer-reviewed journal***. Guided by the archived hands-on Microbiome Informatics Webinar Series (available here), students will progress through the microbiome informatics analyses needed to analyze a metagenomic dataset using genome-resolved approaches to understand what microbes are there, what metabolisms they are capable of, and how they may interact (or a virus parallel story if viruses are the focus). Weekly assignments will vary, and will be graded individually through the term with an emphasis on helping students understand how to interpret microbiome science data. Example weekly assignments include 1) produce a figure + write the methods; 2) write results and literature context for a figure; 3) present your figure, methods, and interpretations. On the latter, student presentations will broaden the class exposure to project related microbiome science, while also helping students improve presentation skills and earn 'participation' and 'engagement' points towards their grade. Projects will be conducted as a group with the goal of developing the analyses and figures that one would publish in a peer-reviewed scientific paper. The course final will consist of each individual writing up their part of the peer-reviewed paper including background to motivate their analyses, methods and results, and discussion to contextualize their findings. In general, grades will be based upon a clear statement of your goal, the analyses presented (how you did them and the presentation of results), interpretation of the analyses (including literature context for the final), planned next steps, as well as the quality of the writing/presentation (though specific rubrics are below). All weekly assignments are due Monday @ midnight each

week, and the course final paper is due during the designated "final exam" slot for the course, except where re-assigned via Carmen by the instructors.

Grading: The final grade will be determined from the following spread of points, with grades assigned as an A = >90%, B = 80-89.9%, C = 70-79.9%, D = 60-69.9%, and E = <60%.

40% - Weekly assignments are varied and will be assigned in class, but will focus on applying analytical methods to your project dataset(s) and using online tools to make discoveries about microbial communities. The 'outputs' for these latter items will vary as described above. ***Assessment of 'research' homeworks*** will look for a clear statement of your goal, the analyses presented (how you did them and the presentation of results), interpretation of the analyses (including literature context for the final), planned next steps, as well as the quality of the writing. None of these should be more than one page of text total (figures can be additional).

40% - Class participation, presentations and engagement will be evaluated by all instructors (rubric in following table). Because this science is moving so quickly, this course will encourage you to ask a lot more questions – are the methods being suggested to be used to study something the most efficient way to do something? Are the inferences being made even appropriate, or have fundamental assumptions been made that are wrong? You will want to constantly be thinking about whether an approach is the best way forward or not, oftentimes in Microbiome Informatics there are better ways! Student will present multiple times through the semester. ***Assessment of presentations will be made upon*** the effectiveness of the presentation as assessed for relevant establishment of a key question, motivation and background to study that question, and proposed means to study the question and/or inferences made from the attempt to study it. Finally, student engagement in the class will vary depending upon your background and training goals in the course with engagement acceptable across all aspects of the training, or more specialized either as **'thinkers'** whom will steer the ship and identify the big questions to be explored, or **'doers'** whom will write pseudocode or code to provide a roadmap to or directly analyze new datasets, respectively.

Participation Rubric

	A	B	C/D	F
Preparation	Arrives on time fully prepared at every class session	Arrives mostly, if not fully, prepared (ongoing)	Inconsistent preparation	Rarely or never prepared
Participation	Plays an active role in discussions (ongoing)	Participates constructively in discussions (ongoing)	When prepared, participates constructively in discussions	Comments vague if given; frequently demonstrates lack of interest
Contribution to Class	Comments advance level and depth of dialogue (consistently)	Makes relevant comments based on assigned material (ongoing)	When prepared, relevant comments are based on assignments	Demonstrates a noticeable lack of interest

Courtesy of Jesse Kwiek; Adapted from The Teaching Professor, March 2005.

YOU WILL POSITIVELY AFFECT YOUR PARTICIPATION GRADE BY:

1. Becoming more active and/or making more effective comments that raise overall level of discussion.
2. Asking thoughtful questions that will enhance discussion and engage peers.

3. Listening carefully to, supporting, and engaging your peers in discussion.

YOU WILL NEGATIVELY AFFECT YOUR PARTICIPATION GRADE BY:

1. Not attending class (unexcused), or **arriving to class late**.
2. Using electronic devices (*e.g.* cell phone, iPad, computer, etc.) for personal, non-class related reasons.
3. Dominating class discussions, thereby restricting others' participation.
4. Making offensive, and/or disrespectful comments during discussions.

20% - a final paper will be your opportunity to step back and synthesize what you have contributed to the overall group research paper as described above. ***Assessment of the final paper*** will look for a clear statement of your goal, the analyses presented (how you did them and the presentation of results), interpretation of the analyses (including literature context for the final), planned next steps, as well as the quality of the writing.

Lecture Schedule:

Class #	Lead	Topic
Aug 22/24	MS/BB/SD	Intro to the course and OSC primer / Intro to UNIX
Aug29/ 31	BB/MS	OSC & HPC/Review M5161 (Structure/functional annotation, MSA, Phylogeny, DBs)
Sep 5/7	MS/MSov	Genome-resolved metaG, project options / Intro to R for microbiome science #1
Sep 12/14	MSov/MS	Intro to R #2, #3 / genome-resolved metaG workflow (QC, assembly, MAGs, viruses)
Sep 19/21	DV	Ecological stats primer and hands-on applications
Sep 26/28	MS	Select projects and transition to project phase of the course
Oct 3/5	MS	In class troubleshoot project work (MAGs, DRAM)
Oct 10	MS	Project report-outs
Oct 13	--	Autumn break, no class
Oct 17/19	MS/SD+BB	In class troubleshoot project work (GTDB if microbes or virusID+tax if viruses)
Oct 24/26	MS	Project report-outs
Oct31/Nov2	MS	Literature context, what are the low-hanging fruit analyses to do?
Nov 7/9	MS/SD+BB	In class troubleshoot project work (varied depending upon needs)
Nov 14/16	MS	Project report-outs
Nov 21	MS/SD+BB	In class troubleshoot project work (varied depending upon needs)
Nov28/30	--	Project presentations
Dec 5	--	Project presentations
Finals week	--	Final paper due

Academic integrity: It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term "academic misconduct" includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487). For additional information, see the Code of Student Conduct http://studentaffairs.osu.edu/csc/.

Title IX makes it clear that violence and harassment based on sex and gender are Civil Rights offenses subject to the same kinds of accountability and the same kinds of support applied to

offenses against other protected categories (e.g., race). If you or someone you know has been sexually harassed or assaulted, you may find the appropriate resources at http://titleix.osu.edu or by contacting the Ohio State Title IX Coordinator, Kellie Brennan, at titleix@osu.edu.

Disability Services: The University strives to make all learning experiences as accessible as possible. If you anticipate or experience academic barriers based on your disability (including mental health, chronic or temporary medical conditions), please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. SLDS contact information: slds@osu.edu; 614-292-3307; slds.osu.edu; 098 Baker Hall, 113 W. 12th Avenue.

Communication: All emailed communications should go through Carmen. Students are responsible for announcements made in class, available on the course's Carmen site, or sent by e-mail. Late assignments will not be accepted without prearrangement with TA or instructor. Assignment due dates will be explicitly noted and followed, including turned in at the start of class or via Canvas at an assigned time.

Diversity, Equity and Inclusion: The Ohio State University affirms the importance and value of diversity in the student body. Our programs and curricula reflect our multicultural society and global economy and seek to provide opportunities for students to learn more about persons who are different from them. We are committed to maintaining a community that recognizes and values the inherent worth and dignity of every person; fosters sensitivity, understanding, and mutual respect among each member of our community; and encourages each individual to strive to reach his or her own potential. Discrimination against any individual based upon protected status, which is defined as age, color, disability, gender identity or expression, national origin, race, religion, sex, sexual orientation, or veteran status, is prohibited. There is no tolerance for hateful speech or actions. All violations of this policy should be reported to the OSU Bias Assessment and Response Team (BART, http://studentaffairs.osu.edu/bias/).