

Biology 493 | Independent Study

M: 10-4, T: 12-2:30, Th: 12-4, F: 3-5
4305 FFSC Building
Fall 2024

Pre-requisites:
Permission of instructor

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Office Hours: By appointment

[JUMP TO SCHEDULE](#)

Research Overview

Abiotic and biotic stresses lead to crop loss and dramatically reduced yield each year. As the first layer of defense against stress, the plant leaf cuticle protects inner cell layers from UV damage, dehydration, and invading pathogens, among other threats to plant health. The benefits of robust cuticle function become even more critical in a warming climate as the frequency of heat waves, drought, and pathogen outbreaks increases. Plants and microbes are impacted individually by elevated temperature, and microbiota play important roles in overall plant health. However, we currently have little basic understanding of how microbiota influence plant performance in a warming climate.

To address knowledge gaps in “temperature-microbiota-plant” interactions, one area of my research simultaneously examines changes in microbial composition and plant performance at elevated temperature using Arabidopsis, tomato, synthetic and natural microbial communities. This approach has revealed emergent properties including changes to cuticle barrier function that only occur in the presence of elevated temperature, microbiota colonization, and the plant environment. Intriguingly, some bacteria with beneficial effects at normal temperature independently reduce barrier function at elevated temperature, suggesting that plant-microbe interaction dynamics shift in predicted future climate scenarios. Ongoing research aims to identify bacterial and plant mechanisms through which cuticle damage and possibly other changes to plant leaf surfaces occur at elevated temperature. The insights gained from this research will lay the groundwork for future work to examine how to predict and mitigate leaf surface damage from microbes in changing environmental conditions. Understanding microbiota impact on plant cuticle function at elevated temperature provides one target for crop protection treatments and has the potential to reveal new principles of host-microbiota-environment interactions that could apply even beyond plant systems.

Key questions for this project include:

- 1) Which microbes result in compromised cuticle at elevated temperature?
- 2) What are the microbial genes or operons that control cuticle degradation? How conserved are they across many bacterial genera?
- 3) If we can get the system running or a collaboration established – how conserved is the phenotype where barrier function is compromised at elevated temperature? Do the same microbes impact barrier function in mammalian systems?

Course Objectives

In this independent research course, you will learn to:

1. Formulate scientific questions, design, and carry out experiments to explore three-way interactions between plants, microbes, and the environment
2. Implement basic techniques of plant care, microbiology, and molecular biology with additional opportunities to learn skills of particular interest, such as bioinformatic approaches
3. Search relevant literature, summarize main questions from primary sources, and critically evaluate scientific results
4. Translate knowledge gained from the literature to develop skills as an experimentalist, proposing new experiments to follow up on recent results and learning to troubleshoot techniques
5. Present scientific discoveries and discuss new approaches, limitations, and future directions

Readings

There are no official textbooks. You will help select very recent journal articles for us to read in advance and discuss throughout the independent study.

Assignments and Evaluations

Work will be assessed on a 10-point scale or for completion, as indicated below. For example, 90-100 results in an A, 80-90 a B, and so on. Please note that no late work will be accepted except under extenuating circumstances and with documentation in accordance with Duke policies. Deadlines for drafts of the final report sections are flexible with prior discussion and approval.

The final grade will be calculated using the following percentages:

Proposal and Bibliography	5%	
Weekly Meeting Updates	5%	Graded for completion
Paper Discussions	5%	Graded for completion
Drafts of Final Report Sections	5%	Graded for completion
Final Report	15%	
Research Presentation	10%	
Lab Citizenship	5%	Graded for completion
Overall Output and Effort	50%	

Proposal and Annotated Bibliography

The 2-page research proposal should contain a title, abstract, brief introduction to the topic, specific aims/questions to be addressed, proposed methods/general experimental approach, and expected results. The annotated bibliography should consist of no fewer than twenty peer-reviewed articles with the perceived relevance of each noted in a brief sentence or two. Please note that it is not necessary to read each reference in detail to create the bibliography; we will select some publications from this list for our paper

discussions and the rest can be read in the process of writing drafts of the final report sections.

Weekly Meeting Updates

We will have informal meetings each week to discuss results, plan experiments, and ask questions. To help make these meetings productive, please prepare a powerpoint presentation of any results collected that week and plans for experiments in the upcoming week. A typical results slide should include the goal of the experiment, a plot of the data with appropriate axis and significance labels, the conclusions, and any troubleshooting.

Paper Discussions

We will meet periodically throughout the semester to discuss papers from the annotated bibliography as well as from recently published articles in the field (i.e. papers published during the course of the independent study). While you are expected to read the paper and come prepared with questions or commentary, you are not expected to understand everything perfectly! During our discussion, we will work together to understand any confusing aspects of the study, limitations of the design, and implications of the findings.

Drafts of Final Report Sections

Throughout the independent study, you will submit for feedback drafts of each section required for the final report. This is meant to help you get feedback early on each section and reduce the workload towards the end of the semester. For guidance on what to include in each section as well as formatting requirements, see the final research report rubric at the end of this syllabus. Example reports are also available, just ask me to send them. The draft sections required will be as follows:

1. Introduction and Background

Using the references compiled in the annotated bibliography as well as any additional publications discussed throughout the independent study, compose a brief introduction to provide context and rationale for the scientific questions and proposed experiments.

2. Methods

This section should describe in detail each method used to conduct the various experiments. Methods should be written in prose rather than listed as in a protocol and should include the number of replicates, specific procedures for carrying out the experiment, descriptive information about the samples used, in addition to any other pertinent information. Include methods for wet-lab experiments as well as bioinformatic pipelines and statistical approaches. Code used for *in silico* analysis should be included as supporting files with the final report.

3. Results

The results section should include figures for each piece of data as well as a description of the data, including any statistical significance. Implications of the findings can be summarized briefly in this section; however, the majority of the discussion should be saved for the section below.

4. Conclusions and Future Directions

In this section, summarize the key findings from the results and discuss implications for the field. Make note of unexpected findings and provide possible explanations for their meaning in a biological context. In light of your findings, provide possible future directions that would continue to move the project forward.

Final Report

Throughout the semester, you will generate drafts of each section of the final report. The final research report should be written in the style of a scientific paper, with sections for the abstract, introduction, results, methods, and discussion. We have scheduled time to go over each section as well as the full draft of the final report to provide ample time for feedback. The final report will be graded according to the rubric at the end of this syllabus.

Research Presentation

At the end of the semester, you will give a presentation to the lab on the work you have completed. Your presentation should walk listeners through your project from start to finish, including relevant background information and rationale, the main questions asked throughout the project, experimental design, results, conclusions, and future directions. Each slide should have a title that clearly states either the question being asked or the conclusion from the data. Expect people to interrupt to ask questions about the design and results – they will be curious about your findings and excited to learn more!

Lab Citizenship

The He Lab has outlined a code of conduct available on Dropbox in addition to the Duke code of conduct. Please read the guidelines and follow them during your time in the lab. In general, all lab members are expected to be respectful and considerate of one another. You are expected to adhere to good lab practices such as cleaning up your workspace when you finish, making sure refrigerators, freezers, and incubators are fully closed after opening, ordering or notifying someone that lab supplies are low, etc. Additionally, you are encouraged to attend lab meetings and subgroup meetings, as your schedule permits, and engage with other members of lab.

Overall Output and Effort

You are expected to be in lab during the times discussed at the beginning of the independent study and listed at the top of this syllabus unless prior arrangements are made or in the event of [extenuating circumstances](#). These meeting times amount to 8-10 hours per week, and ~120 hours per semester. Further, you are expected to work with your mentor to plan and carry out experiments, select and discuss papers, troubleshoot technical issues, and analyze and interpret data. All experimental work and planning should be documented in your lab notebook. Experiments don't always work the way we expect them to, but we often learn the most when we get a surprising result!

Attendance and Late Work Policies

Attendance is expected in all class meetings. More than 3 unexcused absences will result in one letter grade reduction from the final grade for the course. Please note that no late work will be accepted except under extenuating circumstances and with documentation in accordance

with Duke policies. Deadlines for drafts of the final report sections are flexible with prior discussion and approval. The following circumstances constitute excused absences and exceptions to the late work policy:

1. Significant illness
2. Personal instances of distress or emergency
3. Religious observance
4. Varsity athletic participation
5. Required court or legal appearances

For required forms and more detailed policies, please consult this [Duke policy](#).

Disability Statement

Student learning increases within diverse lab environments. This lab welcomes students from all backgrounds, identities, and abilities. Students who need accommodations to create a more productive learning environment are encouraged to contact the [Student Disabilities Access Office](#) at 919-668-1267 or disabilities@aes.duke.edu before the start of the semester or early in the semester.

Title IX, Harassment, and Diversity

Duke University and this lab are committed to encouraging and sustaining a learning and living community that is free from harassment, violence, and prohibited discrimination. In that regard and consistent with federal law (e.g., Title IX of the Education Amendments of 1972 and the Violence Against Women Act), Duke has developed this comprehensive [Student Sexual Misconduct Policy](#), applicable to all students (undergraduate, graduate, and professional, or any student enrolled in any Duke program).

The [Student Sexual Misconduct Policy](#) prohibits all forms of sex/gender-based harassment, sexual/gender violence, sexual exploitation, relationship violence (domestic violence and dating violence), and stalking. Collectively, these terms are referred to in this policy as “Sexual Misconduct.” They are defined below under “Prohibited Conduct.” Non-sex/gender-based harassment is also a violation of university policy, as described under the university’s [Harassment Policy](#).

Duke and this lab aspire to create a community built on collaboration, innovation, creativity, and belonging. Our collective success depends on the robust exchange of ideas—an exchange that is best when the rich diversity of our perspectives, backgrounds, and experiences flourishes. To achieve this exchange, it is essential that all members of the community feel secure and welcome, that the contributions of all individuals are respected, and that all voices are heard. All members of our community have a responsibility to uphold these values. More information on resources at Duke can be found on the [Office of Diversity and Inclusion website](#).

Academic Integrity

Duke University is a community dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Citizens of this community commit to reflect upon and uphold these principles in all academic and non-academic endeavors, and to protect and promote a culture of integrity. To uphold the [Duke Community Standard](#):

- I will not lie, cheat, or steal in my academic endeavors;
- I will conduct myself honorably in all my endeavors; and
- I will act if the Standard is compromised.

Proposed Schedule

Assignments are due by 8AM by email on the date listed below unless otherwise noted. No late work will be accepted without proper documentation or extenuating circumstances. Deadlines for drafts of the final report sections are flexible with prior discussion and approval. Additional goals will be added as the semester progresses based on experimental planning and discussions with your mentor.

Week	Class	Goals	Assignments
1	8-26-24	We will fill out the goals for each day as needed throughout the semester.	
2			
3			
		Weekly meeting, data recap, and planning	2-page research proposal and annotated bibliography Powerpoint summarizing any results and methods
4			Submit application for Graduation with Distinction
		Weekly meeting, data recap, and planning	Powerpoint summarizing any results and methods
5			
		Weekly meeting, data recap, and planning	Powerpoint summarizing any results and methods
6			

		Weekly meeting, data recap, and planning Discussion of draft introduction	Powerpoint summarizing any results and methods Draft of introduction for final report
7			
			Mid-semester evaluation due
		Fall Break begins after classes	
8		Fall Break	
		Weekly meeting, data recap, and planning	Powerpoint summarizing any results and methods Discuss mid-semester evaluation
9			(could be through staining the whole syncom)
		Weekly meeting, data recap, and planning Discussion of draft methods	Powerpoint summarizing any results and methods Draft of methods for final report
10			
11			
		Weekly meeting, data recap, and planning Discussion of draft results	Powerpoint summarizing any results and methods Draft of results for final report
12			
		Discussion of draft conclusions and future directions Discuss research presentation for the lab	Draft of conclusions/future directions for final report Draft of research presentation
13			Research presentation (date is flexible based on which lab meeting you are able to attend)
		Weekly meeting, data recap, and planning Discussion of draft final report	Powerpoint summarizing any results and methods Draft final research report
14		Thanksgiving	
		Thanksgiving	
		Thanksgiving	
15			
16		Reading Period begins	Final research report

Final Research Report Rubric

CATEGORY	90-100	80-90	70-80	<70
Abstract	Abstract is concise, informative, and clearly indicates the relevant details of the research study.	Abstract is relevant and of appropriate length, offering details about the proposed study	Abstract lacks relevance, fails to offer appropriate details about the research study, or is too lengthy.	Abstract is missing or inappropriate given the problem, research questions, and method.
Introduction and Background	Provides exceptional background information needed to understand the rationale, details, and results of the research study. The knowledge gap is stated clearly, and the research questions are articulated succinctly.	Background information is provided and linked to the research questions. Some details of the study may be difficult to understand without further reading.	The background provided is verbose and digressive, not clearly linked to the research questions or goals of the study. The gap in knowledge is not stated, and the research questions or rationale are unclear.	There is no background information provided and/or the background provided is irrelevant for the research study. The gap in knowledge and/or specific research questions are omitted.
Results	The purpose, questions, and design are mutually supportive and coherent. Data are presented in a logical and descriptive manner with appropriate figures and statistics. Concluding remarks are informative but kept to a minimum.	The purpose of the experiments are identified and the experimental design is supportive. Data are presented well, but some details may be missing or statistics may be unclear. Concluding remarks may be vague or too lengthy.	The purpose and/or experimental design is unclear. Data are presented but are missing many details. Statistics are absent or improperly applied. Conclusions may be missing or verbose.	The purpose of the experiment and/or overall design are missing. Some data or figures are missing or lacking information needed to interpret the results. No statistics are provided. No concluding remarks are made.
Methods	All protocols are clearly defined with ample details to replicate all experiments presented in the study.	Most protocols are defined in enough detail to replicate the experiments but may be missing common steps that vary slightly between lab groups.	Method details lack enough information to replicate the experiment without consulting the author.	Methods are omitted or lack critical information such as reagent concentrations, timing, sample age, etc.
Discussion and Conclusions	Appropriate and important limitations and assumptions have been clearly stated. Conclusions accurately reflect the data presented in the results section. Implications for the field and directions for future study are logical.	Some limitations and assumptions have been identified. Conclusions reflect the data presented in the results section but may overstate the results. Implications and directions for future study are stated but may become speculative.	Important limitations and assumptions have not been identified. Conclusions grossly overstate or do not reflect the data presented in the results section. Implications are provided but not clearly linked to the data or too speculative.	Limitations and assumptions are omitted. Conclusions are not linked to the data presented in the results. No implications or future directions are noted.
Organization	The ideas are presented in a clear, logical manner with links explicitly drawn between the various sections.	The narrative presents the ideas in an almost logical manner, but links between sections may be implicit or unclear.	The content of the proposal is inadequate (i.e. there is some logic in the narrative, but the ideas lack clear focus and structural argumentation).	The ideas are presented in a random manner with no focus.