

BIOL 514H

EVOLUTION & DEVELOPMENT

An advanced course aimed at integrating Genetics, Development, Ecology & Evolution

I. Course Logistics

Location: Wilson 202 (on Zoom - ID: 915 6897 3374)

Time: TuTh, 11:00 AM – 12:15 PM

Professor: Dr. David Pfennig

Email: dpfennig@unc.edu

Office: 320 Wilson Hall (on Zoom)

Office Hours: Th 12:15–1:15 (by appt.)



II. Course Description

Living things are amazingly diverse. Not only are there innumerable species, different species differ from each other as do individuals within species. In this course, we will explore how and why such remarkable biodiversity has evolved. To do so, we will examine the intersection of genetics, development, ecology, and evolution. As we will see, these processes are inextricably linked. Genetic and developmental systems are the products of past evolution. However, developmental systems can bias or constrain what mutations are visible to selection and thus what new forms can arise. Moreover, because the environment acts as a source of cues that guide development and as the source of selective pressures that drive evolutionary change, the ecological context of development is critical.

III. Learning Objectives

By fully engaging with the material and class assignments, by the end of the semester you will be able to:

- Explain how an interdisciplinary approach involving genetics, development, evolutionary biology, and ecology can be used to explain biodiversity.
- List and describe major questions, findings, and experimental approaches in the fields of evo-devo.
- Critically evaluate and interpret the primary scientific literature.
- Combine factual material with deductive reasoning to propose hypotheses.

IV. Course Prerequisites

To take this class, you must be in the Honors Carolina program or have a GPA of at least 3.0. In addition, there are three course prerequisites: 1) Biology 201 (Ecology & Evolution), 2) Biology 202 (Molecular Biology & Genetics), and 3) Biology 205 (Cell & Developmental Biology). If you lack these course prerequisites, please talk to me.

V. Course Format

This course is a hybrid lecture and seminar course. Generally, lectures will be presented on Tuesdays. The goals of the lectures will be to introduce you to conceptual frameworks, historical context, and biological



Among biology's most persistent problems is to explain biodiversity. Consider, for example, the beetles. (a) Although it is unclear how many beetle species there are (350,000 species have been described), they are thought to be among the most diverse group of organisms. (b) Even closely related species typically differ; e.g., male stag beetle species differ in body size, pigmentation, and genitalia length (circled). (c) Pronounced trait variation can even be found within species. For instance, horned beetles consist of minor males and larger, major males.

information relevant to the week's theme(s). At the end of several lectures, small groups of students will deliver a short presentation on a technique that we might encounter in our readings. On several Tuesdays and on all Thursdays, class meetings will be focused on discussions of the classic and recent papers from the scientific literature on the week's theme(s). Early in the semester, I will lead these discussions. Later in the semester, these discussions will be led by you, the students.

VI. Textbooks & Readings

There is one required textbook:

Pechenik, J. A. 2014. *The Readable Darwin: The Origin of Species Edited for Modern Readers*. Sinauer Associates. [we will discuss this book in the first third of the semester]

There are also two (highly) recommended textbooks:

Gilbert, S. F. & D. Epel. 2015. *Ecological Developmental Biology*, 2nd edition. Sinauer Associates. [this book contains helpful background information]

Hofmann, A. H. 2020. *Scientific Writing and Communication: Papers, Proposals, and Presentations*, 4th edition. Oxford University Press. [this book is full of useful pointers for preparing your written work and presentations]

All three textbooks can be rented or purchased (new or used) from the UNC Student Stores.

In addition, there are supplementary readings as well as weekly discussion readings (see below). Links to these readings are on the course Sakai site.

VII. Activities and Assignments

There will be no exams in this course. Instead, you will be asked to demonstrate your mastery of learning objectives through weekly assignments plus TWO capstone assignments. The weekly assignments will help prepare you and the class for engaging the lecture material and participating in the group discussions each week. The capstone assignments will strengthen your scientific muscles and allow us to model what biologists do in their careers by applying the methods and conceptual framework you will learn throughout the term to subjects and questions that fascinate you.

A. Weekly Assignments

There will be two categories of “weekly” assignments: 1) Student-led Discussions (SLD), and 2) Experimental Approach Presentations (EA). Please sign up for these assignments by the end of the first week of class by replying to the appropriate thread on the Sakai Forum.

A.1. Student-led Discussions (SLD)

Each Thursday during the semester, there will be a student-led discussion of readings that will be posted on Sakai. Each student will lead (as part of a team of no more than 3 students) TWO different SLDs of one or more scientific papers that I will upload on Sakai (NOTE: your team should not be the same for both discussions). EVERYONE will be involved in each SLD; however, your responsibilities will vary, depending on whether or not you are a discussion leader or a discussion participant. NOTE: the papers are listed on the syllabus and are available on Sakai under ‘Resources’ in the folder marked ‘Readings’.

A.1.a. Responsibilities of discussion leaders:

On days when you are leading a discussion, you will be engaged in two types of activities:

First, you (or your teammate[s]) should spend no more than 20 minutes at the outset of the class period presenting an overview of the reading material. During this time, you should tell the class why the material is important and what the central messages of the reading(s) were. In doing so, feel free to use Powerpoint and/or whatever tools will help you make your points effectively. If you're part of a team, each team member must present a different aspect of the paper(s) being discussed.

Second, after the overview, the remainder of the class period should focus on your classmates' questions and leading a discussion of these questions.

How to lead a successful discussion:

- 1) Use the submitted questions to get the discussion rolling and to keep it rolling. It's a good idea to put these questions into your Powerpoint and handouts so everyone can read them. It also helps to put basic questions first and the most interesting questions just after them, leaving other questions to the end if time permits.
- 2) Once the discussion gets started, ease up and let your classmates talk. You do not need to respond to everything that others say; in the best discussions, everyone is speaking to each other rather than solely to the discussion leaders. Be prepared to redirect the conversation if it becomes bogged down on meaningless argumentation, but don't be too eager to shift topics if the class is confused.
- 3) Be fair to the author's arguments. Present the author's position first before voicing your opinion.
- 4) Avoid jargon. If it's necessary to use special terms, make sure you define them (a glossary in your presentation is a good idea).
- 5) Be prepared to support your arguments. The best way to do so is to read the material carefully. It also helps to consult additional, outside readings for opposing views or to clarify points made in the assigned reading. If you find useful outside readings, provide these additional references in your presentation.

After the class period during which the discussion that you are leading takes place, you are required to prepare a written 1 to 2-page synopsis of the reading assignment, in which you summarize (1) the week's reading and (2) the major issues that we discussed and how we resolved these issues. You should also prepare (3) a bibliography of no fewer than 10 references for those who want to read more on the topic (please include a mix of new and old references; be sure to include some references that were NOT cited in the reading(s); NOTE: when SLDs are presented as part of a team, the team needs to submit only one synopsis on behalf of all of its members). After you have prepared this synopsis, please upload it (by the following Thursday at noon) on the appropriate Sakai Forum.

A.1.b. Responsibilities of discussion participants:

For the days when you are not leading a discussion, you should come to class prepared to participate actively in the discussion. It's important that you read the material carefully and be prepared to discuss it in class, as 10% of your final course grade will be based on your class participation; this means that you will need to speak up in every discussion. To help you prepare, and to assist the discussion leader(s), you will be asked to post at least two questions based on each week's reading assignment on the Sakai Forum no later than 5 pm the day before the discussion (to post your questions, go to the Sakai Forum, click 'Start a New Conversation', and insert your questions in the open text box). Note that 5% of your final course grade will be based on your turning in satisfactory questions each week.

A.2. Experimental Approach Presentation

Each student will be required to present (as part of a team of no more than 3 students) TWO 15 to 20-minute presentations on techniques used in the field of evo-devo. Each of your two presentations should cover the experimental goal of the technique(s), the technique's history and merit relative to older or alternative methods, the step-by-step process of the method, and caveats to interpretation. To give you guidance in developing the presentations, you are welcome to schedule an appointment with me.

B. Capstone Projects

There will be two categories of “capstone” projects: 1) a “News and Views” Article, and 2) a Grant Proposal.

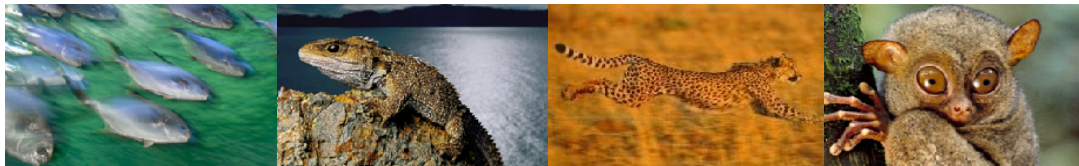
B.1. News and Views Article

A short paper assignment will allow you to demonstrate your abilities to explain and critically evaluate the scientific literature in writing. Modeled after a News and Views piece in *Nature* or a Perspective in *Science*, the goal of the short paper is to convey to a broad scientific audience why you find an article of your choice so exciting in terms of what it tells us about the ecology and evolution of development. Articles in this format do so by relating the context, findings, and significance of a scientific publication. We will read several articles of this format during the first part of the term, and therefore you will quickly become familiar with the more conversational style of this format as well as its purpose in providing additional historical and forward-looking context to the findings of the paper at hand. Your article should be a maximum of 3 pages, double spaced (NOTE: *you cannot prepare a News and Views piece on any of the articles that we discuss in class, nor can you prepare one on an article for which a News and Views or Perspectives piece has already been published.*)

B.2. Grant Proposal

The final assignment of the semester will give you the opportunity to synthesize what you have learned and apply it to a question and system of your choosing by writing a grant proposal. You will develop and pitch a compelling research program in the format of a National Science Foundation pre-proposal (1-page project summary and 4-page project description, single spaced; sample [successful!] proposals will be provided on Sakai). To give you additional guidance in developing your proposal, you're welcome to schedule an appointment with me.

This assignment will be completed in several stages to guide you toward generating a polished final draft. A half-page description of the research question and project objectives will be due in class about half way through the semester, at which time I will give you feedback on your plans. The final proposal is due on the last day of class.



VIII. Grade Determination

A. Grade Composition

Capstone Project: News and Views Article - 20% of your final grade[†]

Capstone Project: Grant Proposal - 25% of your final grade[†]

Student-Led Discussion (SLD) Presentations - 30% of your final grade (15% for each SLD)

Experimental Approach (EA) Presentations – 10% of your final grade (5% for each EA)

Class Participation - 10% of your final grade[§]

Questions for SDLs - 5% of your final grade[§]

[†]Ten (10) points (on a 100-point scale) per day after the deadline will be deducted for late capstone projects. Extensions will be allowed only in the event of a documented family or medical emergency.

[§]Because the aim of the class is for everyone to learn from each other's insights, successful lecture activities and discussions depend on everyone's attendance *and participation* (including weekly submission of questions). If you must miss a class, I request notification at least two classes prior to the planned absence. Unplanned absences from discussion will not be eligible for makeup credit except in the case of a documented illness or family emergency. Participation credit for excused absences will be earned through completion of a makeup written assignment.

B. Grading Scale

Your course grade will be determined as follows:

Final <u>average</u>	Course <u>grade</u> [*]
93+	A/H
92-90	A-/P
89-87	B+/P
86-83	B/P
82-80	B-/P
79-77	C+/L
76-73	C/L
72-70	C-/L
69-67	D+/L
66-63	D/L
62-60	D-/L
<60	F/F

^{*}undergraduate/graduate student grading scheme

IX. How to Succeed in this Class:

- 1) Attend all classes and *actively* participate in the discussions.
- 2) While reading papers for the SLD presentations, summarize the question being addressed and the take-home message of each paper *in your own words*.
- 3) For the SLD presentations, before you come to class, consider the readings in light of questions posted by your classmates so you will be prepared to talk about them.
- 4) Make connections with your classmates, so you can work together to understand the assigned readings and swap notes in the event you miss a class.
- 5) Dig deep into one or more topics/systems/approaches that excite you.
- 6) Help me (and the rest of the class) help you! Bring your questions about the material to class, and if they go unanswered, speak up during the class or come talk to me during office hours.



Date	Topic [†]	Expt. Approach [†]	Reading	Assignments Due
Aug. 11	Lecture 1: Introduction to the Class		Gilbert & Epel pp. 377-382	
Aug. 13	Lecture 2: Introduction to Evolutionary Biology		Gilbert & Epel Ch. 9	Sign-up for 2 Student-Led Discussion (SLD) & 2 Experimental Approaches (EA) Presentations
Aug. 18	FILM: <i>Charles Darwin and the Tree of Life</i>			
Aug. 20	ILD#1–Darwin’s Origin of Species: Variation under Domestication	EA#1: Measuring Natural Selection in the Wild	Pechenik Ch. 1	Discussion Qs (due day before)
Aug. 25	ILD#2–Darwin’s Origin of Species: Variation in Nature	EA#2: Radiometric Dating	Pechenik Ch. 2	Discussion Qs (due day before)
Aug. 27	ILD#3–Darwin’s Origin of Species: The Struggle for Existence	EA#3: Basic Phylogenetic Methods & Molecular Clocks	Pechenik Ch. 3	Discussion Qs (due day before)
Sept. 1	ILD#4–Darwin’s Origin of Species: Natural Selection	EA#4: Creating a Transgenic Organism	Pechenik Ch. 4	Discussion Qs (due day before)
Sept. 3	ILD#5–Darwin’s Origin of Species: Laws of Variation	EA#5: CRISPR/Cas9 Genome Editing	Pechenik Ch. 5	Discussion Qs (due day before)
Sept. 8	ILD#6–Darwin’s Origin of Species: Difficulties with the Theory	EA#6: Detecting Epigenetic Modifications	Pechenik Ch. 6	Discussion Qs (due day before)
Sept. 10	ILD#7–Darwin’s Origin of Species: Instinct	EA#7: Measuring Gene Expression	Pechenik Ch. 8	Discussion Qs (due day before)
Sept. 15	NO CLASS (watch the film “ <i>The Gene: An Intimate History</i> , Episodes 1 & 2” [4 hours] on: https://unctv.pbslearningmedia.org/resource/the-gene-full-film/the-gene-intimate-history/)			

Date	Topic	Expt. Approach	Reading	Assignments Due
Sept. 17	ILD#8–Open Discussion of the Film: “ <i>The Gene</i> ”			Discussion Qs (due day before)
Sept. 22	Lecture 3: Origins of Variation: Genetic Change		Gilbert & Epel pp. 382-403	
Sept. 24	SLD#1–Mutation-Led Evolution		Sakai (Carroll 2008; Santos et al. 2017)	Discussion Qs (due day before)
Sept. 29	Lecture 4: Origins of Variation: Environmentally Initiated Change		Gilbert & Epel Ch. 1, 2 & pp. 444-448	
Oct. 1	SLD#2–Epigenetic Inheritance		Sakai (Charlesworth et al. 2017; Hu & Barrett 2017)	Discussion Qs (due day before)
Oct. 6	Lecture 5: Phenotypic Plasticity & the Origins of Novelty		Gilbert & Epel Ch. 11	
Oct. 8	SLD#3–Plasticity-Led Evolution		Sakai (Levis & Pfennig 2016; Allf et al. 2016)	Discussion Qs (due day before)
Oct. 13	Lecture 6: The History of Life: What, How, & Why?		(Lecture notes)	Capstone Grant Proposal “rough draft”
Oct. 15	SLD#4–Developmental Symbiosis		Sakai (Funkhouser & Bordenstein 2013; Brucker & Bordenstein 2013)	Discussion Qs (due day before)
Oct. 20	Lecture 7: Comparative Development & Evolution		Gilbert & Epel pp. 403-429	
Oct. 22	SLD#5–Macroevolution		Sakai (Bhullar et al. 2012; Jackson 2019)	Discussion Qs (due day before)

Date	Topic	Expt. Approach	Reading	Assignments Due
Oct. 27	Lecture 8 (The Major Transitions in Evolution)		(Lecture notes)	
Oct. 29	SLD#6–Evolution of Multicellularity		Sakai (Grosberg & Strathmann 2007; Ratcliff et al. 2013)	Discussion Qs (due day before)
Nov. 3	Lecture 9: The Evolution of Sex, Sexes, & Sex Allocation		(Lecture notes)	
Nov. 5	SLD#7–Sex Determination		Sakai (Georges and Holleley 2018; Ge et al. 2018)	Discussion Qs (due day before)
Nov. 10	Lecture 10: Human Genetics, Evolution & Development		(Lecture notes)	Capstone News & Views Article
Nov. 12	SLD#8–Cultural Evolution		Sakai (Dunbar 1998; González-Forero & Gardner 2018)	Discussion Qs (due day before)
Nov. 17	Course Wrap Up			Capstone Grant Proposal

***** NOTE: THERE WILL BE NO FINAL EXAM *****

†Class discussions are indicated by blue font: ILD= *Instructor*-Led Discussion; SLD= *Student*-Led Discussion Presentation; EA= (Student-Led) *Experimental Approach* Presentation

NOTE: UNFORESEEN EVENTS MAY REQUIRE ME TO MAKE CHANGES TO THIS SCHEDULE – CHECK SAKAI FOR ANY SUCH CHANGES