SIO186: Microbiomes Across Environments

Fall 2023

MCTF Tuesday and Thursday 1-4pm

Instructor Information

Instructors	Email	Office Location & Hours
Jack Gilbert	jagilbert@ucsd.edu	By appointment only
Rob Knight	robknight@eng.ucsd.edu	
Sarah Allard	smallard@health.ucsd.edu	

Teaching Assistant

1 - Sho Kodera (skodera@ucsd.edu)

Guest Instructors

Sho Kodera, Gertrude Ecklu-Mensah, Maxwell Neal

General Information

Description

This course will provide a comprehensive introduction to microbiome research, tools and approaches for investigation, and a lexicon for understanding the biological role of microbial communities in the environment and in their hosts.

Expectations and Goals

20% of final grade: Weekly Feedback and Knowledge Assessment

Each week we will ask you to answer 2 questions: What did you find interesting this week, and what did you find confusing and/or want to learn more about. We expect 2-3 sentences for each response, with specifics, to be submitted by midnight Friday each week, from weeks 1-9 (2 points each).

On the first and last days of class, we will conduct a knowledge assessment to get an idea of which concepts the students are already familiar with. This will be scored only for participation (2 points each).

10% of final grade: Journal Club

Daily paper discussion: **You will be assigned a peer reviewed microbiome paper and report on it in class**. 10 mins to present your paper and 10 mins for class discussion.

Think about:

(1) What role did microbes play?

(2) What was the experimental design the authors used?

(3) What can we conclude from the figures?

(4) What was the main conclusion?

(5) Do the data support the conclusion the authors made?

(6) What would you do differently to improve the paper?

10% of final grade: Experimental Protocol (Due Oct 12th)

In your group you will produce a 2-page description of the experimental design you intend to perform including brief descriptions of: (1) Title of study; (2) Question being asked; (3) Hypothesis(es) being tested; (4) Expected Results,

i.e. what will new knowledge will the study generate; (5) Rationale for why the results and new knowledge are interesting; (5) Experimental design, including what samples will be collected, what additional data will be collected to facilitate testing of hypothesis, and how the samples and data will be collected; (6) References that support your study design. You will be graded on completeness of the protocol, how viable the hypothesis is, and how likely it will be to generate data that can test your proposed hypothesis.

20% of final grade: Oral Presentation (final week of classes)

You will provide a 12-min presentation (3 mins for questions) on your research project. The presentation should include no more than 12 slides (including title slide), and should include a background on the topic chosen, justification for the question being asked, outline of the question and hypothesis being tested, experimental design (including description of the sampling methodology, laboratory techniques and informatics analysis), results, conclusions, and future research on this topic. You will be graded on the clarity of your presentation, the quality of your slides, your assessment of the background of your chosen research topic, and knowledge of the techniques and experimental methodologies used.

40% of final grade: Written report (Due December 12th)

You will write a no-more-than 1500-word research report on your research project. This paper will follow a specific format, including an abstract (brief overview of the paper), introduction (intro of topic of research, existing studies, and rationale for carrying it out), materials and methods (including description of the sampling methodology, laboratory techniques and informatics analysis), results (including a max of 3 figures presenting the results), discussion (contextualizing your findings in the available literature – a discussion of what your results tell you) and conclusion (summation of the findings). The introduction and discussion will include references to the relevant scientific peer-reviewed literature, which will be included at the end of the report. At the end of the introduction, you will include a paragraph that outlines the question and hypothesis being tested, and the experimental design. You will be graded on the clarity of the presentation of the topic, your results, and findings, your interpretation of the results, use of literature, and rigor of your statistical analysis.

Typical Course Schedule

2 x 80 min lectures, 2 x 80 min labs

Week	Topic	Lecturer	Date	Notes
1	Lecture: Introduction to Microbial Ecology Lab: Introduction to Microbiology I	Jack Gilbert Sarah Allard	Sept 28th Sept 28th	Lectures: Microbiology and microbial ecology from Leuwenhoek to modern day. Lab: Sampling, culturing. Assignments: stats pre-quiz (graded for participation only), feedback
2	Lecture/Lab: Evaluating Microbiome Projects, with case study and hands-on Qiita walkthrough Lecture: Experimental Design Lab: Introduction to Microbiology II	Rob Knight Jack Gilbert Sarah Allard	Oct 3rd Oct 5th Oct 5th	Lectures: Study design, experimental approaches, metadata, techniques, and analysis, using a case study. Lab: Qiita walkthrough with keyboard case study; Counting colonies, alpha diversity analysis, simple DNA extraction Assignments: feedback
3	Lecture: Introduction to Multi-omics Lab: Writing study protocols Lecture: Student Journal Club 1 Lab: PCR and gel electrophoresis	Sarah Allard Sarah Allard Jack Gilbert Sarah Allard	Oct 10th Oct 10th Oct 12th Oct 12th	Lectures: Modern day multi-omics techniques; First 4 journal club presentations. Lab: Designing and writing the experimental protocol; PCR and gel electrophoresis; Assignments: journal club slides, feedback, Experimental Protocol.

Week	Topic	Lecturer	Date	Notes
4	Lecture: Introduction to Statistics I Computational Lab: Introduction to Bioinformatics I Lecture: Feedback on sample collection protocols Lab: Sample collection	Rob Knight Rob Knight Jack Gilbert Jack Gilbert	Oct 17th Oct 17th Oct 19th Oct 19th	Lectures: Statistical analysis and beginning class projects. Labs: Statistical analysis using QIIME2/QIITA and Sample collection Assignments: feedback
5	Lecture: Introduction to Statistics II Lab: Computational Lab: Introduction to Bioinformatics II Lecture: Student Journal Club 2 Lab: Microbiome Core tour	Rob Knight Rob Knight Jack Gilbert Sarah Allard	Oct 24th Oct 24th Oct 26th Oct 26th	Lectures: Statistical analysis; Journal club 2 Labs: Statistical analysis using QIIME2/QIITA, Microbiome Core tour Assignments: feedback
6	Lecture: Environmental Microbial Ecology Lab: Metadata handling Lecture: Student Journal Club 3 Lab: Data analysis	Jack Gilbert Sarah Allard Jack Gilbert Sarah Allard	Oct 31st Oct 31st Nov 2nd Nov 2nd	Lectures: Exploring environmental microbial ecology; Journal Club 3. Labs: Combining class metadata and practicing data analysis. Assignments: feedback
7	Lecture: Recent advances in the Human microbiome Lab: Data analysis Lecture: Student Journal Club 4 Lab: Data analysis	Jack Gilbert Sarah Allard Jack Gilbert Sarah Allard	Nov 7th Nov 7th Nov 9th Nov 9th	Lectures: Human microbiome, Journal Club 4 Labs: Data analysis Assignments: feedback
8	Lecture: Behind the paper: CAWS Lab: Data Analysis Lecture: Behind the paper: METS Lab: Data Analysis	Sho Kodera Rob Knight Gertrude Ecklu-Mensah Rob Knight	Nov 14th Nov 14th Nov 16th Nov 16th	Lectures: Examples of 12-min research presentations followed by a walkthrough of how researchers analyzed the data. Labs: Data Analysis and review with Rob. Assignments: feedback
9	Lecture: Wrap up discussion/Ask Jack and Rob anything panel Lab: Data Analysis and paper writing, with feedback opportunity Lecture: Metabolic modeling Lab: Presentation skills/slide preparation	Jack Gilbert and Rob Knight Maxwell Neal? Sarah Allard	Nov 28th Nov 28th Nov 30th Nov 30th	Lectures: Discussion of class concepts and remaining questions, metabolic modeling. Labs: Developing presentations and papers for next week. Assignments: feedback, bring draft figures for presentation/paper (recommended but optional)
10	Session 1: Student presentations of final projects Session 2: Student presentations of final projects Session 3: Student presentation of final projects Session 4: Student presentation of final projects.	Jack Gilbert and Rob Knight Jack Gilbert and Rob Knight	Dec 5th Dec 5th Dec 7th Dec 7th	Presentations! Assignments: submit slides

Rubrics

Journal club (10)

Clarity of presentation (2): Oral presentation should fall within the time limit and use clear and concise language focused on the topic, with a logical flow. It should be clear that the presenter has practiced their presentation.

Quality of slides (2): Slides should be clear, concise, and visually appealing. Main takeaways should be apparent from each slide. Original text should be used as much as possible, however images from the papers should be included.

Understanding of study design and approach (2): Student should demonstrate their understanding of how the study was carried out and what techniques were applied, and clearly state the main question or hypothesis of the paper.

Understanding of results and conclusions (2): Students should guide the class through interpretation of the results using a subset of figures from the paper and demonstrate an understanding of the main conclusions.

Discussion of limitations and future directions (2): Students should discuss whether the data in the paper supports the main findings reported in the paper, highlight limitations they identified in the study, and discuss areas of future research.

Experimental Protocol (10)

Justification and viability of hypothesis (3): Demonstrates an understanding of the field and the need for the proposed study, cites several published studies to build rationale, proposes a clear and testable hypothesis.

Completeness of protocol (4): Document should contain all required sections and should include all necessary information for a person outside the study team to collect and process samples and metadata.

Potential of study design to generate quality data (3): The study design should directly test the hypothesis, with adequate replication. Student should demonstrate that they have a reasonable plan for how the data will be analyzed.

Final presentation (20)

Clarity of presentation (5): Oral presentation should fall within the time limit and use clear and concise language focused on the topic, with a logical flow. It should be clear that the presenter has practiced their presentation.

Quality of slides (5): The presentation should include no more than 12 slides (including title slide), and should include a background on the topic chosen, justification for the question being asked, outline of the question and hypothesis being tested, experimental design (including description of the sampling methodology, laboratory techniques and informatics analysis), results (including figures and statistics), conclusions, and future research on this topic. Slides should be clear, concise, and visually appealing.

Understanding of research topic (5): Student should demonstrate knowledge of the research topic by synthesizing information gleaned from published studies and justifying the need for their study. Conclusions should demonstrate an understanding of how the study results relate to what is already known.

Knowledge of techniques and experimental methodologies (5): Main approaches used in the paper should be clearly and accurately described, from sample collection techniques to data analysis techniques, both in the presentation and in follow-up questions.

Final paper (40)

Clarity of writing (8): Paper should follow the described format, fall within the word limit, use clear and concise language focused on the topic, and be free from grammatical and spelling issues.

Rigor of statistical analysis (8): Appropriate statistical tests should be applied to comprehensively address the study hypotheses. Analytical techniques applied should be described in the methods and results sections (including statistical tests applied, distance metrics used, statistical test results, etc.).

Quality of figures (8): Figures should illustrate the main findings of the study and include comprehensive information required for interpretation either on the figure or in the figure legend (color/shape legends, statistics, metrics used, etc.) Limit of 3 figures, but multi-panel figures are allowed and encouraged.

Interpretation of results (8): Results should be interpreted in the context of the hypothesis, demonstrating knowledge of the statistical tests applied. Discussion should summarize the main findings concisely and demonstrate synthesis of ideas incorporating results from this and other studies.

Use of literature (8): Scientific studies should be appropriately cited throughout the text and used to contextualize both the justification for the study design and the results of the study in the available literature (i.e. introduction, methods, discussion). Writing should demonstrate an understanding of the cited material and how sources relate to each other and to the student's study.