Course Title: Is Evolution Predictable?

Prerequisite: BIOL 3020 or permission from instructor
Course Materials: *Improbable Destinies: Fate, Chance and the Future of Evolution* (2017) by Jonathan Losos. Additional articles from the primary literature are available on the website.
Instructor: Mike Hague, PhD Candidate, Brodie Lab
Office Hours: Thurs. 2-4pm (GIL 073A) or by appointment
Email: mh6nf@virginia.edu
Course Website: https://wordpress.its.virginia.edu/18F_BIOL4585_PREDICT/

Course Description: Is evolution predictable? Convergent adaptations like camera-type eyes and prey toxins have evolved repeatedly in different species faced with the same evolutionary challenge. Or, could evolution be unpredictable? Many bird species have adapted to high-altitude conditions through disparate evolutionary changes at the genetic level. In this discussion-based seminar, you will learn about convergent adaptations and explore what happens when we replay the evolutionary tape of life and test for predictability.

The primary goal of this class is to synthesize exciting new research on the predictability of evolution. In doing so, you will learn to find and read new publications from the primary literature. Each week, a new student will lead class discussion on a recent scientific publication. Discussion leaders will help their classmates identify the researchers' questions, hypotheses, and key findings, and then contextualize the study into boarder understandings of evolution and ecology. By discussing new research each week, you will practice decoding scientific literature, which can seem impenetrably dense at first glance.

Learning Objectives: By fully participating in classroom activities, at the end of the course you will be able to:

- Use examples from the primary literature to describe why biases in the evolutionary process may (or may not) make adaptation predictable.
- Detail how scientists collect and interpret data in evolutionary biology.
- Use online resources to locate newly published research from the primary literature.
- Evaluate the quality of new research and integrate findings into your broader understanding of evolution and ecology.
- Share your complex scientific ideas with peers and non-scientists through written and oral communication.

Class Format and Student Expectations: Class will begin each week with a short 15-minute quiz on the assigned reading. The rest of the class period will consist of student-led discussion on an assigned reading from the primary literature. I will help guide the direction of discussion, but you *must* come prepared each week to both ask and answer questions about the readings. Each week, a new student leader will begin with a 15-minute presentation on important background information, followed by an open discussion about the readings. I hope by the end of the semester you feel comfortable sharing your scientific ideas in a group of your peers.

Assessments:

- **Class Participation:** This discussion-based seminar is fundamentally dependent on class participation. For discussion to thrive, students must arrive to class each week having carefully read and reflected on the reading. Active participation includes asking questions and sharing your thoughts during discussion. The class will benefit from a diversity of backgrounds and perspectives. If something is unclear, ask a question! In the first week of class, you will work with your classmates to develop a rubric that I will use to grade participation.

- **Optional Reading Responses:** Before class each week, you have the option to write a one-paragraph reading response on the class blog at our website. If something confused you, explain. What needs further clarification in class? If other students have already posted, you can read and respond to their posts. The goal is to clarify your thinking and get discussion started online before class. **These online responses are optional.** Students who post a reading response by 5pm the night before class **will receive a bonus point** that can be used to make up for missed points on that day's quiz.

- **Reading Comprehension Quizzes**: Each week, we will begin class with a quick short-answer quiz question about the assigned reading. The quizzes are designed to assess whether you critically read the assignment and prepared for a meaningful discussion in class. No curveballs. Quizzes are open-note, so I strongly encourage you to write notes, definitions, and questions in the margins while you read.

- **Discussion Leader:** You will each sign up to take a turn at leading class discussion. Your goal is to present important background information on the week's reading assignment, and then focus discussion on aspects of the research you found important, confusing, and/or interesting. I encourage you to meet with me during office hours for help developing your discussion plan. To provide examples, I will lead discussion for the first few weeks of the semester. See Discussion Leader Assignment handout on the course website.

- **Semester-Long Popular Print Project:** Biologists have the responsibility of communicating new research to their colleagues and the general public. Over the course of the semester, you will select a recent scientific publication related to class (since 2014) and write a popular print piece that reports on the new research to the general public. To provide examples, we will couple the primary literature with readings from *Improbable Destinies*, a new popular print book by evolutionary biologist Jonathan Losos. At the end of the semester, you will present your piece to the class. See Popular Print Assignment handout on the course website.

Grade Composition:

Assignment	Value
Class Participation	30%
Reading Comprehension Quizzes	20%
Discussion Leader	10%
Popular Print Piece Rough Draft (**due Oct 31**)	5%
Peer Evaluation of Popular Print Piece (**due Nov 7**)	5%
Popular Print Piece (**due Nov 28**)	20%
Presentation of Print Piece (**Dec 5**)	10%

Office Hours: I strongly encourage you to visit during office hours, particularly when you are planning your guide for class discussion. Talking through ideas can help to clarify your thinking. If office hours do not work with your schedule, please email me to set up another time.

Academic Integrity: Placing your name on your work confirms that you neither received nor gave aid in completing your assignment. You must properly cite the scholarship of others, especially when you are presenting as a discussion leader. Of course, you are expected to comply with the UVA Honor System.

Course Schedule: The course is organized around two major questions: (1) How do convergent traits evolve through changes at the underlying genetic level? and (2) How predictable is the evolutionary process?

Week	Class	Reading Due
Aug 29 1	How to learn about new scientific research (while avoiding clickbait)	*Improbable Destinies* (ID) pp. 1-24
Sept 5 2	Island anoles: What is convergent evolution?	ID pp. 27-79 Sign up for email alerts Losos et al. 1998
Sept 12 3	Darwin's finches: Can evolution really be predicted?	ID pp. 81-107 *The New York Times* piece Grant and Grant 2002
Sept 19 4	Trinidad guppies: Intro to experimental evolution	ID pp. 111-179 Reznick et al. 1990
Sept 26 5	Armored sticklebacks: Linking phenotypes to underlying genes	ID pp. 181-216 Colosimo et al. 2005
Oct 3 6	Garter snakes and their deadly prey: Toxins and (co)evolution ***First student presentation*** ***Select manuscript for popular print piece***	Brodie and Brodie 2015

Oct 10 7	Monarchs and milkweed: Toxins and (co)evolution	Dobler et al. 2012
Oct 17 8	Domesticated zombie fungus: A wild story of recurrent (co)evolution	*The Atlantic* piece Matsuura et al. 2018
Oct 24 9	Experimental evolution: Adaptation in a test tube	ID pp. 220-262 Blount et al. 2008
Oct 31 10	Experimental evolution: Mapping the trajectory of evolution ***Popular print piece rough draft due***	ID pp. 263-309 Weinreich et al. 2006
Nov 7 11	Birds at high-altitudes: Protein evolution and epistasis ***Peer evaluation of popular print piece due***	Natarajan et al. 2016
Nov 14 12	Garter snakes and their deadly prey: Historical contingency	*The Washington Post* piece McGlothlin et al. 2016
	Thanksgiving	
Nov 28 13	Cryptic stick insects: Synthesis of ideas ***Popular print piece due***	Nosil et al. 2018
Dec 5 14	Presentations of popular print pieces	

Readings from Primary Literature

Blount, Z. D., C. Z. Borland, and R. E. Lenski. 2008. Historical contingency and the evolution of a key innovation in an experimental population of Escherichia coli. Proc. Natl. Acad. Sci. 105:7899–7906.

Brodie III, E. D., and E. D. Brodie Jr. 2015. Predictably convergent evolution of sodium channels in the arms race between predators and prey. Brain. Behav. Evol. 86:48–57.

Dobler, S., S. Dalla, V. Wagschal, and A. A. Agrawal. 2012. Community-wide convergent evolution in insect adaptation to toxic cardenolides by substitutions in the Na, K-ATPase. Proc. Natl. Acad. Sci. 109:13040–13045.

Grant, P. R., and B. R. Grant. 2002. Unpredictable evolution in a 30-year study of Darwin's finches. Science 296:707–711.

Losos, J. B., T. R. Jackman, A. Larson, K. de Queiroz, and L. Rodríguez-Schettino. 1998. Contingency and determinism in replicated adaptive radiations of island lizards. Science 279:2115–2118.

Matsuura, Y., M. Moriyama, P. Lukasik, D. Vanderpool, M. Tanahashi, X.-Y. Meng, J. P. McCutcheon, and T. Fukatsu. 2018. Recurrent symbiont recruitment from fungal parasites in cicadas. Proc. Natl. Acad. Sci. 201803245.

McGlothlin, J. W., M. E. Kobiela, C. R. Feldman, T. A. Castoe, S. L. Geffeney, C. T. Hanifin, G. Toledo, F. J. Vonk, M. K. Richardson, E. D. Brodie Jr., M. E. Pfrender, and E. D. Brodie III. 2016. Historical contingency in a multigene family facilitates adaptive evolution of toxin resistance. Curr. Biol. 26:1616–1621.

Natarajan, C., F. G. Hoffmann, R. E. Weber, A. Fago, C. C. Witt, and J. F. Storz. 2016. Predictable convergence in hemoglobin function has unpredictable molecular underpinnings. Science 354:336–339.

Nosil, P., R. Villoutreix, C. F. de Carvalho, T. E. Farkas, V. Soria-Carrasco, J. L. Feder, B. J. Crespi, and Z. Gompert. 2018. Natural selection and the predictability of evolution in Timema stick insects. Science 359:765–770.

Reznick, D. A., H. Bryga, and J. A. Endler. 1990. Experimentally induced life-history evolution in a natural population. Nature 346:357–359.

Weinreich, D. M., N. F. Delaney, M. A. DePristo, and D. L. Hartl. 2006. Darwinian evolution can follow only very few mutational paths to fitter proteins. Science 312:111–114.