Biology 488/588
Evolutionary Processes
Fall 2014

Instructor: Matt Streisfeld
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Meeting Times: M/W 4:00-5:20
Location: 12 Pacific

Course Description: A major goal of evolutionary biology is to understand the processes that generate and maintain patterns of variation in nature. In addition, it is well-known that organisms routinely show a remarkable fit with their environments, suggesting that these phenotypes are adaptive. However, there are several ecological and evolutionary processes that can operate to produce similar patterns of phenotypic variation in nature. So what are the tools that we - as evolutionary biologists - use to determine whether a phenotypic trait is adaptive in nature? The main goal of this course is to learn how evolutionary biologists experimentally study adaptation. Such a course is interdisciplinary, in that it unites several areas of biology, including ecology, genetics, statistics, molecular biology, and genomics. By the end of the term, you will have an appreciation for the different techniques and skills that are required to understand the evolutionary process.

Learning outcomes:

- Demonstrate how the evolutionary process is used to understand the process of adaptation
- Proficiency in critical thinking based on evaluation of data from primary literature
- Analyze data from primary literature using statistical and population genetic approaches
- Develop verbal and written communication skills through in-class discussion and assignments

Prerequisite: BI 380, Evolution; or Instructor approval

Details: This is an advanced, upper-level biology course. It should be challenging, but fun. Our meetings will be mostly discussion-based, but I will lecture as well. **<u>I expect that you will come prepared to each class for a lively discussion.</u>** This is an advanced course in evolutionary biology. As such, I expect that you are comfortable with basic evolutionary theory, such as population genetics. To make sure that we are on the same page, during the first week, I will provide you with an overview of the basic concepts that you will need to understand to be successful in this class. However, if these topics are not familiar to you or if you would like a better foundation in basic evolutionary theory, I strongly recommend that you do some additional background reading. If you would like information on appropriate reading, please see me.

Because the statistics, techniques, and advances in this area are ever-changing, there is no textbook that covers all of the relevant topics. Therefore, we will use the primary literature as our guide to the approaches that currently are being used in the field. Starting in week 2, we will begin each class period with a discussion about one or two papers. We will focus on the merits of the methods used and the major implications of the results identified by the investigators. To make sure that you have the appropriate background to critically evaluate each paper, I will end the previous class with an approximately 30-minute lecture on the upcoming topic.

Readings: Papers from the primary literature constitute all of the reading for the course. At the end of the syllabus is a list of the readings that we will work through during the term. All papers will be available on the course blackboard site as pdfs for download. Readings must be completed by the time of the class meeting in which they will be discussed. **<u>Class participation is essential to an intellectually lively course; it will also contribute to your grade.</u>**

I have chosen these papers because they are either technical descriptions of a relevant approach in the field or because they represent exemplar cases that experimentally use these approaches. Many of the papers will contain lots of technical information. It is OK if you don't understand everything when you read the paper. The purpose of the discussion is for the entire class to work through the papers to gain a better understanding of the material. **<u>You should come to class prepared with questions about what you didn't understand.</u>** Some questions to ask yourself when you read each paper:

- What is the purpose of this paper?
- What is the main question that the authors ask?
- What are the main findings? Can I explain what each figure represents?
- Do the findings support the conclusions that the authors draw?

Quizzes: There will be a series of 5 short pop-quizzes spread throughout the course. The quizzes will test your careful reading of the papers. Their purpose is to ensure that you come prepared to class each day and have critically read and evaluated the papers. If you read the papers carefully and come to class each day, the quizzes will be easy. Each quiz should take no more than 5-7 minutes to complete. I will drop the lowest score from your final grade. There will be no make-up quizzes without medical justification.

Critical Review: This assignment is due via email as a word (ot text) document by 5pm the day it is due. Scientific writing is a skill that only can be mastered with practice. This is an excellent opportunity to develop these skills. To promote your ability to summarize and evaluate scientific research succinctly, each student will submit a **2-page (MAXIMUM)** critical review on a recent paper. Reviews should be typed, double-spaced, no less than 11-point, with 1-inch margins. I will provide you with a list of 3 papers, and you must select <u>one</u> to critique. Reading related papers on the topic may help you with this, but the review should focus on the single paper from my list. As a guideline, you can look at the commentary articles in recent issues of the journal *Science* (called 'Perspectives') or *Nature* (called 'News and Views'). In addition to your careful attention to ***<u>making this paper well-written</u>***, your review will be graded on its ability to:

- Give a clear picture of the idea(s), concepts, or hypotheses that motivated the research. Why is the research interesting? What topic(s) that have been discussed in class does this research touch on?
- Provide a concise explanation of the methods and major findings. Do NOT re-state the Methods and Results sections. Summarize. You should give enough information so that the reader can understand what sorts of experiments or observations were used.
- Provide constructive criticisms of the methods or conclusions of the research. Are the conclusions justified by the data?
- Provide suggestions as to appropriate future experiments or comparisons.

Problem Sets: There will be two problem sets that you will need to complete. I will provide you with a data-set and you will be required to analyze and interpret the data using methods that we learn about in the class. These will be due in weeks 5 and 8.

Term Paper: Each student will submit a **3-5 page** term paper that critically examines one of five different case studies of adaptive evolution. Each paper should be double spaced, with 1-inch margins and be fully referenced in the style of the journal *Evolution* (please look at a recent issue and follow the style). I will provide you with a list of 5 case studies – currently, these are accepted in the field as some of the most complete studies of adaptive evolution. It is your job to select one and determine how well the investigators have done characterizing the different aspects of the evolutionary process. The paper has three parts: a short introduction stating the scientific question and justifying its importance, a literature review of the relevant studies, and your assessment of the quality of the work. This final area requires that you defend your point using specific examples. Typically, the study of adaptive evolution is a long-term research objective. Therefore, you should not expect to find all of the relevant information in a single paper. I expect that you will read and present a summary of the background literature on the study system, and then critically interpret the significance of these results for the study of adaptation. Your grade will be determined by the clarity of your writing - both in terms of its flow, style, etc, as well as the arguments that you make. **Email as a word (or text) document by 5pm on the due date.**

Research Proposal (Graduate students only): One of the main parts of graduate work in the natural and life sciences is independent research. The way research is conducted is by securing funding from granting agencies. This is a critical aspect of any career in research. Therefore, your assignment will be to choose a trait or traits from any organism you like and design a research proposal describing how you would study whether that trait is adaptive in nature. The traits can come directly from your own research or they can be traits that we discussed in class. By the end of week 6, I require that you set up a time to meet with me to discuss your trait/system and for me to answer any questions that you have.

The format of the proposal follows that of the National Science Foundation Graduate Research Fellowship, which some or many of you have or will be applying for. This is a 2-page (single space, 11-point, minimum) proposal including references (they can be numbered, with 10-point literature cited). No broader impacts section is required. The proposal should give the background to the problem, state the research objectives, describe the study system, and conclude with the research methods/experimental design. The methods can be things that we talked about in class or other methods that you are familiar with from your own research. The main goal is that you demonstrate how your experimental design will address the research objectives that you put forth. You should have at least 2 research objectives and describe the experiments in sufficient detail so that I (as a reviewer) can determine whether the project appears feasible. Compiling this information into only 2 pages is a challenge; therefore, I highly recommend that you do not wait until the last minute to start working on this project. This project will be due the beginning of week 10. **This assignment is due via email as a word (ot text) document by 5pm the day it is due.**

Evaluation: Your final grade will be determined as follows:

	Undergraduate Percent of Final Grade	**Graduate Percent of Final Grade**
Term Paper	30%	25%
Problem sets (2)	25%	20%
Critical Review	25%	15%
Quizzes	10%	10%
Participation	10%	10%
Research Proposal (Grad only)	--	20%

Please note that late assignments will incur a 5% penalty per day.

Academic Integrity: I have a zero tolerance policy for cheating, plagiarism, or any other form of academic dishonesty. For this course, that means your paper and assignments must be your work, and all references to others' scholarship should be properly cited. All persons involved in academic dishonesty will be disciplined in accordance with University regulations and procedures.

Students with Disabilities: The University of Oregon is working to create inclusive learning environments. Please notify me during the first week of the term if there are aspects of the instruction or design of this course that result in barriers to your participation. You may also wish to contact Disability Services in 164 Oregon Hall at 346-1155 or disabsrv@uoregon.edu.

Date	Discussion Topic (I will present lectures on each discussion topic in the class period before they are discussed)	Readings (Discussed on this day of class)
29-Sept	Course introduction, review of genetic and evolution terms	None
1-Oct	Population genetics: review; selection vs. drift	Schemske and Bierzychudek 2001
6-Oct	Quantitative genetics: introduction	Conner 2002
8-Oct	First discussion: What is (and is not) adaptation?	Gould and Lewontin 1979
13-Oct	Phenotypic selection: direct vs indirect; univariate/ multivariate	--
15-Oct	Phenotypic selection: direct vs indirect; univariate/ multivariate (continued)	Campbell et al. 1997
20-Oct	Experimental manipulations to measure agents/targets of selection	Bradshaw and Schemske 2003; Mauricio and Rausher 1997
22-Oct	Experimental evolution – mode and tempo of adaptation	Lenski and Travisano 1994
27-Oct	Population differentiation – Fst **1st Problem Set Due**	Lowry et al. 2008
29-Oct	Clines – selection vs. drift	Streisfeld et al. 2013
3-Nov	Molecular population genetics – introduction	Sabeti et al. 2006
5-Nov	Molecular population genetics – single genes	Wang et al. 1999
10-Nov	Population genomic scans for selection **Critical Review Due**	Hohenlohe et al 2010
12-Nov	Finding the genes – QTL mapping and candidate genes (lecture)	--
17-Nov	Finding the genes – QTL mapping and candidate genes (discussion)	Steiner et al. 2007
19-Nov	What is the origin of adaptive alleles? New mutations? **2nd Problem Set Due**	Linnen et al. 2009
24-Nov	What is the origin of adaptive alleles? Standing variation?	Barrett et al. 2008
26-Nov	*Thanksgiving – No Class*	--
1-Dec	Parallel/convergent evolution – same or different mutations? **Graduate Student Research Proposal Due**	Protas et al. 2006; Rosenblum et al. 2010
3-Dec	Final Synthesis	Nielsen 2009; Barrett and Hoekstra 2011
9-Dec Tues Final's Week	**Term Paper Due** **5pm**	

Citations for the papers we will read:

Barrett, R. D. H, and H. E. Hoekstra. 2011. Molecular spandrels: tests of adaptation at the genetic level. Nature Reviews Genetics 12: 767-780.

Barrett, R. D. H., S. M. Rogers, and D. Schluter. 2008. Natural selection on a major armor gene in threespine stickleback. Science 322: 255-257.

Bradshaw, H. D., and D. W. Schemske. 2003. Allele substitution at a flower colour locus produces a pollinator shift in monkeyflowers. Nature 426:176-178.

Campbell, D. R., N. M. Waser, and E. J. MelendezAckerman. 1997. Analyzing pollinator-mediated selection in a plant hybrid zone: Hummingbird visitation patterns on three spatial scales. American Naturalist 149:295-315.

Conner, J. K. 2002. Genetic mechanisms of floral trait correlations in a natural population. Nature 420:407-410.

Gould, S. J., and R. C. Lewontin. 1979. Spandrels of San-Marco and the Panglossian paradigm - A critique of the adaptationist program. Proceedings of the Royal Society of London Series B-Biological Sciences 205:581-598.

Hohenlohe, P. A., S. Bassham, P. D. Etter, N. Stiffler, E. A. Johnson, and W. A. Cresko. 2010. Population genomics of parallel adaptation in threespine stickleback using sequenced RAD tags. Plos Genetics 6.

Lenski, R. E., and M. Travisano. 1994. Dynamics of adaptation and diversification – a 10,000 generation experiment with bacterial populations. Proceedings of the National Academy of Sciences of the United States of America 91:6808-6814.

Linnen, C.R., Kingsley, E.P., Jensen, J.D., and H. E. Hoesktra. 2009. On the origin and spread of an adaptive allele in deer mice. Science. 325: 1095-1098.

Lowry D. B., Rockwood, R. C., and J. H. Willis. 2008. Ecological reproductive isolation of coast and inland races of *Mimulus guttatus*. Evolution 62: 2196-2214.

Nielsen, R. 2009. Adapationism – 30 years after Gould and Lewontin. Evolution 63:2487-2490.

Protas, M. E., C. Hersey, D. Kochanek, Y. Zhou, H. Wilkens, W. R. Jeffery, L. I. Zon, R. Borowsky, and C. J. Tabin. 2006. Genetic analysis of cavefish reveals molecular convergence in the evolution of albinism. Nature Genetics 38:107-111.

Rosenblum, E. B., Rompler, H, Schoneberg, T, and H. E. Hoekstra. 2010. Molecular and functional basis of phenotypic convergence in white lizards at White Sands. Proceedings of the National Academy of Sciences, USA. 107:2113-2117

Sabeti, P. C., Schaffner, S. F., Fry, B., Lohmueller, J., Varilly, P., Shamovsky O., Palma, A., Mikkelsen, T. S., Altshuler, D., and E. S. Lander. 2006. Positive natural selection in the human lineage. Science 312: 1614-1620.

Schemske, D. W., and P. Bierzychudek. 2001. Perspective: Evolution of flower color in the desert annual *Linanthus parryae*: Wright revisited. Evolution 55:1269-1282.

Steiner, C. C., J. N. Weber, and H. E. Hoekstra. 2007. Adaptive variation in beach mice produced by two interacting pigmentation genes. Plos Biology 5:1880-1889.

Stern, D. L., and V. Orgogozo. 2009. Is genetic evolution predictable? Science 326:746.

Streisfeld, M. A., J. M. Sobel, and W. N. Young. 2013. Divergent selection drives genetic differentiation in an R2R3-MYB transcription factor that contributes to incipient specation in *Mimulus aurantiacus*. Plos Genetics. 9(3): e1003385.

Wang, R. L., Stec, A., Hey, J., Lukens, L. & Doebley, J. 1999. The limits of selection during maize domestication. Nature 398: 236-239.