SYLLABUS
BIOL 221L: Evolution of Extraordinary Adaptations
Fall 2017

Course description:
Did you know that the Venus flytrap is native almost entirely to North Carolina? Or that some fish make a living by eating scales? This class will conduct publishable research in evolution and ecology by doing actual science on the origins of the Venus flytrap and scale-eating in pupfishes. We will attempt to answer unknown questions about the evolution of complex traits in these systems using prey capture experiments and high-speed video analysis of fish and carnivorous plants. Students will be taught how to generate hypotheses, collect and analyze data in the R statistical programming language, discuss scientific literature, and publish their results. This research-intensive class will enable students to ask their own independent research questions and conduct experiments to answer them. The class will include a field trip to the Green Swamp, the home of the Venus flytrap, and high-speed video recording of live pupfish.

This is meant to be an introduction to research: students are not expected to have any prior research experience. The science will be focused on laboratory and field experiments measuring prey capture ability in the Venus flytrap and the scale-eating pupfish. By focusing on both the instructor's own system and a wonderful plant found in North Carolina, students will receive a broad perspective on how to investigate and test hypotheses about adaptation in the field and lab. Additional topics covered include adaptationism, natural selection, convergent evolution, exaptation, phylogenetic thinking, evolutionary novelty at multiple levels, applications to human health, and conservation status of our study systems.

Credit hours:
1 hours per week

Meeting times:
Monday 3:30 – 4:30 pm

Room:
Wilson 134

Instructors:
Dr. Chris Martin
Phone: 919-962-4841; Email: chmartin@unc.edu; Office: GSB 2256;
Office hours: Tues 4-5 or by appointment (preferred).

Please contact me if you cannot meet during the times listed here. I am happy to meet with you!

Dr. Martin is broadly interested in the ecology and evolution of organismal diversity. In grad school he developed two new integrative case studies for studying speciation and adaptation genomics: adaptive radiations of Caribbean pupfishes and Cameroon crater lake cichlids. His work at UNC focuses on further study of the evolution, ecology, genomics, functional morphology, and quantitative genetics of these fascinating examples of evolution-in-action.

Readings: There is no required textbook. Readings from the primary literature and/or popular press for each week's discussion will be posted to Sakai.

Requirements: The laboratory and non-laboratory sections of this course (271/271L) must be taken concurrently.

Additional requirements: Basic knowledge of biology as demonstrated by a B or above in BIOL 101.

Laboratory exercises: I will collect laboratory exercises from time to time. These will often be based on the discussions we have about scientific literature in the field but could also relate directly to your research project. In addition, you will receive 5 points for actively participating each week in lab work as well as points for maintaining a lab notebook.

Final paper and presentation: You will write up your results in a manuscript/paper at the end of the semester. This final paper will take the place of a final exam in the course. In addition, you will give a scientific talk on your findings to the group.

What you should bring to class each week:
1. Your lab notebook
2. Computer
3. Writing utensil
4. Enthusiasm and creativity!

Course Goals:
To introduce you to the process of science.
The lecture and the reading material will provide the basic content. You will gain hands on experience with evolutionary ecology thinking, learn how to formulate testable hypotheses, and design experiments to test them. You will read scientific literature and learn to write like a scientist. After this class, you will be prepared to do research in a lab on campus and to build upon this content with Biol202, Biol201, Biol205 and upper level courses in the Department of Biology.

When you ***Do the Science*** you will acquire basic laboratory techniques and skills needed to use test hypotheses about adaptations in the field and laboratory. You will develop a novel, hypothesis driven question, design an experiment that allows you to answer it, collect data, and interpret your findings.

When you ***Share the science*** you will write a paper / manuscript and give a talk with your lab partners to the class and members of the local community about your science.

You will ***Communicate the relevance of the science***. For example, you will read and discuss journal articles on evolutionary novelty to understand the bigger picture surrounding the science you are doing.
Exam: There will be one mid-term given during the session. For this exam you will need your PID number as identification on your exam sheet. Additionally, you may be asked to verify your identity, so it is required that you bring your one-card to each exam. Failure to produce a one-card or other picture ID if asked may result in a zero on that exam. Test material to study: lab note book, lab exercises, reading, homework, power point slides, learning objectives, and problem sets. To succeed in this class, it behooves you to take each reading/homework seriously and actively engage in all class discussions.

Laboratory Grading:

Your final average is calculated: Total for the semester =
(0.33 x lab exercises) + (0.33 x laboratory participation/engagement/group contributions)+(0.33 x final paper and presentation).

In general, the scale for each assignment comes very close to a 10 point scale. However, I reserve the right to change that scale since it is impossible to predict the difficulty level of any particular assignment.

Final exam period:
The final paper and presentation will act in lieu of a final exam.
Papers due by email to instructor before the time of the final exam.

Homework:
Students are expected to read each paper thoroughly and come prepared to class.

Course Policies:
Assignments turned in late, but before the key posted, will incur a 25% penalty on the final grade. Homework turned in after the key is posted, but before the final exam, will incur a 50% penalty on the final grade.

Honor code:
Students are encouraged to work together on discussing papers, but must submit an independent write-up of their final paper.

Class meetings:
The class will meet each Wednesday 12:20 – 4:30. The laboratory and non-laboratory portions of the course will occur back to back and will intermingle (there will not be a distinct break between the two; students might start a lab experiment, move on to another activity, such as a short lecture or paper discussion or group project, then go back to the laboratory work to complete the task).

Copyright policy: All course materials including your class notes and in-class assignments are covered by University Copyright Policy, http://www.unc.edu/campus/policies/copyright%20policy%2000008319.pdf. This means it is illegal and an honor code offense to share your notes or any other course materials with anyone not directly affiliated with this particular class, i.e., no uploading materials to non-class sharing sites.

Note: The instructor reserves the right to make changes to this syllabus.

Tentative Schedule:

Week 1 – Introduction to the class, grading, and study systems
Reading: Moczek 2008. On the origins of novelty in development and evolution. ***Bioessays.***
Generating scientific hypotheses: discuss Krogh's principle, applied vs. basic science

Week 2 – Class meeting at the UC Botanical Gardens.
Collect photographic data on carnivorous plant prey in nature.

Week 3 – Discuss: Adaptation, Natural Selection
Setup class terraria, "play" with Venus flytrap trigger hairs – class measurements of closing times using high-speed video camera.
Reading: Darwin's chapter on Venus flytrap in *Insectivorous Plants*
Generating scientific hypotheses: fieldwork-inspired questions

Week 4 – Discuss: Convergent evolution, homology
Begin collecting data from photographs of carnivorous plant prey using ImageJ analysis tool
Reading: Gibson Waller 2009. Evolving Darwin's 'most wonderful plant': ecological steps to a snaptrap. ***New Phytologist.***
Data analysis: introduction to data entry in Excel and graphing a histogram in R.
Generating scientific hypotheses: Tinbergen's proximate vs. ultimate questions

Saturday Field trip to Green Swamp Preserve, NC

Week 5 – Discuss: Phylogenetics, tree-thinking
Class activities: explore the TimeTree app, make a geneology/tree from a set of objects
Continue collecting data from field photographs of prey capture
Reading: Cameron et al 2002. Molecular evidence for the common origin of snap-traps among carnivorous plants. ***American Journal of Botany.***
Generating scientific hypotheses: phylogeny-based questions

Week 6 – Discuss: Exaptation
Finish collecting data from field photographs of prey capture
reading: Gould Lewontin 1979. The spandrels of San Marco and the Panglossian paradigm: a critique of the adaptationist programme. ***Proceedings of the Royal Society of London B.***
Data analysis: introduction to graphing in R
Generating scientific hypotheses: experiment vs. observation

Week 7 – Discuss: Evolution of novelty
Class tour of live pupfish colonies and introduction to vertebrate animal research from Division of Laboratory Animal Medicine staff.
Collect initial high-speed videos of pupfish feeding

readings: Martin and Wainwright 2013. On the measurement of ecological novelty: scale-eating pupfish are separated by 168 my from other scale-eating fishes. ***PLOS ONE.***
Janovetz 2005 Functional morphology of feeding in the scale-eating specialist *Catoprion mento*. ***Journal of Experimental Biology.***
Generating scientific hypotheses: the case study approach

Week 8 – Discuss: Morphology-Performance-Fitness relationship
Independent research proposals due (1 page NIH specific aims format)
Scientific process: peer-review, discuss examples
In-class peer review of research proposals
Introduction to analysis of high-speed videos of pupfish feeding using ImageJ.
Reading: Arnold 1983 Morphology, performance and fitness. ***American Zoologist.***

Week 9 - Discuss: the adaptive landscape
Begin collecting data for independent projects in flytrap/pupfish systems
Readings: Martin and Wainwright 2013. Multiple fitness peaks on the adaptive landscape drive adaptive radiation in the wild. ***Science.***
Carl Zimmer's popular press summary of this research: Watching Fish Climb Darwin's Mountain.
Data analysis: Introduction to bootstrap resampling / null distributions in R

Week 10 - Discuss: evolutionary novelty
Continue independent projects
Readings: Long et al. 2003 The origin of new genes: glimpses from the young and old. ***Nature Reviews Genetics.***
Blount et al. 2008 Historical contingency and the evolution of a key innovation in an experimental population of Escherichia coli. ***Proceedings of the National Academy of Sciences.***
Writing a scientific paper: methods/results

Week 11 - Discussion co-option and the evolution of novelty
Continue independent projects
Reading: Bemm et al. 2016 Venus flytrap carnivorous lifestyle builds on herbivore defense strategies. ***Genome Research.***

Week 12 - Discuss: conservation of flytraps / pupfishes
Finish independent projects / graphing of results.
Reading: 2016. Venus flytraps risk extinction in the wild at the hands of poachers. ***Scientific American***. Climate change projections for NC and Bahamian pupfish lakes.
Discussion of ex situ conservation of extinct in the wild pupfish species and the instructor's 'Fish Ark' database of these species.
Writing a scientific paper: introduction/discussion

Week 13 – Final student presentations / class evaluations