



Metagenomics 487/587 (3 units)

Shantz 440; Tuesday and Thursday 12:30 - 1:45 pm

Description of Course

Metagenomics is revolutionizing our understanding of microbes from the environment to human health. At its core are new molecular methods to sequence DNA directly from an environment, capturing the genetic signature of the entire microbial community and bypassing culture. Next-generation sequencing technologies produce massive sequence datasets that allow for these new insights, but also present new computational hurdles in interpreting data. This course teaches students the biological concepts behind working with genetic data from these complex communities, and a practical understanding of bioinformatics approaches for analyzing data. Students work in a collaborative learning classroom to gain skills in (1) metagenomic experimental design and next-generation sequencing; (2) interpreting results from bioinformatics analyses from recent studies; (3) comparative analyses to understand how genes, pathways, and environmental context can be translated into ecosystem-level knowledge.

Course Prerequisites or Co-requisites

MCB 181 Introductory Biology is required.

Instructors and Contact Information

Bonnie Hurwitz, Ph.D., Associate Professor

Office: Bio5 Keating room 223

Phone: 520-626-9819

E-mail: bhurwitz@email.arizona.edu

Office Hours: T 2:00 pm – 3:00 pm at the Catalyst Cafe (and by appointment only)

Jana U'Ren, Ph.D., Assistant Professor

Office: Bio5 Keating room 221/Shantz 504A

Phone: 520-621-1607

E-mail: juren@email.arizona.edu

Office Hours: M 2:00 pm – 3:00 pm at the Catalyst Cafe (and by appointment only)

Course Format and Teaching Methods

The course is designed based on weekly learning modules that include concept exploration and application (hands-on activities). Each learning module will have (1) assigned reading and homework questions based on the reading (due before class on Tuesdays), and (2) weekly in-class assignments (due at the end of class on Thursdays). Assigned reading, homework, and in-class activities will be posted on D2L on Thursdays the week before.

Course Objectives

This course is designed to provide students with a foundational understanding of metagenomics and bioinformatics analyses in a project-based collaborative work environment to understand (1) experimental design and best practice for amplicon and whole-genome shotgun next-generation sequencing and (2) bioinformatics analyses and interpretation of real-world microbiome datasets. This year's class focuses on the human microbiome with topics ranging from the development of the infant gut microbiome, the effect of exercise and diet, and dysbiosis in clinical contexts (e.g. colon cancer). We will also explore the Earth Microbiome and environmental microbes from the soil to the atmosphere.

Expected Learning Outcomes

Upon completing this course students will be able to understand: (1) the difference between genomes and metagenomes, (2) the need for controls and standards in metagenomics studies, (3) experimental design, sample size and material, and processing, (4) sample processing for bacterial, fungal, and viral metagenomics, (5) next-generation sequencing technologies, (6) steps in metagenomics studies including quality control, assembly, gene calling, read count analysis, and mapping to reference databases, (7) how to interpret metagenomic analyses from both amplicon and whole-genome shotgun sequence datasets for a variety of applications from the Earth to human microbiome.

Graduate students will go beyond these basic learning outcomes to (1) go deeper into the primary literature to synthesize and present results in a given metagenomic topic area, (2) understand the challenges of “microbial dark matter”, and (3) articulate the differences in metagenomic tools, approaches, and algorithms that can lead to differences in the interpretation of results.

Absence and Class Participation Policy

Attending lectures and participating in in-class activities are vital to the learning process. As such, attendance is required at all class sessions. 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.

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>

Makeup Policy for Students Who Register Late

Students who register after the first class meeting may make up missed assignments by the deadline 9/5/19.

Course Communications

Online communication, assignments, tests, and grading will be conducted through D2L. Course materials (reading, homework assignments, in-class exercises, and lectures) will also be available through D2L. Homework assignments will be turned in using D2L. All tests will be administered using D2L.

Required Texts or Readings

[A Primer on Metagenomics](#), PLoS Computational Biology, Wooley, et al. 2010.

Readings will be assigned the week before class on Thursdays, and available in D2L.

All texts and readings are available free of charge.

Required or Special Materials

None.

Required Extracurricular, Activities

Optional events related to metagenomics and bioinformatics will be announced in D2L.

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 (see details for each category below):

Category	# Assessments	Points per assessment	Percentage	Points total
Homework	12	30	36%	360
In-class	12	30	36%	360
Journal Club	1	80	8%	80
Final exam	1	200	20%	200

Total				1000
--------------	--	--	--	-------------

Grading Scale:

Grade	A	B	C	D	F
Points	900 or more	800-899	700-799	600-699	less than 600

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

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 an assignment, quiz, or exam must be made within three days of when the grade is posted.

Assignments and Examinations

All assignments, quizzes, and examinations are listed on D2L in the course calendar.

Homework (36%)

12 assignments, 30 pts each; 360 points total

Homework assignments are an opportunity for you to learn about metagenomics through reading and interpreting results from real-world metagenomics studies. These assignments are geared toward understanding metagenomics as a science, and for studies that use both amplicon and whole-genome shotgun sequence datasets to define the role of the human microbiome in nutrition, health, and disease, or the world around us (the Earth Microbiome). Each homework assignment will have a reading assignment and set of questions on that reading in D2L. Homework should be completed independently. Each assignment will include a random set of questions from a pool of questions that must be answered in an allotted time frame. Homework is assigned on Thursdays and due before class on the following Tuesday.

In-class Assignments (36%)

12 in-class assignments, 30 pts each; 360 points total

Each learning module will include an in-class assignment that will be assigned and discussed on Tuesdays and due on Thursdays by the end of class. Students will work on these assignments in small groups in-class as part of a collaborative learning environment. However, students are expected to turn in their own independent work in D2L each week on Thursdays.

Metagenomics Journal Club (8%)

In-class presentation; 80 pts total

Undergraduates will be required to give a 5-minute “lightning talk” (no slides) on a metagenomics paper of their choice related to the human gut microbiome that includes both taxonomic and functional analyses. Bullet points from this talk should be summarized and uploaded to D2L to receive credit.

Graduate students will be required to give a 15-minute talk (with a maximum of 10 slides) on a topic associated with the human gut microbiome introduced as part of the course. The talk should summarize recent metagenomics literature in this topic area. The slides should be uploaded to D2L to receive credit.

All students are expected to ask questions and participate in discussions following each talk as part of this collaborative learning opportunity.

Metagenomics Final (20%)

Final: 200 pts

Students will take a final exam that is based on course reading materials and weekly in-class assignments. The final will be administered in D2L using a pool of randomly assigned questions with varying levels of difficulty. Exams for graduate students will include additional short-answer essay questions (worth 100 of the 200 points).

Final Exam Schedule: <http://www.registrar.arizona.edu/schedules/finals.htm>

Final Exam Regulations:

<https://www.registrar.arizona.edu/courses/final-examination-regulations-and-information>

Scheduled Topics/Activities

<i>Week</i>	<i>DATE</i>	<i>DAY</i>	<i>Instructor</i>	<i>TOPIC</i>	<i>HOMEWORK ASSIGNMENTS (Due by the start of class)</i>	<i>IN CLASS ASSIGNMENTS (Due at the end of class)</i>
1	27-Aug	T	Hurwitz	Welcome; overview; introduction to course (pre-assessment)		
	29-Aug	Th	Hurwitz	What is metagenomics?		
2	3-Sep	T	Hurwitz	Practical computing skills (Part 1)	Homework 1	
	5-Sep	Th	Hurwitz	Practical computing skills (Part 1)		Assignment 1
3	10-Sep	T	Hurwitz	Practical computing skills (Part 2)	Homework 2	

	12-Sep	Th	Hurwitz	Practical computing skills (Part 2)		Assignment 2
4	17-Sep	T	U'Ren	Concepts in microbial ecology	Homework 3	
	19-Sep	Th	U'Ren	Concepts in microbial ecology		Assignment 3
5	24-Sep	T	U'Ren	Experimental design, reproducibility, and bias	Homework 4	
	26-Sep	Th	U'Ren	Experimental design, reproducibility, and bias		Assignment 4
6	1-Oct	T	U'Ren	Earth microbiome project	Homework 5	
	3-Oct	Th	U'Ren	Earth microbiome project		Assignment 5
7	8-Oct	T	Hurwitz	Where does your microbiome come from?	Homework 6	
	10-Oct	Th	Hurwitz	Where does your microbiome come from?		
8	15-Oct	T	Hurwitz	WGS assembly continued		Assignment 6
	17-Oct	Th	U'Ren	Oral microbiome	Homework 7	
9	22-Oct	T	U'Ren	Role of nutrition in gut microbiome	Homework 8	Assignment 7
	24-Oct	Th	U'Ren	Role of nutrition in gut microbiome		Assignment 8
10	29-Oct	T	U'Ren	Exercise and gut microbiome	Homework 9	
	31-Oct	Th	Hurwitz	Exercise and gut microbiome		Assignment 9
11	5-Nov	T	Hurwitz	Microbiome in cancer and immunotherapy	Homework 10	
	7-Nov	Th	Hurwitz	Microbiome in cancer and immunotherapy		Assignment 10
12	12-Nov	T	Hurwitz	Skin microbiome (and HMP)	Homework 11	
	14-Nov	Th	Hurwitz	Skin microbiome		
13	19-Nov	T	U'Ren	Designing your microbiome	Homework 12	
	21-Nov	Th	Ponsero	Read-based metagenomics		Assignment 11
14	26-Nov	T	Hurwitz	Read-based metagenomics cont.		Assignment 12
	28-Nov	Th		THANKSGIVING BREAK; NO CLASS		
15	3-Dec	T	Hurwitz	Journal club presentations		
	5-Dec	Th	U'Ren	Journal club presentations		
16				Journal club presentations, course wrap-up, post-assessment		
		TBD	U'Ren	FINAL EXAM		

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>.

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.).

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>.

Accessibility and Accommodations

At the University of Arizona, we strive to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability or pregnancy, you are welcome to let me know so that we can discuss options. You are also encouraged to contact Disability Resources (520) 621-3268 to explore reasonable accommodation.

If our class meets at a campus location: 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://new.library.arizona.edu/research/citing/plagiarism>.

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

The 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.