Microbiology 8161: *Microbiome informatics*

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[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: 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 humans, soils, and the oceans. 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. Through concept-introducing lectures, hands-on practical exercises and a semester-long group research project, this course 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 around, on, and within you.

Pre-requisite: This course is best entered with Micro 5161 (Bioinformatics and Molecular Microbiology), Micro6155 (Microbial Evolution and Ecology) and basic knowledge of using the Ohio Supercomputer (OSC) and working at the command line. Experience with R is desired, but can be learned in-term. Engagement in the Center of Microbiome Science Working Group training or self-training can also substitute for above with lead instructor permission.

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. However, 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 the OSC (see here), UNIX/Linux (see online tutorials available at XSEDE, which may require free xsede portal account set up, see here more specifically here). 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.

Semester-long project: The bulk of the course will be devoted towards exposing the students to various flavors of sequence-enabled microbiology, so as to guide students towards choosing a project focus for a semester-long research experience. Critical reading assignments of scientific papers will be made throughout the semester to help students sharpen their analytical skills, and expose them to project related science. Brief summaries from this reading will be graded individually. Student presentations on analytical approaches will broaden the class exposure to project related 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. All 'literature' homeworks (first part of the class during the exploration phase) will be graded based upon the case for relevance of the material and the quality of the summary of the relevant analyses from the published paper being examined. The project group, once selected, will review original research papers on the topic of interest, identify sequence related datasets to investigate, and analyze the data to develop new research findings from the analyses. Each individual's project progress will be evaluated through weekly 'analysis' homeworks, and the course final will consist of each individual writing a brief summary paper. All 'analysis' homeworks and the final paper will be graded 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. All homeworks are due Monday @ 8am 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 early-on include reading and analyzing primary literature, but then will shift almost exclusively to applying analytical methods to your project or provided dataset(s) and using online tools to make discoveries about microbial communities. The 'outputs' for these latter items will vary from scripts and figures made and described to one-page summaries of relevant assigned reading. ***Assessment of 'literature reading' homeworks*** will evaluate whether the key Qs and experimental approaches are summarized, how the findings are articulated and contextualized, and the quality of the writing. ***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 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 learned in a 2-4 page paper (single-spaced, fonts 11 or 12) for each individual. Though part of a group project through the term, weekly homeworks (described above) and this final paper will be written and graded individually. **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 25/27	MS/SD	Intro to the course, unix and the OSC
Sep 1/3	MS	Review M5161 (Structural + functional annotation, MSA, phylogenies, DBs)
Sep 8/10	MS	Intro to current topics in human, ocean, soil microbiome science
Sep 15/17	SD/MS	Explore community taxonomic approaches (QIIME, Mothur) / Intro ecol stats
Sep 22/24	MS	Project options / small group project brainstorming and guided discussion
Sep 29/Oct1	MS	Commit to projects, establish contacts and scheduling / 1st in-class work sessions
Oct 6/8	MS/BB	Front-end metagenomic processing (QC, assemble, read mapping, binning)
Oct 13/15	MS/SD+BB	MAGs, DRAM and pathway prediction
Oct 20/22	MS/SD+BB	Genome-based taxonomy and phylogenomics
Oct 27/29	MS	2nd + 3rd in-class work sessions
Nov 3/5	MS/BB	Virus week: iVirus, IMG/VR
Nov 10/12	MS	Multi-omics data types (metaT, metaP, metabolomics, etc) / 4th in-class work sessio
Nov 17/19	MS	New sequencing technologies, with nanopore hands-on session
Nov 24	All	5th in-class work session
Dec 1/3	--	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.