**Metagenomics 487/587 (3 units)**

**Tuesday and Thursday 9:30 - 10:45 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 a sample, capturing the genetic signature of the entire microbial community and bypassing culturing. Next-generation sequencing technologies produce massive sequence datasets that allow for these new insights, but also present 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 collaboratively 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 (or similar course) is required.

**Instructors and Contact Information**

**Bonnie Hurwitz, Ph.D., Associate Professor**

E-mail: bhurwitz@arizona.edu

**Jana U’Ren, Ph.D., Assistant Professor**

E-mail: juren@arizona.edu

**Office Hours**

Office hours will be held by appointment only. Please email us to schedule a Zoom meeting.

**Course Information**

* This class is scheduled to be taught **IN-PERSON** on Tuesday/Thursday at 9:30-10:45 in Shantz 440
* **Equipment and software requirements:** For this class you will need daily access to the following hardware: [laptop or desktop computer with webcam and microphone]; regular access to reliable internet signal; ability to download and run the following software: [web browser, Adobe Acrobat, Microsoft Office Suite]. Specialty software for metagenomics will be made available on the UA High Performance Computer.
* **Class attendance:** Attending lectures and participating in in-class activities are vital to the learning process. As such, attendance is required at all class sessions.
	+ Notify the instructors ASAP if you will be missing class.
	+ If you feel sick, or may have been in contact with someone who is infectious, stay home. Except for seeking medical care, avoid contact with others and do not travel.
	+ [Campus Health](https://health.arizona.edu/) is testing for COVID-19. Please call (520) 621-9202 before you visit in person.
	+ Visit the [UArizona COVID-19](https://www.arizona.edu/coronavirus-covid-19-information) page for regular updates.
	+ 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>
* **Life challenges:** If you are experiencing unexpected barriers to your success in your courses, please note the Dean of Students Office is a central support resource for all students and may be helpful. The [Dean of Students Office](https://deanofstudents.arizona.edu/) can be reached at 520-621-2057 or DOS-deanofstudents@email.arizona.edu.
* **Physical and mental-health challenges**: If you are facing physical or mental health challenges this semester, please note that Campus Health provides quality medical and mental health care. For medical appointments, call (520-621-9202. For After Hours care, call (520) 570-7898. For the Counseling & Psych Services (CAPS) 24/7 hotline, call (520) 621-3334.
* **Class Recordings:**
	+ Course recordings will be made available via D2L. If you *do not* wish to be identified by name in these recordings please notify the instructor immediately.
	+ Students *may not* modify content or re-use content in recorded lectures for any purpose other than personal educational reasons. All recordings are subject to government and university regulations. Therefore, students accessing unauthorized recordings or using them in a manner inconsistent with UArizona values and educational policies are subject to suspension or civil action.
* **Academic advising:** If you have questions about your academic progress this semester, or your chosen degree program, please note that advisors at the [Advising Resource Cente](https://advising.arizona.edu/)r can guide you toward university resources to help you succeed.

**Course Format and Teaching Methods**

The course includes **six learning modules** that explore concepts and applications of metagenomics research.

Each learning module includes **in class assignments and quizzes, two homework assignments with guided bioinformatics analyses, assigned research paper with a journal club presentation, class discussion, and a written summary**. There will be **two exams**: Exam 1 will cover modules 1-3 and be held in the middle of the semester; Exam 2 will cover modules 4-6 and be held at the end of the semester.

**Course Objectives**

This course is designed to provide students with a foundational understanding of metagenomics. At the completion of the course, students will understand experimental design and best practices for amplicon and whole-genome shotgun next-generation sequencing, bioinformatics analyses and interpretation of real-world microbiome datasets, and computational skills for executing bioinformatics pipelines on the UA high-performance computer. Over the course of the semester, students explore original research from the human to Earth microbiome to understand how these techniques have been applied and resulted in new discoveries on interactions between microbes, their hosts, and the environment.

**Expected Learning Outcomes**

**Upon completing this course students will be able to:**

(1) Use UNIX utilities to create, edit, manage files/directories, and submit analyses on the campus high-performance compute cluster;

(2) Define microbial ecological concepts (e.g., richness, diversity, OTU) and multivariate statistical methods used to compare and contrast microbial communities;

(3) Synthesize and list common sources of bias in metagenomic studies and best practices for scientific reproducibility, replicability, robustness, and generalizability for metagenomic experiments;

(4) Compare and contrast the pros and cons of whole genome shotgun (WGS) vs amplicon sequencing for understanding microbial taxonomy, diversity, and function;

(5) List all steps involved in a workflow to assemble and annotate a genome from a metagenome, find genes, and annotate proteins next-generation sequencing technologies;

(6) List the steps involved in connecting ‘omics data to environmental features using comparative metagenomic methods.

**Graduate students will go beyond these basic learning outcomes to:**

(1) Understand and explain the challenges of “microbial dark matter”;

(2) Articulate how differences in metagenomic tools, approaches, and algorithms that can lead to different results.

**Makeup Policy for Students Who Register Late**

Students who register after the first class meeting may make up missed assignments by the deadline 9/6/22.

**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**

Readings will be assigned for each learning module and posted or linked in D2L.

 All texts and readings are available free of charge.

**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** |
| **In-Class Quizzes** | 12 | 15 | 18% | 180 |
| **Homework** | 12 | 30 | 36% | 360 |
| **Journal Club Questions** | 6 | 10 | 6% | 60 |
| **Journal Club Presentation** | 1 | 30 | 3% | 30 |
| **Journal Club Written Summaries (graduate) or Highlights (undergrad)** | 6 | 20 | 12% | 120 |
| **Exams** | 2 | 125 | 25% | 250 |
| **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>.

**Policy on Late Work**

If you are unable to meet deadlines for assignments due to an emergency, please contact Dr. Hurwitz and Dr. U'Ren to arrange an alternative deadline.

**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.

**In Class Quizzes (15 points per Quiz; 180 points total)**

Short, in-class quizzes will be given during each learning module. Quizzes will be based on content for that module.

**Homework (30 points per homework; 360 points total)**

Homework assignments are an opportunity for students to interpret results from real-world metagenomics data, bioinformatics tools, and Jupyter notebooks. These assignments are geared toward understanding metagenomics as a science, using 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) and are based on core concepts taught during each learning module. Homework assignments should be completed independently. Due dates are listed in the course schedule.

**Metagenomics Journal Club (210 points total)**

Metagenomics is a relatively new and methods and techniques are rapidly changing; thus, is critical that students to learn to read and understand primary research articles. As part of this class, **one scientific paper will be assigned for each of the six modules**. Students will be responsible for thoroughly reading the article and **formulating two well-written questions** **(i.e., Journal Club Questions)** that will be submitted to D2L for grading (2 points per question; 10 total points per article).

Each student will be responsible for a **ca. 30 minute** **class** **presentation of one the research articles (i.e., Journal Club Presentation; 30 points total)**. Each presentation will include (but not be limited to) the scientific rationale, methods, and findings of each of the manuscripts. Students will be assigned to a presentation date the first week of class. After the journal club presentation, students will be broken into small groups to briefly discuss the questions from the class.

Lastly, students will be responsible for writing a **summary of each research article (i.e., Journal Club Written Summaries (graduate) or Highlights (undergraduates); 20 points each)**. Graduate students will be expected to write a minimum of 1 page summary that includes detailed answers to the questions that they addressed in their group. Undergraduate students will be responsible for writing a minimum of 1 pg. bulleted list of important points (highlights) for each research paper.

**Exams (250 points total)**

Students will take two exams based on course reading materials, homework, and in-class discussions (see course schedule for dates). Exam 1 will cover learning modules 1-3 and exam 2 will cover modules 4-7. Each exam will be administered in D2L using a pool of randomly assigned questions with varying levels of difficulty.

**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>.

**Class 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.

**Scheduled Topics/Activities**

 **\*Topics and deadlines are subject to change, please reference D2L regularly for updates**