

**EVOLUTIONARY ECOLOGY**  
**ECOL 4500 / 6500**

**Lecture: TR 12:30-1:45 AM in Odum School of Ecology, room 117**  
**Discussion: W 11:15am-12:05 PM in Odum School of Ecology, room 12**

**Instructor:**

Dr. Jill Anderson  
Odum School of Ecology and Department of Genetics  
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**Office hours:**

Wednesdays 9:00 – 11:15 AM, and by appointment in Davison C314A

**Objectives:** Evolutionary ecology examines how the abiotic and biotic environment shapes evolutionary dynamics. This class will explore the fundamental concepts and techniques used in evolutionary ecology. We will examine general themes that cover a diversity of organisms in terrestrial, aquatic and marine ecosystems to highlight interactions among evolutionary and ecological processes. We will cover theory and applications, including examples in conservation and global change biology, phylogenetics, and community ecology.

This course is divided into three main sections: (1) Microevolution (agents and targets of selection, quantitative genetics, life history evolution, and population dynamics), (2) Macroevolution (phylogenetics, speciation, and coevolution), and (3) Community Ecology (evolutionary consequences of biotic interactions: competition, predation, disease and mutualisms). The last section draws on micro- and macro-evolutionary concepts.

**Course Requirements:** Students taking this course need to understand the basics of evolution and population ecology. Coursework equivalent to GENE 3000 and/or ECOL 3500 should provide this background. The course will consist of a combination of lectures, classroom activities, and discussions. Students will write weekly response papers to the readings and a research proposal on a topic of their choosing. In addition, students will take a mid-term and a final exam.

**Materials:** There is no textbook for this seminar. I will distribute readings on ELC.

**Values Statement:** I am committed to helping you continue to develop as scholars and scientists by creating an inclusive space and equitable learning environment in this class. Please use speech and actions that communicate respect for diversity and honor each individual's uniqueness. Diversity of race, skin color, ethnicity, sexual orientation, gender identity, country of origin, physical ability, and religion enriches our community. As a class, we will all respect every student's preferred pronouns.

**Accessibility Statement:** I am committed to helping every student succeed in this course. Your performance depends on active participation in classroom discussions and activities and excellent written work. If there are circumstances that may affect your ability to succeed, please speak with me at the beginning of the semester so that I can develop strategies to meet both your needs and the requirements of the course. I am happy to make accommodations for students with a documented disability. If you have a disability and need accommodations to participate fully in this class,

contact the UGA Disability Resource Center, 114 Clark Howell Hall, Athens, GA 30602. Phone: 706.542.8719 Fax: 706.542.7719 Email: dsinfo@uga.edu; <https://drc.uga.edu>. All accommodations must be approved through the UGA Disability Resource Center. Please note that accommodations cannot be provided retroactively.

### **Student responsibilities**

**Readings, attendance and participation:** To succeed in this course, you will need to attend, complete all readings, and participate in discussions. It is your responsibility to read assignments before class, prepare the response paper, and bring specific questions about the readings to class. We do not use a standard textbook for this course; therefore, attendance is crucial for success. ***I will provide ample opportunity for both introverts and extroverts to actively participate in class, through written work, collaborations with other students, and group discussions.***

**Student-led discussions:** During the semester, you will lead one discussion section. I ask students to meet with me prior to class to go over the strategy for the discussion. Student discussion leaders will be graded on preparedness and quality of discussion. Undergraduate students enrolled in ECOL 4500 will co-lead a discussion with a classmate. Graduate students enrolled in ECOL 6500 will be responsible for leading a full discussion on their own.

**Writing projects:** You will complete several writing projects for this course. The write-up for each assignment should be submitted electronically. Please see the relevant handouts for more information on these assignments.

**Response papers:** You will prepare short reports (1-2 page) on weekly readings. In summaries of empirical papers, please: 1) identify the research question, 2) briefly describe the methods, 3) relate the main results, 4) explain what is important about the paper, 5) briefly discuss what could have been improved, and 6) list 2-3 questions that you had about the study. In summaries of review articles, list questions that you had about the paper, or aspects that you found confusing. **Response papers will be due before class on the indicated day, generally Tuesday of each week** (see “Class schedule” on pp. 4-8). **Response papers will not be accepted after 9:30 AM on the due date.** Each response paper is worth 2.5 points. There are 16 response papers over the course of the semester, but you only need to complete 12 to get full credit for this activity. If you submit all 16 response papers, you can earn a maximum of 38 points (i.e., 8 bonus points).

**Grant proposal:** You will complete a grant proposal on a topic of your choosing relating to evolutionary ecology. **The purpose of this activity is to identify a topic and research question in need of further study, pose alternative hypotheses, identify predictions, and design an experiment.** Over the course of the semester, you will turn in the topic for your proposal, a summary including hypotheses (which will be peer-reviewed), and a final draft. Assume your budget is not a concern.

**Peer review:** The peer review process is central to the dissemination of new concepts, ideas, hypotheses, and results in science. During this semester, I will ask you to critique the grant proposal outline of one of your classmates. The objective of this assignment is twofold: 1) to acquaint you with the peer review process, and 2) to help you improve your own understanding of evolutionary ecology. The peer review of the grant outline will be done during class time.

**Late Policy:** Late assignments will be penalized 5% per day of the total available points. I will not accept late response papers or final papers (grant proposals). A paper will be considered “on time” if I receive an uncorrupted electronic version submitted on or before the deadline.

**Make-up exams:** There will be no makeup exams. Athletes and students who have an excused absence during the time of an exam need to arrange to take the exam in advance. If you fall ill before the exam, contact me as soon as possible and bring a doctor’s note explaining that you were unable to take the exam. In the case of an excused illness, your final exam will count as the final and the midterm.

**University Honor Code & Academic Honesty:** Students are expected to follow the University of Georgia Student Honor Code and should understand that every instance of a suspected violation will be reported. UGA Student Honor code: “I will be academically honest in all of my academic work and will not tolerate academic dishonesty of others.” A Culture of Honesty, the University's policy and procedures for handling cases of suspected dishonesty, can be found at

<https://honesty.uga.edu/>

You are responsible for informing yourself about the university’s standards before performing any academic work. Lack of knowledge of the academic honesty policy is not a reasonable explanation for a violation. Please ask if you have questions related to course assignments and the academic honesty policy. Any form of possible academic dishonesty will be reported to the UGA Office of the Vice President for Instruction.

**\*A note on plagiarism:** I encourage you to discuss ideas, concepts, and assignments with your peers. However, we expect that all work that you submit to be your own. **Please ensure you are familiar with rules of conduct regarding plagiarism, of other student’s work and of sources such as the primary literature and web sites. Any student found plagiarizing will receive an F in the course.** I suggest that you consult this website for more information on what constitutes plagiarism: <http://plagiarism.arts.cornell.edu/tutorial/index.cfm>.

**Classroom Behavior:** Please be respectful, arrive on time, put away cell phones during class, and refrain from web browsing, etc.

**Grading (300 points total):**

Attendance and *active* participation in class (lectures and discussions): 30 points

Brief response papers (1-2 pages): 30 points

Student-led discussions: 25 points

Midterm: 50 points

Grant proposal outline: 15 points

Peer review of proposal: 15 points

Final grant proposal: 75 points

Final exam: 60 points

**Grading scale**

A: 93.4-100%	C+: 77.7-79.9%
A-: 90-93.3%	C: 73.4-77.6%
B+: 87.7-89.9%	C-: 70-73.3%
B: 83.4-87.6%	D: 60-69.9%
B-: 80-83.3%	F: below 60%

**Class Structure:** Classes on Tuesdays and Thursdays will be a combination of lectures, activities, and discussions. In our weekly 50 minute discussion section on Wednesdays, we will focus on readings from the primary literature. I expect students to participate actively and lead one discussion.

**Official University Policy:** The course syllabus is a general plan for the course; deviations announced to the class by the instructor may be necessary. All academic work must meet the standards contained in *A Culture of Honesty*. Students are responsible for informing themselves about those standards before performing any academic work.

**Mental Health and Wellness Resources:** If you or someone you know needs assistance, you are encouraged to contact Student Care and Outreach in the Division of Student Affairs at 706-542-7774 or visit <https://sco.uga.edu>. They will help you navigate any difficult circumstances you may be facing by connecting you with the appropriate resources or services. UGA has several resources for a student seeking mental health services (<https://www.uhs.uga.edu/bewelluga/bewelluga>) or crisis support (<https://www.uhs.uga.edu/info/emergencies>). If you need help managing stress anxiety, relationships, etc., please visit BeWellUGA (<https://www.uhs.uga.edu/bewelluga/bewelluga>) for a list of FREE workshops, classes, mentoring, and health coaching led by licensed clinicians and health educators in the University Health Center. Additional resources can be accessed through the UGA App.

**Class Schedule:** The class schedule is subject to modification due to availability of guest speakers, publication of new and relevant articles, etc. Readings are posted on ELC, but may be updated as the semester proceeds. Citations for the readings are listed below the class schedule. Please read the required papers before class on the indicated date. Response papers are due for required readings only. I have also listed recommended readings if you would like additional information.

Date	Topic/Activity	Readings	Discussion leader	Assignment
TH, 1/10	Introduction to Evolutionary Ecology		Anderson	Assigned: (1) Grant proposal (2) Response papers
T, 1/15	Microevolution: Natural selection and adaptive evolution	Required for response paper: [1, 2]	Anderson	Due: Response paper 1
W, 1/16	Discussion prompts: What is fitness? Why do studies often quantify <i>components</i> of fitness? What would be the ideal metric of fitness? Why manipulate traits in field studies? How do researchers estimate selection in nature?		Anderson	
TH, 1/17	Microevolution: Estimating selection in nature.		Anderson	
T, 1/22	Microevolution: Agents of selection	Required for response paper: [3, 4]  Recommended: [5, 6]	Anderson	Due: Response paper 2
W, 1/23	Discussion prompts: Why is it important to understand agents and targets of selection? Is evolution fast enough to affect ecological dynamics?		(1) _____ (2) _____	
TH, 1/24	Microevolution: Targets of selection.		Anderson	
T, 1/29	Microevolution: Local adaptation.	Required for response paper: [7, 8]	Anderson	Due: Response paper 3
W, 1/30	Discussion prompts: What is local adaptation? When might local adaptation evolve? What factors restrict the evolution of local adaptation?		(3) _____ (4) _____	
TH, 1/31	Microevolution: Gene flow		Anderson	
T, 2/5	Microevolution: Migration-selection balance and source-sink dynamics	Required for response paper: empirical [9] and review: read pp. 787-788 of [10] Recommended: [11]	Anderson	Due: Response paper 4

Date	Topic/Activity	Readings	Discussion leader	Assignment
W, 2/6	Discussion prompts: When does gene flow promote vs. constrain adaptive evolution?		(5) _____ (6) _____	
TH, 2/7	Microevolution: Quantitative genetics I		Anderson	
T, 2/12	Microevolution: Quantitative genetics II	Required for response paper: [12, 13] Recommended: [14]	Anderson	Due: Response paper 5 Due: Topic for grant proposal
W, 2/13	Discussion prompts: Why focus on additive genetic variation? Is total genetic variation useful? Dissect the formula $R=h^2S$		(7) _____ (8) _____	
TH, 2/14	Microevolution: Genetic constraints on adaptation		Anderson	
T, 2/19	Life history evolution: Fitness tradeoffs and the cost of reproduction	Required for response paper on senescence: [15, 16] Recommended: [17-19]	Anderson	Due: Response paper 6
W, 2/20	Discussion prompts: How do genetic tradeoffs across fitness components influence life history evolution? What factors underlie the evolution of aging (senescence)?		(9) _____ (10) _____	
TH, 2/21	Life history evolution: Senescence		Anderson	
T, 2/26	Writing workshop: In class peer review of grant outline (research questions and hypotheses). Useful readings: [20, 21]		Students	Due: Grant abstract: Research question and hypotheses
W, 2/27	Review for midterm. Please bring your questions to discussion section.		Anderson	
TH, 2/28	Midterm exam			
T, 3/5	Life history evolution: Phenotypic plasticity	Required for response paper: empirical [22] and review [23] Recommended: [24, 25]	Anderson	Due: Response paper 7
W, 3/6	Discussion prompts: Under what environmental conditions would natural selection favor phenotypic plasticity? What factors constrain the evolution of plasticity?		(11) _____ (12) _____	

Date	Topic/Activity	Readings	Discussion leader	Assignment
TH, 3/7	Life history: Demography and population dynamics	Required for response paper: [26, 27]	Anderson	Due: Response paper 8  Due: Peer review of grant outline
3/11	Spring Break, no class			
T, 3/19	Macroevolution: Phylogenetics I	[28, 29]	Anderson	Due: Response paper 9. This assignment has a different format than the other response papers. You only need to complete Tree Thinking Quizzes I and II in the supplementary materials at the bottom of Baum et al. (2005). These quizzes are on pp. 4-18. I will not deduct points for incorrect answers. This is an opportunity for you to test your knowledge of reading phylogenetic trees.
W, 3/20	Discussion prompts: Why are phylogenies central to evolutionary biology? Be sure you understand how to read a tree.		Anderson	
TH, 3/21	Macroevolution: Speciation	Required for response paper: [30, 31]  Recommended: [32, 33]	Anderson	Due: Response paper 10
T, 3/26	Evolutionarily Stable Strategies	Required for response paper: [34-36]	Anderson	Due: Response paper 11
W, 3/27	Discussion prompts: What insights can we gain about the evolution of cooperation from game theory?		(13) _____  (14) _____	
TH, 3/28	Bet hedging and variable environments	Recommended: [37, 38]	Anderson	
T, 4/2	Genetics of speciation.	Required for response paper: [39]		Due: Response paper 12

Date	Topic/Activity	Readings	Discussion leader	Assignment
W, 4/3	Discussion prompts: What ecological and geographic factors contribute to reproductive isolation? Do you think the focus on geographic modes of speciation has been productive?		(15) _____ (16) _____	
TH, 4/4	Evolutionary consequences of biotic interactions		Anderson	
T, 4/9	Biotic interactions: Competition	Required for response paper on the Red Queen Hypothesis [40] and character displacement: [41] Recommended: [42, 43]	Anderson	Due: Response paper 13
W, 4/10	Discussion prompts: Why do species often show exaggerated divergence in traits when they co-occur in sympatry?		(17) _____ (18) _____	
TH, 4/11	Biotic interactions: Herbivory		Anderson	
T, 4/16	Biotic interactions: Evolutionary ecology of disease	Required for response paper: [44, 45] Recommended: [46]	Anderson	Due: Response paper 14
W, 4/17	Discussion prompts: Why are some pathogens more virulent than others?		(19) _____ (20) _____	
TH, 4/18	Biotic interactions: Kin selection and altruism		Anderson	
T, 4/23	Biotic interactions: Mutualisms	Required for response paper on cheating in mutualisms and cheating [47] and kin selection: [48]	Anderson	Due: Response paper 15
W, 4/24	Discussion: What constrains cheating in mutualistic interactions? What is inclusive fitness, and why is it germane to altruism?		(21) _____ (22) _____	
TH, 4/25	Global Change: Eco-Evolutionary consequences		Anderson	
T, 4/30	Global change II	Required for response paper: [49] Piao, 2019 #9762}[50, 51] Recommended: [52, 53]	Anderson	Due: Response paper 16 Due: Grant proposal



Date	Topic/Activity	Readings	Discussion leader	Assignment
T, 5/7	Final exam (Cumulative). 12:00-3:00 PM, Odum School, room 117			

Assigned (and recommended) articles:

1. Brodie, E.D., A.J. Moore, and F.J. Janzen, *Visualizing and quantifying natural selection*. Trends in Ecology & Evolution, 1995. **10**(8): p. 313-318.
2. Santangelo, J.S., K.A. Thompson, and M.T.J. Johnson, *Herbivores and plant defences affect selection on plant reproductive traits more strongly than pollinators*. Journal of Evolutionary Biology, 2019. **32**(1): p. 4-18.
3. Calsbeek, R. and D.R. Cox, *Experimentally assessing the relative importance of predation and competition as agents of selection*. Nature, 2010. **465**: p. 613-616.
4. Campbell-Staton, S.C., et al., *Winter storms drive rapid phenotypic, regulatory, and genomic shifts in the green anole lizard*. Science, 2017. **357**(6350): p. 495.
5. Linnen, C.R., et al., *Adaptive evolution of multiple traits through multiple mutations at a single gene*. Science, 2013. **339**(1312-1316).
6. Weber, J.N., B.K. Peterson, and H. Hoekstra, *Discrete genetic modules are responsible for the evolution of complex burrowing behaviour in deer mice*. Nature, 2013. **493**: p. 402-405.
7. Hereford, J. and A.A. Winn, *Limits to local adaptation in six populations of the annual plant *Diodia teres**. New Phytologist, 2008. **178**(4): p. 888-896.
8. Hereford, J., *A quantitative survey of local adaptation and fitness trade-offs*. American Naturalist, 2009. **173**: p. 579-588.
9. Saccheri, I., et al., *Selection and gene flow on a diminishing cline of melanic peppered moths*. Proceedings of the National Academy of Sciences, 2008. **105**: p. 16212-16217.
10. Slatkin, M., *Gene flow and the geographic structure of natural populations*. Science, 1987. **236**: p. 787-792.
11. Farkas, T.E., et al., *Evolution of camouflage drives rapid ecological change in an insect community*. Current Biology, 2013. **23**: p. 1835-1843.
12. Barrett, R.D.H. and H. Hoekstra, *Molecular spandrels: tests of adaptation at the genetic level*. Nature Reviews Genetics, 2011. **12**: p. 767-780.
13. Etterson, J.R. and R.G. Shaw, *Constraint to adaptive evolution in response to global warming*. Science, 2001. **294**: p. 151-154.
14. Barrett, R.D.H., et al., *Rapid evolution of cold tolerance in stickleback*. Proceedings of the Royal Society B-Biological Sciences, 2011. **278**: p. 233-238.
15. Read, A.F., P.A. Lynch, and M.B. Thomas, *How to make evolution-proof insecticides for malaria control*. PloS Biology, 2009. **7**(4): p. e1000058.
16. Rose, M., et al., *What is Aging?* Frontiers in Genetics, 2012. **3**: p. 134.
17. Keller, L.F. and M. Genoud, *Extraordinary lifespans in ants: a test of evolutionary theories of aging*. Nature, 1997. **389**: p. 958-960.
18. Velando, A., H. Drummond, and R. Torres, *Senescent birds redouble reproductive effort when ill: confirmation of the terminal investment hypothesis*. Proceedings of the Royal Society B, 2006. **273**: p. 1443-1448.

19. Roach, D., C.E. Ridley, and J. Dudycha, *Longitudinal analysis of Plantago: Age-by-environment interactions reveal aging*. *Ecology*, 2009. **90**(6): p. 1427-1433.
20. Gopen, G.D. and J.A. Swan, *The science of scientific writing*. *American Scientist*, 1990. **78**: p. 550-558.
21. Carraway, L., *Improve scientific writing and avoid perishing*. *American Midland Naturalist*, 2006. **155**: p. 383-394.
22. Agrawal, A.A., *Induced Responses to Herbivory and Increased Plant Performance*. *Science*, 1998. **279**(5354): p. 1201.
23. Miner, B.G., et al., *Ecological consequences of phenotypic plasticity*. *Trends in Ecology & Evolution*, 2005. **20**(12): p. 685-692.
24. Spitze, K. and T. Sadler, *Evolution of a generalist genotype: Multivariate analysis of the adaptiveness of phenotypic plasticity*. *The American Naturalist*, 1996. **148**: p. S108-S123.
25. DeWitt, T.J., A. Sih, and D.S. Wilson, *Costs and limits of phenotypic plasticity*. *Trends in Ecology & Evolution*, 1998. **13**(2): p. 77-81.
26. Metcalf, C.J. and S. Pavard, *Why evolutionary biologists should be demographers*. *Trends in Ecology & Evolution*, 2007. **22**: p. 205-212.
27. Sheth, S.N. and A.L. Angert, *Demographic compensation does not rescue populations at a trailing range edge*. *Proceedings of the National Academy of Sciences*, 2018. **115**(10): p. 2413-2418.
28. Baum, D.A., S. Smith, and S. Donovan, *The Tree-thinking challenge*. *Science*, 2005. **310**: p. 979-980.
29. Ward, P., *The phylogeny and evolution of ants*. *Annual Review of Ecology, Evolution and Systematics*, 2014. **45**: p. 23-43.
30. Edwards, S.V., et al., *Speciation in birds: Genes, geography, and sexual selection*. *Proceedings of the National Academy of Sciences*, 2005. **102**(suppl 1): p. 6550.
31. Seehausen, O., J.J.M. van Alpen, and F. Witte, *Ciclid fish diversity threatened by eutrophication that curbs sexual selection*. *Science*, 1997. **277**: p. 1808-1811.
32. Seehausen, O. and C.E. Wagner, *Speciation in freshwater fishes*. *Annual Review of Ecology, Evolution and Systematics*, 2014. **45**: p. 621-651.
33. McKinnon, J.S., et al., *Evidence for ecology's role in speciation*. *Nature*, 2004. **429**: p. 294-298.
34. Flaxman, S., *The evolutionary stability of mixed strategies*. *Trends in Ecology & Evolution*, 2000. **15**(12): p. 482-484.
35. Axelrod, R. and W.D. Hamilton, *The evolution of cooperation*. *Science*, 1981. **211**(4489): p. 1390-1396.
36. Turner, P.E. and L. Chao, *Prisoner's dilemma in an RNA virus*. *Nature*, 1999. **398**(6726): p. 441-443.
37. Philippi, T. and J. Seger, *Hedging one's evolutionary bets, revisited*. *Trends in Ecology & Evolution*, 1989. **4**(2): p. 41-44.
38. Koons, D.N., C.J. Metcalf, and S. Tuljapurkar, *Evolution of Delayed Reproduction in Uncertain Environments: A Life - History Perspective*. *The American Naturalist*, 2008. **172**(6): p. 797-805.
39. Zuellig, M.P. and A.L. Sweigart, *Gene duplicates cause hybrid lethality between sympatric species of Mimulus*. *PLOS Genetics*, 2018. **14**(4): p. e1007130.

40. Brockhurst, M.A., et al., *Running with the Red Queen: the role of biotic conflicts in evolution*. Proceedings of the Royal Society B, 2014. **281**: p. 20141382.
41. Grant, P.R. and B.R. Grant, *Evolution of character displacement in Darwin's finches*. Science, 2006. **313**: p. 224-226.
42. Martin, R.A. and D.W. Pfennig, *Evaluating the targets of selection during character displacement*. Evolution, 2011. **65**: p. 2946-2958.
43. Stuart, Y.E. and J.B. Losos, *Ecological character displacement: glass half full or half empty?* Trends in Ecology & Evolution, 2013. **28**: p. 402-408.
44. de Roode, J.C., A.J. Yates, and S. Altizer, *Virulence-transmission trade-offs and population divergence in virulence in a naturally occurring butterfly parasite*. Proceedings of the National Academy of Sciences, 2008. **105**(21): p. 7489-7494.
45. Ezenwa, V.O. and A.E. Jolles, *Opposite effects of anthelmintic treatment on microbial infection at individual versus population scales*. Science, 2015. **347**(6218): p. 175.
46. Gilbert, G.S., *Evolutionary ecology of plant diseases in natural ecosystems*. Annual Review of Phytopathology, 2002. **40**: p. 13-43.
47. Porter, S. and E.L. Simms, *Selection for cheating across disparate environments in the legume-rhizobium mutualism*. Ecology Letters, 2014. **17**: p. 1121-1129.
48. Foster, K.R., T. Wenseleers, and F. Ratnieks, *Kin selection is the key to altruism*. Trends in Ecology & Evolution, 2006. **21**: p. 57-60.
49. Bell, G. and A. Gonzalez, *Adaptation and Evolutionary Rescue in Metapopulations Experiencing Environmental Deterioration*. Science, 2011. **332**: p. 1327-1330.
50. Champion, C., et al., *Rapid shifts in distribution and high-latitude persistence of oceanographic habitat revealed using citizen science data from a climate change hotspot*. Global Change Biology, 2018. **24**(11): p. 5440-5453.
51. Campbell-Staton, S.C., et al., *Parallel selection on thermal physiology facilitates repeated adaptation of city lizards to urban heat islands*. Nature Ecology & Evolution, 2020. **4**(4): p. 652-658.
52. Carlson, S., C.J. Cunningham, and P. Westley, *Evolutionary rescue in a changing world*. Trends in Ecology & Evolution, 2014. **29**(9): p. 521-530.
53. Smith, T.B., et al., *Prescriptive evolution to conserve and manage biodiversity*. Annual Review of Ecology, Evolution and Systematics, 2014. **45**: p. 1-22.