Evolution and Ecology of Development

Course Description

Phenotypic variation is rampant in nature at all scales. Species differ: i.e., you would not be confused with a dandelion. Individuals within species differ: i.e., you and your neighbor are each unique. Individuals even differ with themselves over time: i.e., your summer tan will be a distant memory by the end of term. Much of this variation helps adapt organisms to their environments and over time has fostered major evolutionary transitions like the origin of vertebrates or the colonization of land from water. In this course, we will discover how and why such a remarkable and vast diversity of forms and functions has evolved. We will also consider why all possible forms do not exist: i.e., don't blame your parents for being born without wings.

To gain a comprehensive understanding of how biodiversity arises, we will explore the intersection of concepts and mechanisms from development, evolution, and ecology, as these processes are inextricably linked. The developmental systems by which seeds turn into trees or larvae turn into butterflies are the products of past evolution. However, as the palette upon which new mutations appear, developmental systems can bias or constrain what mutations are beneficial or even visible to natural selection and thus what new forms can arise. Finally, because the environment acts both as a source of cues that guide how development proceeds and as the source of selective pressures that drive or frustrate evolutionary change, a consideration of the ecological context is frequently critical to understanding both processes.

Learning Objectives

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

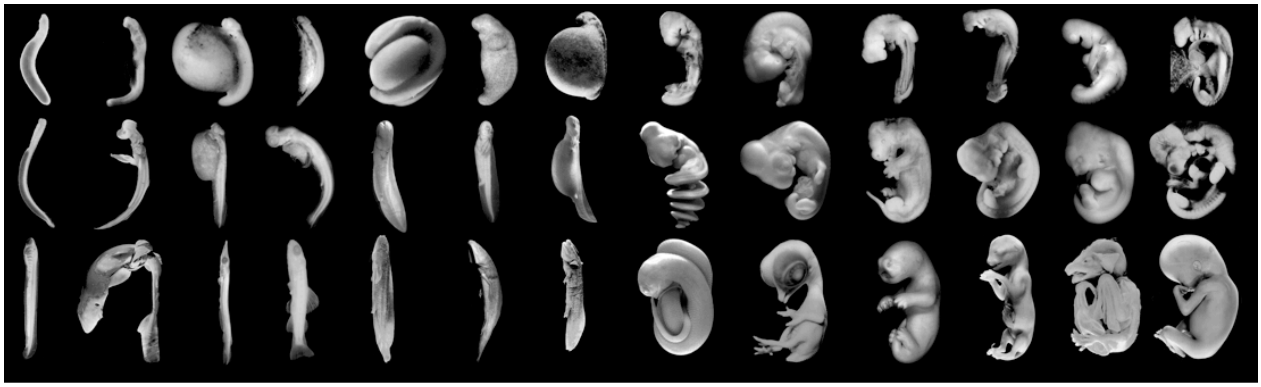
- Explain how an interdisciplinary approach involving genetics, development, evolutionary biology, and ecology can be used to understand the processes that generate patterns of biodiversity.
- List and describe major questions, findings, and experimental approaches in the field of ecological and evolutionary developmental biology.
- Discuss biological research using specialized terminology and defend your opinions.
- Critically evaluate and interpret the primary scientific literature.
- Combine factual material with deductive reasoning to propose hypotheses and future research directions

Course Format
This course is a hybrid lecture and seminar course. Monday class meetings will be in lecture format, though these classes may often involve breakout group activities in the course of the lecture as appropriate. The goals of the lectures will to be to introduce you to conceptual frameworks, historical context, and biological information relevant to the week's theme(s). Because many experimental approaches from diverse fields will be relevant, at the end of each Monday's lecture, a graduate student will present on an experimental approach relevant to the week's reading. Wednesday class meetings will be focused on discussions of the classic and recent papers from the scientific literature on the week's theme(s).

Required Text: Evolution, Development, and the Predictable Genome by David L. Stern, Roberts & Company (2011).

Recommended Additional Texts:
The Elements of Style by William Strunk, Jr. and E. B. White, 4th edition, Longman (1999)

From DNA to Diversity: Molecular Genetics and the Evolution of Animal Design by Sean B. Carroll, Jennifer K. Grenier, and Scott D. Weatherbee, Blackwell Science (2004).



Activities and Assignments:
There will be no exams in this course. Instead, you will be asked to demonstrate your mastery of learning objectives through a combination of weekly and capstone assignments. The goal of the weekly assignments is to help prepare you and the class for engaging the lecture material and participating in the group discussions each week. The goal of the capstone assignments is to flex and strengthen your scientific muscles and to model what biologists do in their careers by applying the biology, methods, and conceptual frameworks you will learn throughout the term to subjects and questions that fascinate you.

Weekly Assignments
Weekly Reading Responses and Activities: Every week, there will be a set of assigned readings. With the exception of the required textbook, the readings will be posted through the course Collab site. These readings will be the foundation for understanding the Monday lectures and Wednesday discussions. In preparation for Monday's class, you will be asked to complete a series of questions or activities designed to aid or extend your comprehension of the subject

material. These will be due electronically (by Collab or e-mail depending on the assignment) by noon on Monday each week.

Participation in Group Discussions: During the Wednesday group discussions, all students are expected to contribute questions, answers, and insights. Discussion will involve going through one or more of the week's assigned readings figure by figure and will often be centered on the discussion questions provided before class. However, the discussion may also move into unexpected but related topics.

Discussion Questions: Each week, a subset of the class will help the rest of the class prepare for discussion by writing discussion questions and posting them on the course Collab site. Given the size of the class, each person will be responsible for posting discussion questions 4 times during the course. Questions should be posted by Tuesday at 2pm to receive full credit.

Additional Reading Blurbs (undergraduate students only): Undergraduates assigned to provide discussion questions for a week will also be required to identify additional papers on the same theme that would be interesting to the class. Students will be responsible for posting a one-paragraph description of one article (also by Tuesday, 2pm), and they should be prepared to briefly highlight the article at the end of the Wednesday discussion period.

Experimental Approach Presentation (graduate students only): At the end of each Monday lecture, a graduate student will give a 5-10 minute presentation on one of the molecular, genetic, developmental, or computational techniques from an empirical paper to be discussed on Wednesday. The presentation should cover the experimental goal of the technique, the technique's history and merit relative to older or alternative methods, the step-by-step process of the method, and caveats to interpretation. Each graduate student will give two such presentations during the term. To give you guidance in developing the presentation, I request that you schedule an appointment with me to go over your slides in the week prior to your presentation.

Capstone Projects
More specific information about each of these projects will be covered in other handouts, but here are the basics.

1) Field Trip and Wiki Project. The class will take a field trip to the National Zoo and National Museum of Natural History on Saturday September 21st. The observations made during this trip will serve as the starting point for a midterm project where you will be asked to create a team wiki on the novelties of a focal set of species. The goal will be to demonstrate your grasp of the foundational concepts—phylogeny, adaptation, development, and gene regulation—introduced in the initial part of the course by considering the evolution of several derived traits in a fascinating taxonomic group of your team's choice. This will be a team project completed in assigned groups of three, but grading will be largely based on individual contributions. (Field Trip Sat. 9/21; Project Due Fri. 10/4, 5pm)

2) 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. (Maximum of 3 pages, double spaced; Due Fri. 10/25, 5pm)

3) 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. Like many investigators in the fields of eco-devo and evo-devo, 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). 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 Mon. 11/4 in class. A first draft of the proposal will be circulated to two peer reviewers by Mon. 11/25, 2pm. Everyone will review two proposals and return their comments by Mon. 12/2, 2pm. The final draft of the proposal is due Thu. 12/12, 11:59pm.

Ten 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 family or medical emergency.

How to Succeed in this Class:

1) Finish the reading assignments before lecture, and make ample notes while reading.
2) While reading papers for discussion, summarize the question being addressed and the take home message of each figure in your own words.
3) Reconsider the readings in light of discussion questions posted by your classmates before class so you will be prepared to talk about them.
4) Make connections with others in the class so you can work together to understand the assigned readings and swap notes in the event of an absence from class.
5) Take advantage of the framework provided by the capstone assignments to dig deep into one or more systems that excite you.
6) Help me (and the rest of the class), help you (and each other)! Bring your questions about the material to class, and if they go unanswered, post them on Collab or come to office hours.
7) Seek out additional resources as necessary to improve your research, writing and well being
    a. UVA Writing Center (http://www.engl.virginia.edu/undergraduate/writing/center)
    b. UVA Library (including document delivery and interlibrary loan services; http://www.library.virginia.edu/)
    c. Counseling and Psychological Services (http://www.virginia.edu/studenthealth/caps.html)

Grade Composition:

	UG	GS
Weekly Reading Responses / Activities[1]	10%	5%
Class Participation[2]	25%	25%
Discussion Questions	5%	5%
Additional Reading Blurbs (undergraduates)	5%	0%
Experimental Approach Presentations (grad students)	0%	10%
Field Trip Project	15%	15%
News and Views Article	15%	15%
Grant Proposal	25%	25%

[1] Grading will be on a check (full credit) / check-minus (half credit) system. You may miss or drop one assignment over the course of the term. Assignments turned in late but within a week of the deadline will be eligible for half credit.

[2] Because the aim is for everyone to learn from each other's insights, successful lecture activities and discussions depend on everyone's attendance and participation. If you have to 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 illness, injury, or family emergency. Participation credit for excused absences will be earned through completion of a makeup written assignment.

Grading Scale:

100-97	A+
96-93	A
92-90	A-
89-87	B+
86-83	B
82-80	B-
79-77	C+
76-73	C
72-70	C-
69-60	D
<60	F

Rounding: 96.5 = 97, 96.4999999999 = 96

Week	Day	Date	Topic	Exp. Approach	Reading	Due
1	Wed	8/28	Introduction to Evo-Eco-Devo			
	Fri	8/30				Background Knowledge Assessment
2	Mon	9/2	Descent w/ Modification 1: Phylogeny		Stern: Preface, Ch. 1, Ch. 2, Readings from Carroll, Kemp, and Gilbert + Epel	Pre-Class Assignment
	Wed	9/4	Discussion: Serial Homology and Novelty		Prudhomme 2011	DiscQs / Blurbs: Group A
3	Mon	9/9	Descent w/ Modification 2: Genes/Genomes	Reporter Gene Studies	Stern: Ch. 3, Gilbert Ch. 5	Pre-Class Assignment
	Wed	9/11	Discussion: Regulatory Evolution in Humans		King and Wilson 1975, McClean 2011	DiscQs / Blurbs: Group B
4	Mon	9/16	Descent w/ Modification 3: Development and Adaptation 1: Process		Stern Ch. 4 pp 49-59, Ch. 6; Gompel 2005	Pre-Class Assignment
	Wed	9/18	Discussion: Adaptationism and its Alternatives		Gould and Lewinton 1979, Lynch 2007	DiscQs / Blurbs: Group C
	Sat	**9/21**	**Field Trip to National Zoo and Museum of Natural History**			
5	Mon	9/23	Adaptation 2: Genetics of Microevolution	QTL Mapping / Positional Cloning	Stern Ch. 4 pp 59-72	
	Wed	9/25	Discussion: Developmental Genes in the Wild		Colosimo 2005; Barrett 2008, 2009	DiscQs / Blurbs: Group D
6	Mon	9/30	The Evolution of Gene Content		Stern Ch. 4 pp 72-78; Conant and Wolfe 2008	Pre-Class Assignment
	Wed	10/2	Discussion: Gene Duplication and Gene Loss		Preston and Hileman 2011, Demuth 2006	DiscQs / Blurbs: Group A
7	Mon	10/7	Epistasis, Historical Contigency, and Constraint	Ancestral Gene Reconstruction	Stern: Ch. 5, Futuyma 2010	Wiki Capstone Project Due
	Wed	10/9	Discussion: Historical		Ortlund 2007; Blount 2008	DiscQs / Blurbs:

			Contigency and Constraint			Group B
8	Mon	10/14	Reading Day - No Class			
	Wed	10/16	Debate: Coding vs. Regulatory Changes in Evolution		Stern: Ch. 8; Hoekstra and Coyne 2007; Carroll 2008; Lynch and Wagner 2008; Liao 2010; Streisfeld and Rausher 2011; Heffer 2013	Pre-Class Assignment
9	Mon	10/21	Convergence and Constraint Continued	RNAi Knockdown Methods (Catherine)	Stern: Ch. 7 and Historical Note; Losos 2011	Pre-Class Assignment
	Wed	10/23	Discussion: Convergent Evolution Case Studies		Tanaka 2009; Chan 2010	DiscQs / Blurbs: Group C
	Fri	10/25				N&V Capstone Project Due
10	Mon	10/28	Evolution and Evolvability of Gene Networks	Chip-Seq and DNase-Seq	True 2001 and Tuch 2008	Pre-Class Assignment
	Wed	10/30	Discussion: Network Evolution		Schmidt 2010 and Booth 2010	DiscQs / Blurbs: Group D
11	Mon	11/4	The Environment in Development		Gilbert + Epel: Ch 1	Grant Proposal Capstone Idea
	Wed	11/6	Discussion: Phenotypic Plasticity		Warkentin 1995, Higuchi 2013	DiscQs / Blurbs: Group A
12	Mon	11/11	Developmental Mechanisms of Plasticity	Detecting Epigenetic Modifications	Feil 2012	Pre-Class Assignment
	Wed	11/13	Discussion: Epigenetics and Maternal Effects		Kucharski 2008, Heo 2011	DiscQs / Blurbs: Group B
13	Mon	11/18	Evolution of Phenotypic Plasticity		Schlichting and Pigliucci Ch. 3; Galloway and Etterson 2007	Pre-Class Assignment
	Wed	11/20	Discussion: Costs and Limits of Plasticity		DeWitt 1995; Snell-Rood 2011	DiscQs / Blurbs: Group C
14	Mon	11/25	Guest Lecture: Plasticity, Range Size, and Climate			Grant Proposal Capstone Draft

			Change			
	Wed	11/27	Thanksgiving Break - No Class			
15	Mon	12/2	Genetic Assimilation / Genetic Accomodation / Baldwin Effect		Waddington 1942, 1957	Peer Review Due
	Wed	12/4	Discussion: Plasticity and the Origin of Novelty		Rajakumar 2012; Suzuki 2006	DiscQs / Blurbs: Group D
	Thu	12/12				Grant Proposal Capstone Final Draft Due