Biology 421: Advanced Evolution
spring 2021

Lectures: MWF 10:30-11:20, Renfrew 126
Instructor: Paul Hohenlohe -- hohenlohe@uidaho.edu
Office hours: By appointment on Zoom (https://uidaho.zoom.us/j/88532612745) or LSS 256
Required textbook: Futuyma & Kirkpatrick, *Evolution* 4th edition (Sinauer)

Learning outcomes: Evolution is the central explanatory framework that unifies the science of biology. Students in this course should develop a broad understanding of:

- Evolution as an ongoing, observable process in living systems
- The full range of mathematical and conceptual theory that describes this process
- Evolution as a historical science explaining the origins and diversity of organisms
- The major discoveries, experiments, and insights that led to current understanding
- How evolutionary principles can be applied to illuminate all aspects of biology

Course format: The course this year will be a combination of Hyflex, virtual meeting, and online, meaning that students can participate in person, live on Zoom (meeting 897 5490 8048, passcode 210658), and/or watch recorded lectures later. There is sufficient capacity in the classroom to allow all Hyflex students (registered for section 01) to attend all lectures in person, and also room to join in person even if you are registered for virtual meeting (section 02). Occasional lectures throughout the term may be pre-recorded and available online only.

Participation: If you attend in person, please comply with all university COVID19-related guidance. If you participate online through Zoom:

- Please mute your microphone unless you are speaking
- You do not need to turn on your camera, but it is encouraged if you are asking a question
- Please use your camera when you are presenting a paper discussion or research proposal
- Use of the Zoom chat is encouraged, either to ask questions or discuss among the class

Course resources: Readings include the textbook and peer-reviewed scientific papers, available as electronic files online (bblearn.uidaho.edu). Lectures will present additional information not found in these readings. Any powerpoint slides from lectures will be posted online following each lecture, and links to recordings of each lecture will also be posted on bblearn. Questions and discussion are welcome and encouraged at any point during lecture periods. Please treat your fellow students with respect at all times.

Disability services: Reasonable accommodations are available for students who have documented temporary or permanent disabilities. All accommodations must be approved through the Center for Disability Access and Resources located in the Bruce M. Pitman Center, Suite 127 in order to notify your instructor as soon as possible regarding accommodation(s) needed for the course. 208-885-6307; cdar@uidaho.edu; www.uidaho.edu/current-students/cdar.

Grading: Final grades will be calculated as:

Daily quizzes	10%
Paper discussion	10%
Assignments	35%
Research proposal (intro)	10%
Research proposal (final)	25%
Research elevator pitch	10%

Daily quizzes: For each lecture there will be a *very* short quiz posted on bblearn prior to class. These will be due by midnight on the day of each lecture. The goal of these quizzes is to keep everyone up-to-date with lecture material throughout the course.

Paper discussions: For each of the papers, a group of 2-4 students will form a panel responsible for facilitating the discussion. Each student must be part of one discussion panel during the term. You are welcome to choose one of the papers (requests by email, priority according to time sent), or you will be randomly assigned one by Wednesday, January 20. Visual aids like powerpoint slides are possible if you wish. Do *not* just reiterate or summarize the paper – instead, highlight key points and describe how they connect to concepts we are covering; identify strong points or weaknesses with the study; ask questions about parts that were unclear; discuss what might be done next; etc.

Assignments: Homework assignments will be posted as pdf files on bblearn. They are due at the time of the beginning of class on the dates shown below and can be submitted by email. You are welcome to use any materials or references as you work through the assignments. Late assignments will lose points unless an agreement has been made at least 24 hours prior to the due date.

Research proposal: During the course you will write a short research proposal, describing an experiment or research project that is somehow related to a concept or question in evolutionary biology that we cover during the course. The final research proposal should be about 2500-3000 words, including the following sections:

Introduction: Introduce the general conceptual issues and background, based on peer-reviewed scientific literature. Describe the biological system in which you would conduct the study and some of the relevant work that has been done to date.

Hypotheses: State one or more specific questions or hypotheses you will address.

Methods: Describe how the study will be conducted; be as specific as possible. E.g. what will you measure or collect? How many samples? How will you analyze the data?

Expected Results: Describe possible results and how you would interpret them (link back to your hypothesis), and any contingency plans for in case things go wrong.

Significance: If the experiment succeeds and you answer the question, what would that mean for the field?

References: Give full citations for all references used. You must use at least **10** scientific publications from peer-reviewed journals (Wikipedia, websites, and your textbook are great references but they don't count toward this total).

The research proposal must be your own work. You can draw information from any other resources, but it must be written in your own words.

DUE 3/12: The Introduction, Hypotheses, and References sections; these should be about half of the total length of the final proposal.
DUE 4/30: The final proposal with all sections as above.
Elevator pitches: Each student will give a very short (3-4) minute presentation on the research proposal. Imagine you are riding in an elevator with a wealthy benefactor who wants to fund some research – you must convince them that you have a great idea with a compelling question, feasible approach, and potential for high impact, all before the elevator doors open and they walk away.

Date	Topic	Textbook	Papers/assignments
1/13	Introduction to the course		
1/15	History of evolutionary ideas	1	
1/18	NO CLASS – MLK DAY		
1/20	Darwin's insight: natural selection	3	
1/22	Classification and common descent	2	**DUE: research proposal idea**
1/25	Phylogenetics	16	
1/27	Phylogenetics		PAPER 1: Shaw 2002
1/29	History of life on Earth		**DUE: assignment I**
2/1	Diversity and mass extinctions		PAPER 2: Bininda-Emonds et al 2007
2/3	Variation	4	
2/5	Variation: population genetics		**DUE: assignment II**
2/8	Mutation		PAPER 3: Besenbacher et al. 2014
2/10	Natural selection	5	
2/12	Natural selection	7	**DUE: assignment III**
2/15	NO CLASS -- PRESIDENTS' DAY		
2/17	Natural selection		PAPER 4: Linnen et al 2009
2/19	Drift; effective population size		
2/22	NO CLASS -- research prop. mtgs		
2/24	Effective population size		**DUE: assignment IV** PAPER 5: Kuparinen et al 2016
2/26	Evolution across space	8	
3/1	Population genetics synthesis		
3/3	Quantitative genetics	6	
3/5	Phenotypic correlation; trait mapping		PAPER 6: Puentes et al 2016
3/8	Evolution: genes and phenotypes		**DUE: assignment V**
3/10	Selection in nature		PAPER 7: Grant & Grant 2002
3/12	Selection and adaptation		**DUE: research proposal Introduction**
3/15	SPRING BREAK		
3/17	SPRING BREAK		
3/19	SPRING BREAK		
3/22	Speciation	9	
3/24	Speciation		PAPER 8: Sobel & Streisfeld 2015
3/26	Sexual selection	10	
3/29	Why sex		PAPER 9: Morran et al 2011
3/31	Life history evolution	11	**DUE: assignment VI**
4/2	Inclusive fitness	12	PAPER
4/5	Coevolution	13	
4/7	Evolution and disease		PAPER 10: Melnyk et al 2015
4/9	Evolution of genomes	14	**DUE: assignment VII**
4/12	Selection genomics		PAPER 11: Mathieson et al 2015
4/14	Evo-devo	15	
4/16	Biogeography, diversification	17,18	**DUE: assignment VIII**
4/19	Speciation and extinction		PAPER 12: Tank et al 2015
4/21	Macroevolutionary patterns	19,20	
4/23	Research elevator pitches		
4/26	Evolution and cancer		PAPER 13: Shah et al 2012
4/28	Evolution and conservation		
4/30	Research elevator pitches		**DUE: final research proposal**
5/3	Conservation		PAPER 14: Davis et al 2018
5/5	Evolution in public schools		
5/7	Research elevator pitches		

Papers for discussion:

PAPER 1: Shaw KL (2002) Conflict between nuclear and mitochondrial DNA phylogenies of a recent species radiation: What mtDNA reveals and conceals about modes of speciation in Hawaiian crickets. Proceedings of the National Academy of Sciences 99: 16122-16127.

- using phylogenetics to understand colonization and speciation of crickets in the Hawaiian islands

PAPER 2: Bininda-Emonds ORP et al. (2007) The delayed rise of present-day mammals. Nature 446: 507-512.

- massive phylogenetic study to estimate timing of origins of major mammal groups

PAPER 3: Besenbacher S et al (2015) Novel variation and *de novo* mutation rates in population-wide *de novo* assembled Danish trios. Nature Communications 6: 5969.

- application of high-throughput DNA sequencing to directly estimate mutation rates in humans

PAPER 4: Linnen CR, Kingsley EP, Jensen JD, Hoekstra HE (2009) On the origin and spread of an adaptive allele in deer mice. Science 325: 1095-1098.

- evolution in action: identification of a mutation that has appeared and evolved under natural selection in deer mice

PAPER 5: Kuparinen A, Hutchings JA, Waples RS (2016) Harvest-induced evolution and effective population size. PNAS 100: 4334-4339.

- simulations of what harvest does to effective population size in fish populations

PAPER 6: Puentes A, Granath G, Ågren J (2016) Similarity in G matrix structure among natural populations of *Arabidopsis lyrata*. Evolution 70: 2370-2386.

- measurement of genetic variation for multiple traits, and its consequences for evolution in a model plant species

PAPER 7: Grant PR, Grant BR (2002) Unpredictable evolution in a 30-year study of Darwin's finches. Science 296: 707-711.

- a classic long-term study of evolution, showing wide variation in selection over time

PAPER 8: Sobel JM, Streisfeld MA (2015) Strong premating reproductive isolation drives incipient speciation in *Mimulus aurantiacus*. Evolution 69: 447-461.

- direct measurement of pre-mating and post-mating isolation mechanisms, the factors that lead to the formation of new species

PAPER 9: Morran LT, Schmidt OG, Gelarden IA, Parrish RC, Lively CM (2011) Running with the Red Queen: host-parasite coevolution selects for biparental sex. Science 333: 216-218.

- a direct laboratory test of the evolutionary advantages of sexual reproduction

PAPER 10: Melnyk AH, Wong A, Kassen R (2015) The fitness costs of antibiotic resistance mutations. Evolutionary Applications 8: 273-283.

- meta-analysis of known instances of antibiotic resistance

PAPER 11: Mathieson I et al (2015) Genome-wide patterns of selection in 230 ancient Eurasians. Nature 528: 499-505.

- a genome scan for evidence of selection in the human genome, using ancient DNA samples up to 8500 years old

PAPER 12: Tank DC et al (2015) Nested radiations and the pulse of angiosperm diversification: increased diversification rates often follow whole genome duplications. New Phytologist 207: 454-467.

- a phylogenetic approach to understand how whole-genome duplication affects rates of speciation and extinction

PAPER 13: Shah SP et al (2012) The clonal and mutational evolution spectrum of primary triple-negative breast cancers. Nature 486: 395-399.

- cancer genomics: documenting the relationships among mutations and evolution in tumors

PAPER 14: Davis M, Faurby S, Svenning J-C (2018) Mammalian diversity will take millions of years to recover from the current biodiversity crisis. Proceedings of the National Academy of Sciences 115:11262-11267.

- using phylogenetic approach to quantify evolutionary diversity and the rate at which it is produced