

Plant Physiological Ecology

Integrative Biology 151 - lecture (4 credits) (#20383) – limited to 50
Integrative Biology 151L - laboratory (2 credits) (#20386) – limited to 25

Faculty Instructor: **Todd Dawson** (VLSB 4006, 642-6090, tdawson@berkeley.edu)

Lab Website: <http://ib.berkeley.edu/labs/dawson/>

Course Website: <http://ib.berkeley.edu/courses/ib151/>

Graduate Student Instructors:

Gregory (Grey) Arena (gregory.c.arena@berkeley.edu) → Grey has his “office” in the VLSB, room 4007, (510) 642-1054

Jaemin Lee (jaeminlee0622@berkeley.edu) → Jaemin has his “office” in the VLSB, room 4101.

→ **Lecture Course Objective:** To survey the many ways plants respond to the environment and environmental challenges from a physiological perspective. Lectures cover issues such as: what is a physiological adaptation?; the principle of limiting factors; resource acquisition and allocation; the ecology of energy, carbon, and water balance; water acquisition, use and relations; nutritional ecophysiology; stable isotope applications in the field of plant ecophysiology; stress physiology; evolution of physiological performance; physiology at population, community, and ecosystem levels; the ecophysiology of plant-animal-microbe interactions, etc.

→ **Laboratory Course Objectives:** Lab sessions focus on learning the observational and experimental approaches and key methods used in plant physiological ecology investigations. You will be introduced to a wide range of techniques/methods and will make measurements on different plants growing in the field and/or greenhouse (weeks 1-7). The second half of the term will be dedicated to your required group research project (more details below).

Lectures (IB 151)	T, TH	9:30 – 11:00 am	103 Moffitt Library
Sections (required):	Thursday	2-3 pm	3059 VLSB (#20384)
		3-4 pm	3059 VLSB (#20385)

Laboratory (IB 151L) ¹	T	2:00 – 5:00 pm	3059 VLSB
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¹This is a separate enrollment (= second course) and anyone who enrolls in 151L **MUST** also be enrolled in the lecture (IB151).

Grading:

→ **Lecture & Discussion** (1000 points total) - **IB 151**

200 pts.	Exam I (take home questions); Handed out February 22 nd - Due in one week
250 pts.	Exam II (take home questions); Handed out March 28 th - Due in one week
300 pts.	Exam III (take home research problem); Handed out April 30 th , Due in one week
100 pts.	Discussion assignments (3 @ ~33 pts. each)
150 pts.	Discussion participation, attendance, and a 15-minute quiz every third week

→ **Laboratory** (500 points total) - **IB 151L**

100 pts.	Attendance and in-class assignments
100 pts.	Research Proposal
300 pts.	Final Project Report & Oral Presentation

Grades are not curved; instead a percentage scale and the respective grades are used as shown in the list below. You'll see that the minimum grade you will receive based on your cumulative percentage from your numeric score summed across all required assignments and exams. At our discretion, we

may lower the numeric breakpoints (meaning that you could get a higher grade than indicated), but we will not raise them.

Percentage breakdown	Minimum letter grade
> 93.5	A
≥ 90.1 - 93.4	A-
≥ 87.1 - 90	B+
≥ 83.5 - 87	B
≥ 80.1 - 83.4	B-
≥ 77.1 - 80	C+
≥ 73.5 - 77	C
≥ 70.1 - 73.4	C-
≥ 65.1 - 70	D+
≥ 60.1 - 65	D
< 60	F

LECTURE COURSE REQUIREMENTS:

Lectures. Although handouts are provided for each lecture topic, there is a great deal that is discussed during lecture sessions that is not in the handout. And often the examples used contain detailed elaborations of key points that you may see again on exams. We therefore ask you to attend lecture sessions because of the important discussions that often occur in-person that often provide context for the course material and exam answers. Handouts will always outline what is to be covered including the appropriate tables and figures. There is a great deal of information presented in the class so the handouts have been designed to allow you to listen and respond to the lecture materials without the burden of having to write down every detail.

Examinations. Three take-home examinations will be given. They consist of a combination of (i) questions meant to be answered with a short essay, (ii) problem solving questions that may have alternate, yet valid answers, and (iii) questions that will ask you to evaluate experimental data. They will be based primarily on the lectures and reading assignments. You will have one week to answer 2-4 questions. All examinations are open to all resources. Form a team and work together..

Discussion sections. Weekly discussions are intended to provide you with additional opportunities to discuss and build upon the primary lecture topics through (1) question and answer reviews of each weeks materials, (2) additional reading from the peer-reviewed scientific literature, (3) in-class problem solving assignments (e.g. evaluating data, running a computer program that demonstrates a key principle, debating what the data show), (4) quizzes focused on a concept or problem presented in lecture, and (5) short discussions of “current topics” or a scientific paper that teams of 3 or 4 students organize together and then lead an in-class discussion on.

The student community at UC Berkeley has adopted the following [Honor Code](#):

“As a member of the UC Berkeley community, I act with honesty, integrity, and respect for others.”
The hope and expectation are that you will adhere to this code.

Collaboration and Independence: Reviewing lecture and reading materials and studying for exams can be enjoyable and enriching things to do with fellow students. This is recommended. However, unless otherwise instructed, homework assignments are to be completed independently and materials submitted as homework should be the result of one’s own independent work.

Cheating: A good lifetime strategy is always to act in such a way that no one would ever imagine that you would ever consider cheating. Anyone caught cheating on a quiz or exam in this course will receive a failing grade in the course and will also be reported to the University Center for Student Conduct. In order to guarantee that you are not suspected of cheating, please do your own work (we ask you to write answers in your own words) and create your own materials for the answers to quizzes or exams. Using ChatGPT to answer exam or quiz questions is not permitted in this course. ChatGPT is a tool and might be used to help initiate a learning process. But the actual answers it provides can be flawed or incomplete and if copied verbatim this constitutes cheating. .

Plagiarism: To copy text or ideas from another source without appropriate reference is plagiarism and will result in a failing grade for your assignment and usually further disciplinary action. For additional information on plagiarism and how to avoid it, see, for example:

<https://writing.berkeley.edu/academic-honesty>

<http://gsi.berkeley.edu/teachingguide/misconduct/prevent-plag.html>

Academic Integrity and Ethics: Cheating on exams and plagiarism are two common examples of dishonest, unethical behavior. Honesty and integrity are of great importance in all facets of life. They help to build a sense of self-confidence, and are key to building trust within relationships, whether personal or professional. There is no tolerance for dishonesty in the academic world, for it undermines what we are dedicated to doing – furthering knowledge for the benefit of humanity.

Your experience as a student at UC Berkeley is hopefully fueled by passion for learning and replete with fulfilling activities. And we also appreciate that being a student can be stressful. There may be times when there is temptation to engage in some kind of cheating in order to improve a grade or otherwise advance your grade or career. This could be as blatant as submitting a written assignment that has been copied from another source. And it could be as subtle as glancing at a fellow student’s answer when you are unsure of how best ‘you’ should answer a question and are looking for some confirmation. One might do any of these things and potentially not get caught. However, if you cheat, no matter how much you may have learned in this class, you have failed to learn perhaps the most important lesson of all.

For more information: <http://asuc.org/honorcode/resources.php>

Lecture Schedule – we have 30 lecture periods together and a broad scope of topics to cover

I. Introduction

What is the field of Physiological Plant Ecology?

[resources, tradeoffs, limitations, acclimation, adaptation, change]

II. Characterization of the Physical Environment in the Changing World

Climate & Vegetation

Principle of Limiting Factors

Plants and Microclimates

III. Resource Acquisition Aboveground

Radiation Balance and Leaf Energy Budgets

Limitations to Photosynthesis: an overview

Photosynthetic Adaptation to Light and Temperature

Stomatal and Biochemical Control of Leaf Gas Exchange

Stable Isotopes, Water-use Efficiency, and Photosynthetic Performance

Variation in Photosynthetic Pathways

What is Productivity?

IV. Below Ground Processes and Plant Response

Water on Earth

Root Systems and Water Acquisition

Water Use and Tissue Water Relations

Plant Hydraulics

Adaptation to Water Stress - Drought - Salinity - Flooding

Nitrogen Availability, Requirements, Symbiosis, Use-efficiencies

Response to Limited Nutrient Availability

Soil Factors & Edaphic Adaptations

V. Resource Balance in Plants

Carbon Allocation - Construction Costs, Storage, Turnover, Patterns

The Ecophysiology of Defense Against Herbivory

VI. Ecophysiology Above the Individual Level

Ecophysiology in Plant Populations

Ecophysiological Aspects of Competition

Physiological Variation and Plant Traits; ecology and evolution

Reproductive Ecophysiology

The Ecophysiology of Succession

Ecosystem Physiology – Measurements, Models, Scales & Scaling

VII. Physiology and Evolution

The Evolution of Physiological Performance

**** UCB Plant Physiological Ecology Symposium ****

**** Those students enrolled in the laboratory course (IB 151L) will be asked to give an informal presentation of their project results at the bi-annual, UCB Plant Physiological Ecology Symposium the week following the end of classes (week of May 9th). Everyone in the class is welcome to attend.**

Critical dates to remember:

- March 25-28 is spring recess; April 12-14 is an optional overnight field trip to Blue Oak Ranch Reserve where we will conduct field research and daily discussions and data analyses. Meals and accommodations are provided.

Reading

There is no perfect textbook for this course because the course is designed to span an array of topics drawn from the areas of plant physiology and biochemistry as well as ecology and evolutionary biology. There is one required text for the lecture that does provide good background reading. The textbook for the lab has been out-of-print for many years, but copies can be made available in lab and permission to photocopy the text is being sought from the publisher.

The **required text** for the lecture is the third edition of **Plant Physiological Ecology** (2019) by H. Lambers and Rafael S. Oliveira. We recommend that you use the lecture handouts to guide your reading in the book. For this reason, you will want to explore the book on your own and when appropriate specific pages or sections will be recommended. A good formula is to find the relevant pages in the text AFTER each lecture is given and use this reading to supplement and expand upon the examples given and to clarify points or concepts that we address. At times, the lecture and book may provide slightly different perspectives – this is useful. If, however, particular facts or concepts between lecture and the book seem at odds, bring this to our attention!

Some topics, such as Ecophysiological Aspects of Competition, Herbivory and Ecophysiology, Reproductive Ecophysiology, The Ecophysiology of Succession, Scales and Ecosystems in Plant Ecophysiology, and Evolutionary Ecophysiology will have special readings that are not covered in the books.

In addition to the readings outlined above, specific papers taken from the primary literature will be assigned during the semester when they are central to a particular topic being covered. In addition, several other texts are available in the library that provides good coverage of some topics. These texts are all part of either the Academic Press Ecophysiology or Springer-Verlag Ecological Studies series. I will point out the relevant texts as we come to specific topics.

➤ Two **optional texts** that can be helpful for adding to your background in the areas of plant ecology and plant physiology are: (1) ***Plant Ecology***, edited by M. Crawley and (2) ***Plants and Microclimate***, by H.G. Jones, respectively. Relevant readings in Crawley, by week are: Week 3, chap. 11; week 6, chap. 12; week 10, chaps., 2 & 9; week 11, chaps., 4, 5 & 8; week 12, chap. 6. Relevant readings in Jones, by subject are: Radiation, pp. 8-44, 106-116, 124-130; Stomata, pp. 131-162; Light, pp. 223-226; Temperature, pp. 231-245, 251-263; Photosynthesis, pp. 163-171, 176-179; 185-214; Water Relations, pp. 264-293.

➤ The text entitled **Physiological Plant Ecology: field methods and instrumentation**, edited by R.W. Pearcy, J.R. Ehleringer, H.A. Mooney, and P.W. Rundel is now **out of print**, but copies will be made available for students enrolled in 151L. **Readings in PEARCY et al. are:** week 1, chap. 1; week 2, chap. 6, 14; week 3, chap. 4; week 4, chaps. 6, 12, 13; week 5, chaps. 3, 8; week 6, chaps. 5, 9, 10; week 7, chaps. 11, 12; week 8, chaps. 8, 16; week 9, chap. 15.

LABORATORY COURSE REQUIREMENTS (151L)

Laboratory. The lab serves two purposes: (1) to instruct you in the methods and the use of key equipment used in plant ecophysiological research, and (2) to prepare you to conduct your course project (see p. 5 for full details). Some labs may be held at the U.C. Botanical Garden.

Research Proposals / Final Project Reports. During weeks 2 and 4 we will talk about your class projects. At week 5, we will ask you to hand in the specific questions you'd like to address for your project and the methods you intend to employ to address these questions. These will be reviewed and handed back to you with comments. At week 8, a detailed proposal for your project will be turned in. Details about this proposal and the project reports can be found below. The Final Project Reports are worth 200 points will likely be due on April 28th (though with COVID challenges we may adjust this).

Laboratory Schedule

The purpose of the laboratory is to allow you to become familiar with the approaches and methodology used in plant physiological ecology. To do this we will learn a number of techniques and make measurements on different plant species growing in the field or greenhouse. The first several weeks will focus on learning a number of techniques, becoming more familiar with computers for data management, and writing-up your findings. In addition, you will identify and set-up your class research projects. The last four weeks of the semester will be spent working specifically on your projects, i.e., collecting and analyzing the data (we will be following your progress and can offer assistance and guidance if needed), as well as project write-up. Periodically during this time, one of the instructors will meet individually with you to go over the experimental procedures and data evaluation for your project. On the day of the final exam, each group will present a brief talk (15 minutes) on the results of your research. Handouts for each week's lab will be passed out in class on the previous Thursday. It is expected that you will take the time to become familiar with the handout before each week's lab.

Week 1	Introduction to the lab course objectives and requirements
Week 2	Discussion of what you'll learn and how to apply this to your Class Project
Week 3	Principles and Measurements Leaf & Canopy Energy Balance
Week 4	Research Project discussion - Foci, Timelines & Budgets
Week 5	Principles and Measurements of Photosynthesis (+ Project questions due)
Week 6	Principles and Measurements of Plant Water Use & Status - I
Week 7	Principles and Measurements of Plant Water Use & Status - II
Week 8	Class projects discussion and organizations for measurement schedule (+ Project proposals due)
Week 9	Begin Research Projects
Week 10	Principles and Measurements of Stable Isotopes
Week 11	SPRING BREAK
Weeks 12 & 13	Continue working on and complete research projects
Week 14	Work on project data and reports
Week 15	Final Project Reports Due (April 28 th)
Final exam week	Oral Presentations (~15 min.); week of May 11 th (TBD). <i>food & drinks will be provided</i>

Grading for Lab:

1. Attendance and in-class assignments (100 pts.)
2. Research Proposal (100 pts.)
3. Final Project Report (300 pts.; note: your oral presentation will factor into this grade)

About Your Class Research Project

Your GSIs and I will prepare a list of potential project themes and plants that you might want to use for your course projects. Some projects are narrowly defined while others allow you the freedom to ask a range of questions about plant ecophysiology. They are all designed to give you exposure to asking questions about ecophysiology and to the methods that are commonly used in this field. You will carry out these projects in groups of 3 or 4 students who share some common interests.

During our second lab, we will ask you to choose a project topic that is most interesting to you. In the third week of lab, we will set up those experiments together so that you will be ready to make your measurements on established plants later in the semester. By week 5, you will need to turn in refined questions for your project. Three weeks later (week 8), you will turn in a research proposal (100 points) that outlines the research you plan on carrying out for your project. The proposal must include five parts:

- (1) a statement of the research objective(s) and goal(s)
- (2) a description of the methods to be used including what you will measure, how you will measure it, what your experimental design is, the equipment you will need to carry out your project
- (3) a short discussion of the predicted results for your experiment
- (4) a list of references (5-15) on the research topic that clearly indicate you are aware of the relevant literature
- (5) a list of references in which the authors employ the methods you plan to use.

After your proposal has been approved, there will be a sign-up sheet for equipment that you **MUST** put your name on if you hope to have access to any of it.

You will begin your research during the 10th week of the semester and will be able to collect data for approximately four weeks. This should allow sufficient time to collect enough data so that you can draw some firm conclusions. We will be available for consultation throughout the semester.

After you complete your project, you will have TWO things to accomplish: A written report to be handed in the end of April and a 15-minute oral (slide) presentation of your study, its results, and implications that you should be prepared to give at the bi-annual, **UCB Plant Physiological Ecology Symposium** (at the end of classes in early May).

If you are not thoroughly aware of how to use the library for tracking down references, following up specific reference citations, and on how to use the various abstracts, please see one of the instructors - we have handouts to help you.

If you are not thoroughly familiar with how to write a scientific paper, expected for the research project, please see one of the instructors - we have handouts to help you.

During this semester we want you to always keep asking questions, think critically about the context you are learning and discussing, and have fun!