



486/586 Metagenomics: from genes to ecosystems

Shantz 338, T/Th 12:30-1:45pm

Description of the Course

Environmental genomics is revolutionizing our understanding of microbes from the environment to human health, towards a holistic view of ecosystems or “One-Health”. At its core are new molecular methods called metagenomics to sequence DNA directly from an environmental sample, thus capturing the whole microbial community and bypassing culture. Modern (Next-Gen) sequencing technologies offer vast new datasets of short sequence reads representing these microbial communities, however many hurdles exist in interpreting data with high species complexity and specialized software for microbial metagenomic analyses. This course focuses on the science of metagenomics towards understanding (1) questions that environmental ‘omics can address, (2) approaches for metagenomic sequencing and analysis, and (3) how genes, pathways, and environmental context are translated into ecosystem-level knowledge. This course alternates between lectures on bioinformatics methods in metagenomics, and training in a scripting language (Perl 6) for answering biological questions.

Course Prerequisites or Co-requisites

MCB 181 Introductory Biology is required. MCB 416 Bioinformatics and Genomic Analysis, ABE 201 Introduction to Biosystems Engineering and MIC 205 General Microbiology are recommended.

Instructor and Contact Information

Instructor: Bonnie Hurwitz, PhD, Assistant Professor
Office: Shantz 624
Phone: 520-626-9819
E-mail: bhurwitz@email.arizona.edu
Office Hours: F 9:00am – 10:00am (and by appointment only)
Course Website: <http://www.hurwitzlab.org/metafunc-abe487-2016>

Course Format and Teaching Methods

Tuesday lectures on bioinformatics methods, Thursday lectures on scripting for biology

Course Objectives and Expected Learning Outcomes

To develop the broad knowledge and skills needed to: (a) understand metagenomic experimental approaches; (b) implement bioinformatics analyses on metagenomes from complex community samples, and (c) conduct and interpret results from project-based metagenomic analyses.

Topics

Metagenomics experimental approaches; sequencing technologies; platforms and platform specific issues; methodologies; sample preparation; QC-reports & quality controls; mapping sequence reads; taxonomic annotation; functional annotation & determination; gene prediction; comparative metagenomics; amplicon sequencing; shotgun sequencing; metagenome assembly; visualization and

reporting of results; tools & algorithms; bioinformatics tools.

Absence and Class Participation Policy

The UA's policy concerning Class Attendance, Participation, and Administrative Drops is available at: <http://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop>.

The UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated where reasonable, <http://policy.arizona.edu/human-resources/religious-accommodation-policy>.

Absences pre-approved by the UA Dean of Students (or Dean Designee) will be honored. See: <https://deanofstudents.arizona.edu/absences>

Participating in the course and attending lectures are vital to the learning process. As such, attendance is required at all lectures. Students who miss class due to illness or emergency are required to bring documentation from their health-care provider or other relevant, professional third parties. Failure to submit third-party documentation will result in unexcused absences.

Course Communications

Online communication, quizzes, and grading will be conducted through D2L. Course materials (homework assignments, homework answers, and lectures) will be available through the course website. Bioinformatics protocols for metagenomics modules will be maintained in protocols.io (<https://www.protocols.io/groups/metafunc-course>) that you will receive an invitation to join.

Required Readings

Required readings listed on the course website reading calendar.

Required or Special Materials

Special tools or supplies needed: graphing calculator, thumb drives, drafting tools, etc.

Grading Scale and Policies

The final letter grades for the class are based on the TOTAL NUMBER OF POINTS that each student accumulates for the following assessments:

40% Metagenomics term project (400 points total)

30% Computational homework (300 points)

20% Computational quizzes (200 points)

10% Journal club presentations and write up (100 points)

University policy regarding grades and grading systems is available at <http://catalog.arizona.edu/policy/grades-and-grading-system>.

Assignments and quizzes: Schedule/Due Dates

See the assignment schedule for dates and detailed descriptions of assignments. An overview of each component to the class is included below. The assignments schedule may be updated, so make sure to check regularly.

Metagenomics Term Project (40%)

400 points total: 12 bioinformatics modules (25 pts each); final report (100 pts)

Term project theme: this year's project theme will be the human skin microbiome. Each student will work in teams of two, where the team selects one "subject" from a recent study of the normal human skin microbiome and examines 16 skin samples (8 body sites at two time points one month apart). Each student will be responsible for one time point for the subject and execute all of the analyses independently, but can compare and contrast results with their teammate who is working on the other time point. These datasets will provide the input for all of the bioinformatics modules and final project.

Bioinformatics modules: metagenomics homework will be assigned each Tuesday and will be due the following week. The metagenomics homework is meant to help you complete your metagenomics term project, where each assignment contains one bioinformatics module (discussed in lecture) and protocol (in protocols.io) to implement a step for the final term project. To complete the term project on time, it is important to complete each of these assignments in a timely fashion. No credit will be given for late assignments. Because each of the sections build on each other, the assignments will be "turned in" by sharing a google document with the instructor. Each week you will receive comments on the google doc and a grade for new sections. A template for the google doc will be shared with the class.

Final report: If you have completed all of your metagenomics homework and updated the google document according to comments from the instructor, your final report will be nearly complete! The final report contains: an introduction to the project thematic area, methods and results from bioinformatics modules, and a final discussion of the results based on a visualization of the data in a software package called Anvi'o.

Computational Homework (30%)

300 points total: 10 computational modules (30 pts each)

Computational homework: computational homework will be assigned each Thursday and is due the following week. The computational homework is meant to offer you practice in scripting and the Unix command line. The homework will also prepare you for the 10-minute in-class quizzes each week (see below). Homework is turned in by committing your code to Github in a repository that is shared with the instructor(s). At 12:30pm on the day assignments are due, we will download your code from Github. To receive credit for each component of the assignment, your code must compile without syntax errors, and produce the "expected output" provided with the assignment (no logic errors). The final output for your program must match the expected output verbatim. We will be checking your output using a computer program, and computers are unforgiving! Make sure it is exact.

Computational Quizzes (20%)

200 points total: 10 computational quizzes (20 pts each)

Computational quizzes: each week you will be tested on the computational assignment from the previous week. Each of the quizzes will be in-class during the first 10 minutes of the computational lecture on Thursdays.

Journal Club (10%)

100 points total: in-class presentation (50 pts); write-up (50 pts)

Journal club presentations: Undergraduates will be required to give a 5-minute “Ignite talk” on a metagenomics paper of their choice. The paper must include an analysis that results from samples that were sequenced using whole genome shotgun next-generation sequencing. Graduate students will be required to give a 15-minute talk on a focused area of research in metagenomics. The talk should summarize recent metagenomics literature in this area.

Journal club write-up: Undergraduates will be required to turn in a 1-page summary of the paper they presented in-class. Graduate students will be required to turn in a 5-page paper summarizing the literature in their metagenomics focus area.

Incompletes, Withdrawals and Grade Disputes

Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at <http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete> and <http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal> respectively.

Dispute of Grade Policy: disputes on a grade for a paper, project, or quiz must be documented in a email to the instructor within one week of the grade being posted.

Honors Credit

Students wishing to contract this course for Honors Credit should email me to set up an appointment to discuss the terms of the contract. Information on Honors Contracts can be found at <http://www.honors.arizona.edu/faculty-and-advisors/contracts>.

Scheduled Topics/Activities

See the weekly class schedule.

Bibliography

See the weekly reading schedule.

Classroom Behavior Policy

To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.).

Students are asked to refrain from disruptive conversations with people sitting around them during lecture. Students observed engaging in disruptive activity will be asked to cease this behavior. Those who continue to disrupt the class will be asked to leave lecture or discussion and may be reported to the Dean of Students.

The use of personal computers such as laptops is encouraged in this course for computational assignments, following along during lecture on computational techniques and class notes, and note taking. However, the use of iPads and cell phones, and other such mobile devices is distracting to the other students and the instructor. Their use can degrade the learning environment. Therefore, students

are not permitted to use these devices during the class period.

Threatening Behavior Policy

The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See <http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students>.

Notification of Objectionable Materials

This course will contain material of a mature nature, which may include discussion of metagenomic literature related to sampling microbial communities associated with various sites on the human body. The instructor will provide advance notice when such materials will be used. Students are not automatically excused from interacting with such materials, but they are encouraged to speak with the instructor to voice concerns and to provide feedback.

Accessibility and Accommodations

Our goal in this classroom is that learning experiences be as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, please let me know immediately so that we can discuss options. You are also welcome to contact the Disability Resource Center (520-621-3268) to establish reasonable accommodations. For additional information on the Disability Resource Center and reasonable accommodations, please visit <http://drc.arizona.edu>.

If you have reasonable accommodations, please plan to meet with me by appointment or during office hours to discuss accommodations and how my course requirements and activities may impact your ability to fully participate.

Please be aware that the accessible table and chairs in this room should remain available for students who find that standard classroom seating is not usable.

Code of Academic Integrity

Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See: <http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity>.

The University Libraries have some excellent tips for avoiding plagiarism, available at <http://www.library.arizona.edu/help/tutorials/plagiarism/index.html>.

Selling class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructor's express written consent. Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions. Additionally, students who use D2L or UA e-mail to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student e-mail addresses. This conduct may also constitute copyright infringement.

UA Nondiscrimination and Anti-harassment Policy

The University is committed to creating and maintaining an environment free of discrimination; see <http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy>

Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without resorting to bullying or discrimination of others.

Additional Resources for Students

UA Academic policies and procedures are available at <http://catalog.arizona.edu/policies>

Student Assistance and Advocacy information is available at <http://deanofstudents.arizona.edu/student-assistance/students/student-assistance>

Confidentiality of Student Records

<http://www.registrar.arizona.edu/personal-information/family-educational-rights-and-privacy-act-1974-ferpa?topic=ferpa>

Subject to Change Statement

Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.