



Course ID and Title: GEOL 499 'Omics for Microbiomes

Units: 4

Term—Day—Time: MW 1-2:50pm in person

Location: ZHS 200

Instructor: Karen G. Lloyd (she/her)

Office: ACB 304

Office Hours: W 11am-noon

Contact Info: lloydk@usc.edu, @karenlloyd.bsky.social, please include GEOL 499 in the subject line, timeline of response is usually within 48 hrs

IT Help: Steven Lin

Hours of Service: By appointment

Contact Info: slin2@usc.edu

Course Description

Students will become familiar with the fundamental concepts in bioinformatics, practical manipulation of metagenomic datasets, as well as understanding analytical tools to test hypotheses with these datasets.

GEOL 499 is an upper-level course in microbiology, designed to give hands-on experience with DNA- and RNA-based datasets commonly used in microbiology. We will cover the background and algorithms behind bioinformatics pipelines, as well as discuss the relative advantages/disadvantages of different methods. The emphasis will be on effectively wielding bioinformatics tools for a given dataset in order to test specific hypotheses.

The course is designed around a semester-long project, where the students work together in small groups to process and analyze real datasets. At the end of the class, students will present their findings, and compare what they found in their different groups. The focus will be on environmental datasets ranging from natural Earth environments to the human gut.

Learning Objectives

By the end of this course, the student will be able to:

- Explain the difference between 16S rRNA gene, 16S rRNA cDNA, metagenomes, metatranscriptomes, single cell genomes, metabolomes, and metaproteomes.
- Understand the uses of 'omics tools in microbial ecology, including the pros and cons of the different techniques.
- Demonstrate knowledge of public bioinformatics databases and how to access them.

- Be capable of analyzing a metagenomic, genomic, single cell genomic, or metatranscriptomic dataset.
- Be able to design and test hypotheses within those datasets that address microbiological questions.

Prerequisite(s): CHEM 105aLg, BISC 120Lg, one of the following: MATH 118gx OR MATH 125g.

Course Notes

This course will receive letter grades. Copies of lecture slides will be posted on Brightspace.

Technological Proficiency and Hardware/Software Required

Students must have a personal computer that they can bring to class to perform web-based bioinformatics analyses. A computer can be made available through the [USC Computing Center Laptop Loaner Program](#). USC Technology Support Links [Zoom information for students](#), [Brightspace help for students](#), [Software available to USC Campus](#).

Required Readings and Supplementary Materials

Bioinformatics and Data Analysis in Microbiology by Özlem Tastan Bishop. Can be purchased at USC Bookstores and is available online for free at USC Libraries.

Optional Readings and Supplementary Materials

Review papers and background reading will be posted on Brightspace.

Description and Assessment of Assignments

How you will learn the material

Part I. Introduction to the sorts of microbiological questions that can be addressed with omics tools. Then, introduce the tools themselves, illustrating the pros and cons of them. Explore 16S rRNA genes as tools to assess microbial community composition.

Part II. Learning how to process omics data. The principles behind the pipelines will be explained, including alignments, taxonomic identification, de Bruijn assemblers vs. overlap assemblers, annotation, peak-calling in mass spectrometry. This section will cover single gene vs. genomic vs. metagenomic analyses, as well as RNAseq vs. metatranscriptomics, metabolomics, and metaproteomics

Part III. Hypothesis testing within those datasets. How can you use these datasets to answer relevant questions about your microbe, microbial community, or environment? Challenging the assumptions about annotations, correlation analyses, integrating different datasets to reconstruct hypothetical in situ metabolisms. This part will focus on case studies as a way to approach learning 'omics data analysis.

The student will work in teams throughout the semester, with a heavy emphasis during Part III to make a cohesive project on a dataset. The class will be student centered, alternating professor-led lectures with “workshops” with no lecture, where the students put the information from lecture into practice as they engage with their semester-long project. Undergraduates will download datasets from public databases. Any students can bring their own datasets if they have them.

Participation

Regular course attendance, interacting during lectures, completing in-class assignments during workshops, and engaging with other students and the instructor will contribute to course participation grade.

Grading Breakdown

Table 1 Grading Breakdown

Assessment Tool (assignments)	Points	% of Grade
Project progress report	10	10
Class participation	10	10
Final project report	20	20
Final project presentation	10	10
Exam I	25	25
Exam II	25	25
TOTAL	100	100

Grading Scale

Course final grades will be determined using the following scale:

Table 2 Course Grading Scale

Letter grade	Corresponding numerical point range
A	95-100
A-	90-94
B+	87-89
B	83-86
B-	80-82
C+	77-79
C	73-76
C-	70-72
D+	67-69
D	63-66
D-	60-62
F	59 and below

Assignment Submission Policy

Assignments can be turned in on Brightspace or over email to the instructor.

Grading Timeline

Students can expect grading and feedback from instructor a week after assignments are due.

Course Specific Policies

COMMUNICATION: Email is the preferred form of communication with the instructor outside of class. Responses can be expected within 24-48 hours, though there may be an additional delay over weekends/holidays. If an in-person meeting is desired, please email a request to set up a meeting time.

Attendance

Attendance contributes to the student's final grade: the first unexcused absence will not incur any penalty, further unexcused absences will lower the overall in-class activities grade by 1 half letter grade per two absences, in addition to the F that will be received for the missed activities. Excused absences will be issued for student athletes with approved Travel Request Letters, students who give advance notice of religious observation, or students who provide doctor's notes (no specific details of the nature of the illness need to be included). Alternative course work expectations may be arranged for students who have an excused reason to miss a class session, on a case by case basis.

Classroom norms

Expectations for in-class participation: Students will be expected to participate respectfully in the general discussion during lectures, and to participate fully with the groups during workshops and during problem solving exercises. Students are also

expected to participate during the presentation of other groups' projects at the end of the course.

Zoom etiquette

ONLINE COURSE BEHAVIORAL NORMS AND NETIQUETTE:

Behavioral norms

- Treat everyone with respect and dignity.
- Criticize ideas, not individuals.
- Always be mindful of the following: would you say it to the individual in person?
- Be courteous and refrain from interrupting others.
- Don't dominate conversations- ensure everyone has a chance to contribute.
- Ask questions, especially when you don't understand something.
- Support your statements with evidence and explain your rationale.

Course netiquette (if needed for online sessions)

- Mute your microphone if you are not speaking
- Chat will only be used to make comments to the entire class (private chat will be disabled).
- Please use the "raise hand" function in Zoom to request clarification or ask questions. This will reduce interruptions.
- Your video doesn't have to be on but be present and participate if you are attending the live sessions.
- If you have technical issues, please email the instructor (lloydk@usc.edu).

Academic Integrity

The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission of ideas. Academic misconduct is in contrast to the university's mission to educate students through a broad array of first-rank academic, professional, and extracurricular programs and includes any act of dishonesty in the submission of academic work (either in draft or final form).

This course will follow the expectations for academic integrity as stated in the [USC Student Handbook](#). All students are expected to submit assignments that are original work and prepared specifically for the course/section in this academic term. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s). Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity.

Other violations of academic misconduct include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), knowingly assisting others in acts of

academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

Academic dishonesty has a far-reaching impact and is considered a serious offense against the university. Violations will result in a grade penalty, such as a failing grade on the assignment or in the course, and disciplinary action from the university itself, such as suspension or even expulsion.

For more information about academic integrity see the [student handbook](#) or the [Office of Academic Integrity's website](#), and university policies on [Research and Scholarship Misconduct](#).

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment or what information requires citation and/or attribution.

Creating a policy for the use of AI Generators in your course

I expect you to use AI (e.g., ChatGPT and image generation tools) in this class. Learning to use AI is an emerging skill, and I welcome the opportunity to meet with you to provide guidance with these tools during office hours or after class. Keep in mind the following:

- AI tools are permitted to help you brainstorm topics or revise work you have already written.
- If you provide minimum-effort prompts, you will get low-quality results. You will need to refine your prompts to get good outcomes. This will take work.
- Proceed with caution when using AI tools and do not assume the information provided is accurate or trustworthy. If it gives you a number or fact, assume it is incorrect unless you either know the correct answer or can verify its accuracy with another source. You will be responsible for any errors or omissions provided by the tool. It works best for topics you understand.
- AI is a tool, but one that you need to acknowledge using. Please include a paragraph at the end of any assignment that uses AI explaining how (and why) you used AI and indicate/specify the prompts you used to obtain the results and what prompts you used to get the results. Failure to do so is a violation of academic integrity policies.
- Be thoughtful about when AI is useful. Consider its appropriateness for each assignment or circumstance. The use of AI tools requires attribution. You are expected to clearly attribute any material generated by the tool used.]

Collaboration. In this class, you are expected to submit work that demonstrates your individual mastery of the course concepts.

Group work. Unless specifically designated as a 'group project,' all assignments are expected to be completed individually.

If found responsible for an academic violation, students may be assigned university outcomes, such as suspension or expulsion from the university, and grade penalties, such as an “F” grade on the assignment, exam, or in the course.

Course Content Distribution and Synchronous Session Recordings Policies

USC has policies that prohibit recording and distribution of any synchronous and asynchronous course content outside of the learning environment.

Recording a university class without the express permission of the instructor and announcement to the class, or unless conducted pursuant to an Office of Student Accessibility Services (OSAS) accommodation. Recording can inhibit free discussion in the future, and thus infringe on the academic freedom of other students as well as the instructor. ([Living our Unifying Values: The USC Student Handbook](#), page 13).

Distribution or use of notes, recordings, exams, or other intellectual property, based on university classes or lectures without the express permission of the instructor for purposes other than individual or group study. This includes but is not limited to providing materials for distribution by services publishing course materials. This restriction on unauthorized use also applies to all information, which had been distributed to students or in any way had been displayed for use in relation to the class, whether obtained in class, via email, on the internet, or via any other media. Distributing course material without the instructor’s permission will be presumed to be an intentional act to facilitate or enable academic dishonesty and is strictly prohibited. ([Living our Unifying Values: The USC Student Handbook](#), page 13).

Course Evaluations

Course evaluation occurs at the end of the semester university-wide. It is an important review of students’ experience in the class.

Course Schedule

Table 3 Course schedule

	Topics/Daily Activities	Readings/Preparation	Deliverables
Week 1	Part I: Intro to bioinformatics and how the class is run. What are bioinformatics good for? Overview of different omics (16S amplicon libraries, other single gene libraries, genomics, metagenomics, metatranscriptomics, metaproteomics, meta-metabolomics)	Chapter 1	List of biomolecules measurable by 'omics.
Week 2	Part I: Intro to 16S rRNA genes, including history of sequencing technologies and what types of hypotheses can be tested with 16S surveys. Next Gen Sequencing technologies and amplicon experimental design	Chapter 8	NCBI and JGI/IMG assignment, assessing the use of public databases for 16S rRNA gene amplicon data and analysis
Week 3	Part I: Amplification, rarefactions, chimeras	Breitweiser et al., 2019; Suzuki et al., 1999	Primer bias assignment assessing understanding and comprehension of how primer bias works in degenerate and non-degenerate primers
Week 4	Exam I: comprehensive assessment of 16S rRNA gene sequence usages in microbiomes		Download 16S rRNA gene amplicon datasets
Week 5	Part I: Introduction to data visualization and downloading R Studio – bring your computers	Chapter 6	Data visualization assignment assessing use of R.
Week 6	Part I: Intro to metagenomic analysis, alpha diversity indices	Chapter 7	Complete Qiime II analysis of 16S rRNA gene datasets
Week 7	Part II: Beta diversity quantification methods	Ramette et al., 2010	Progress reports due for final project

Week 8	Part II: Metagenomics, genome assembly and intro to annotations	Chapter 2	Metagenomes downloaded from NCBI
Week 9	Part II: Metagenomic binning	Tyson et al., 2004	KBase analysis initiated
Week 10	Part III: Annotations, Hidden Markov Models	Chapter 4	Metagenome assembly complete on KBase
Week 11	Part III: Annotations, Taxonomic Identity	Miller et al., 2010	Metagenome binning complete on KBase
Week 12	Part III: Annotations, Phylogenomics, Examples		Metagenome and bin assembly complete on KBase
Week 13	Exam II: comprehensive exam of metagenomics and the use of them.		Analysis for final project initiated
Week 14	Part III: Rest of the omics, SAGs and contamination	Stepanauskas et al., 2007	Analysis for final project developed
Week 15	Part III: Meta-omics in practice		Final project due
FINAL	In-class presentations of final projects		Refer to the final exam schedule in the USC Schedule of Classes at classes.usc.edu .

Statement on University Academic and Support Systems

Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University's educational programs. [The Office of Student Accessibility Services](#) (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Student Financial Aid and Satisfactory Academic Progress:

To be eligible for certain kinds of financial aid, students are required to maintain Satisfactory Academic Progress (SAP) toward their degree objectives. Visit the [Financial Aid Office webpage](#) for [undergraduate](#)- and [graduate-level](#) SAP eligibility requirements and the appeals process.

Support Systems:

[Counseling and Mental Health](#) - (213) 740-9355 – 24/7 on call

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

[988 Suicide and Crisis Lifeline](#) - 988 for both calls and text messages – 24/7 on call

The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline consists of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

[Relationship and Sexual Violence Prevention Services \(RSVP\)](#) - (213) 740-9355(WELL) – 24/7 on call

Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

[Office for Equity, Equal Opportunity, and Title IX \(EEO-TIX\)](#) - (213) 740-5086

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

[Reporting Incidents of Bias or Harassment](#) - (213) 740-2500

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

[The Office of Student Accessibility Services \(OSAS\)](#) - (213) 740-0776

OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

[USC Campus Support and Intervention](#) - (213) 740-0411

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

[Diversity, Equity and Inclusion](#) - (213) 740-2101

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

[USC Emergency](#) - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

[USC Department of Public Safety](#) - UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call

Non-emergency assistance or information.

[Office of the Ombuds](#) - (213) 821-9556 (UPC) / (323-442-0382 (HSC)

A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

[Occupational Therapy Faculty Practice](#) - (323) 442-2850 or otfp@med.usc.edu

Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.