**SYLLABUS**

**BIOL 255H and 255L: Evolution of Extraordinary Adaptations**

**Spring 2020**

**Course description (255H and 255L):**

Of course you know that the Venus flytrap catches and digests insects, did you also know that it is native almost entirely to North Carolina? Extraordinary adaptations can be found in numerous other organisms as well. In class we will also look at the exceptional environmental stress tolerance of a tidepool copepod (*Tigriopus californicus*). For example, this copepod can survive freezing, high salinities, low pH, and anoxic conditions. Another cool feature of this system is that males possess specialized clasping antennae which they use to hold immature females until mating and these clasped pairs can continue to feed and develop.

This class will conduct publishable research in evolution and ecology by doing actual science on the Venus flytrap and tidepool copepods. We will attempt to answer unknown questions about adaptations in these systems by using techniques such as high-speed video analysis, environmental manipulation, and potentially genetic analysis. Through this course students will be totally immersed in how research is done. 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 experimentation in the lab during the class on campus.

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 primarily laboratory experiments measuring prey capture ability in the Venus flytrap and stress tolerance in the copepod and caterpillar systems. By focusing on both the instructor’s own systems 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, climate change challenges, and conservation status of our study systems.

**Credit hours:**

3 hours per week 255H & 1 hour per week for 255L

**Meeting times:**

Monday & Wednesday 10:10-12:05 in room 134 Wilson

**Class meetings:**

The lecture portion of the 255H course has 225L as a co-requisite so you must attend both. The laboratory and non-laboratory portions of the course will intermingle (there will not be a distinct break between the two during the two class meetings; 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).

Note that we are planning to have one required meeting outside of class time-a field trip to the Green Swamp area of North Carolina to observe and explore the Venus flytraps in their natural habitat. Additionally one meeting will be held at the UNC Botanical Garden.

**Instructors:**

*Dr. Christopher S. Willett*

Phone: 919-843-8663; Email: [willett4@email.unc.edu](mailto:willett4@email.unc.edu); Office: GSB 2252;

Office hours: Friday 10-noon or by appointment

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

Dr. Willett is broadly interested in the ecology and evolution of adaptations. His lab at UNC works on both the tobacco hornworm (*Manduca sexta*) and the tidepool copepod *Tigriopus californicus* and uses them to study thermal adaptation (along with other environmental factors) and as a model for studying speciation. The lab’s work goes from high-throughput sequencing assays of gene expression and genome-wide population genetics to physiological experiments using both of these arthropod systems.

**Teaching Assistant:**

*Aimee Deconinck*

Email: [aimeed@live.unc.edu](mailto:aimeed@live.unc.edu)

Office hours: MW 12:10 – 1:00 pm or by appointment

Aimee is a graduate student studying the impact of mitonuclear incompatibilities on hypoxia tolerance. After graduating with a degree in Marine Biology, she spent several years teaching high school science before returning to graduate school to earn a PhD. She values mentoring, and has received Green Zone and Safe Zone training. She welcomes students to meet with her about her research and about graduate school in general.

**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. During this class we will learn how scientists work with primary sources and delve into and develop the capacity to do so ourselves. This will help foster an understanding of how scientists build upon previous knowledge to build new ideas on how natural systems work.

*Note*: unless otherwise indicated you will need to read the material before the Monday meeting of class each week.

**Additional requirements:** Basic knowledge of biology as demonstrated by a B or above in BIOL 101. Although this is an honor’s course, other students are encouraged to apply if they are interested in participating in the types of research we will do in this class (note, non-honors students are required to have a 3.0 GPA at time of registration).

**In-class assignments:** I will collect in-class assignments 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 discussions.

**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 or elsewhere and to build upon this content with Biol201, Biol202, 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.

**Research and Discovery Reflection and Integration in this Course**

In this course you will immerse yourself in a research project and experience the reflection and revision involved in producing and disseminating original scholarship or creative works.

**Questions to keep in mind as you progress in this course:**

1. How do I establish my point of view, take intellectual risks, and begin producing original scholarship or creative works?
2. How do I narrow my topic, critique current scholarship, and gather evidence in systematic and responsible ways?
3. How do I evaluate my findings and communicate my conclusions?

**Learning outcomes**

1. Frame a topic, develop an original research question or creative goal, and establish a point of view, creative approach, or hypothesis.
2. Obtain a procedural understanding of how conclusions can be reached in a field and gather appropriate evidence.
3. Evaluate the quality of the arguments and/or evidence in support of the emerging product.
4. Communicate findings in a clear and compelling ways.
5. Critique and identify the limits of the conclusions of the project and generate ideas for future work.

# **Natural Scientific Investigation**

This course will also focus largely on natural scientific investigation. You will learn how to make and interpret scientific descriptions and explanations of the natural world, practice the skills of scientific inquiry, and evaluate scientific evidence within the contexts of both scientific communities and society.

**Questions to keep in mind as you progress in this course:**

1. What rules govern the natural world and how are they discovered, tested, and validated?
2. What is distinctive about the approach to understanding employed in the natural sciences?
3. What challenges are encountered in making measurements of the natural world?
4. What are the limits of investigation in the natural sciences?

**As discussed above you will achieve these learning outcomes**

1. Demonstrate the ability to use scientific knowledge, logic, and imagination to construct and justify scientific claims about phenomena, including validation through rigorous empirical testing.
2. Analyze and apply processes of natural scientific inquiry as dictated by the phenomena and questions at hand. These include generating and testing hypotheses or theories; using logic and creativity to design investigations to test these hypotheses; collecting and interpreting data; making inferences that respect measurement error; building and justifying arguments and explanations; communicating and defending conclusions; revising arguments and conclusions based on new evidence and/or feedback from peers; and synthesizing new knowledge into broader scientific understanding.
3. Evaluate science-related claims and information from popular and/or peer-reviewed sources by examining the relationship between the evidence, arguments, and conclusions presented and by assessing consistency with existing knowledge from valid and reliable scientific sources.
4. Identify, assess, and make informed decisions about ethical issues at the intersections of the sciences and society.

**Empirical Investigation Lab**

This course can count as an empirical investigation lab in which you will participate in measurement, data collection and analysis, and hypothesis testing connected to the course content. This will involve all of the following in this course:

1. Take empirical measurements using appropriate apparatus.
2. Generate and test hypotheses.
3. Gather, store, and organize data.
4. Analyze and report on data and hypothesis testing.

**Grading:**

Your final average is calculated:

20% homework quizzes/assignments

10% class participation/engagement/peer review participation

20% mid-term

30% final paper (5% rough draft; 25% final version)

15% final presentation (10% poster; 5% poster presentation)

5% peer evaluation of group work (note: added to final paper if no group work is done)

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 test.

**Exam:** There will be one mid-term given during the session. 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.

**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 and complete homework quizzes or assignments before 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.

**Attendance Policy:** Attendance is crucial and will form a considerable part of your grade. For University approved absences please notify the instructor in advance (when possible) so that appropriate accommodations can be arranged.

**Uphold the Honor Code.** Academic honesty means that we respect each other and the work that we do; this means we behave with integrity in and out of the classroom, and do not lie, cheat or steal (e.g. plagiarism is a form of stealing). The University of North Carolina at Chapel Hill has had a student-led honor system for over 100 years. It is our responsibility to report any instances of academic dishonesty and violations of the Honor Code. The student-led Honor System is responsible for adjudicating any suspected violations of the Honor Code. All suspected instances of academic dishonesty will be reported to the Honor System and students will receive a zero on the assignment or exam in question. Your full participation and observance of the Honor Code is expected. Please report any violations that you observe. Information, including your responsibilities as a student is outlined in the Instrument of Student Judicial Governance (here: <https://studentconduct.unc.edu/sites/studentconduct.unc.edu/files/documents/Instrument.pdf>).

\*\*\*Importantly for this class while students will be working together on many aspects of research pay careful attention to when you must submit independent work e.g. homework and quizzes\*\*\*

**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 we will give you as much notice as possible for changes (i.e. different readings).

**Tentative Schedule:**

**Week 1, 1st meeting Jan. 8th — Introduction to the study of adaptation; study systems; and grading/class organization**

Reading: Moczek 2008. On the origins of novelty in development and evolution. ***Bioessays.***

Generating scientific hypotheses: applied vs. basic science; how can we study evolution and generate testable hypotheses to move our understanding forward?

Conducting science: How to read a paper from the primary literature

**Week 2, Jan. 13th and 15th — Discuss: Evolutionary adaptation vs. physiological adaptation and trade-offs**

Class activities: get introduced to the copepod system and conduct an experiment using temperature. Set up crosses between copepod populations to produce hybrid offspring.

Reading: Willett, CS. Potential fitness tradeoffs for thermal tolerance in the intertidal copepod *Tigriopus californicus*. *Evolution* **64**: 2521-2534

Generating scientific hypotheses: experiment vs. observation (and hypothesis testing versus exploratory science)

**Week 3, Jan. 22nd (no class Jan. 20th)— Discuss: Data collection and presentation**

Class activities: Analyze results from temperature experiments by graphing in R; check on copepod cultures

Reading: TBD

Data analysis: introduction to data entry in Excel and graphing a boxplot in R.

Generating scientific hypotheses: Tinbergen’s proximate vs. ultimate questions

**Week 4, Jan. 27th and Jan. 29th — Discuss: Adaptation and natural selection on morphological traits**

Class activities: Setup class terraria, “play” with Venus flytrap trigger hairs – class measurements of closing times using high-speed video camera.

Reading: Davis et al. 2019. Testing Darwin’s Hypothesis about the Wonderful Venus Flytrap: Marginal Spikes Form a “Horrid Prison” for Moderate-Sized Insect Prey. *Am. Nat.* 193: 309-317.

Generating scientific hypotheses: the case study approach

**Week 5, Feb. 3rd and Feb. 5th — Discuss: Adaptive challenges for marine organisms associated with future climate change**

Class activities: Copepod experiments with temperature and oxygen levels; continue monitoring copepod crosses.

reading: Deutsch et al. 2015. Climate change tightens a metabolic constraint on marine habitats. *Science* 348:1132-1135.

Data analysis: introduction to statistical tests

Generating scientific hypotheses: Physiology-inspired questions

**Week 6, Feb. 10th and Feb. 12th — Discuss: Generalist/specialist and other tradeoffs implications for adaptation**

**NOTE**: Monday meeting at UNC botanical garden (starting at 10:30 to allow time for transport).

Class activities: Collect photographic data on carnivorous plant prey in natural setting.

Begin collecting data from photographs of carnivorous plant prey using ImageJ analysis tool

readings: paper TBD

Generating scientific hypotheses: fieldwork-inspired questions

**Week 7, Feb. 17th and Feb. 19th — Discuss: Morphology-Performance-Fitness relationship**

Class activities: Project planning week-Independent research proposals due (1 page NIH specific aims format)

Scientific process: peer-review, discuss examples

In-class peer review of research proposals

Reading: TBD

**Week 8, Feb. 24th and Feb. 26th — Discuss: Exaptation and adaptive stories**

Group project test week

Readings: 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.*** (Skip section 6 starting on pg. 593)

Caro et al. 2019. Benefits of zebra stripes: Behaviour of tabanid flies around zebras and horses. PlosOne.

Scientific process: the role of failure and iteration in scientific process

**Week 9, March 2nd and March 4th — Midterm week and re-evaluate projects**

Class activities: Midterm will be held during the March 2nd class period. Subsequently, begin collecting data for independent projects in flytrap/copepod systems

Scientific process: the importance of replication within and between studies

**Spring Break March 9th and 11th**

**Week 10, March 16th and March 18th — Discuss: origins of evolutionary novelty**

Class activities: Continue independent projects

Readings: TBD

Scientific process: how to design effective controls

**Week 11, March 23rd and March 25th  — Discuss: conservation of flytraps**

Class activities: Continue independent projects

Reading: 2016. [Venus flytraps risk extinction in the wild at the hands of poachers.](https://blogs.scientificamerican.com/extinction-countdown/venus-flytraps-risk-extinction-in-the-wild-at-the-hands-of-poachers/) ***Scientific American***.

Writing a scientific paper: methods/results

**March 28th Saturday Field trip to Green Swamp Preserve, NC**

**Week 12, March 30th and April 1st — Discuss: testing adaptative hypotheses using genetic data**

Class activities: continue independent projects / work on graphing of results.

Reading: Bemm et al. 2016 Venus flytrap carnivorous lifestyle builds on herbivore defense strategies. ***Genome Research.***

Writing a scientific paper: introduction/discussion

**Week 13, April 6th and April 8th — Discuss: Role of interspecific hybridization in adaptation**

Class activities: continue independent projects / discuss statistical analyses

Reading: Jones et al. 2018. Adaptive introgression underlies polymorphic seasonal camouflage in snowshoe hares. *Science* 360, 1355–1358

How to design and present an effective poster for scientific communication

**Week 14, April 13th and April 15th — Discuss: Sexual Selection and extraordinary adaptations**

Class activities: Peer review of poster presentations/ Finish independent projects

Reading: Emlen et al. 2012. A Mechanism of Extreme Growth and Reliable Signaling in Sexually Selected Ornaments and Weapons. *Science* 337: 860-864.

**Week 15, April 20th and April 22nd — Discuss: Origins of sexually selected traits**

Reading: TBD

Class activities: April 20th-Peer review of final research papers

**NOTE:** April 22nd Final student poster presentations at Celebration of Research and Making Expo the 22nd 2-5pm (two 1hr sections of student presentations)

**Final Exam Period, Monday April 27th 8:00 am— Final research paper due**

**Student Support:**

**College can be challenging in unexpected ways.** It is possible that at some point this semester your multiple competing personal responsibilities and interests may get in the way of your academic success. It is also possible that you may get sick or have other personal emergencies. The bottom line is this: asking for help is a sign of strength and self-care! **Please ask for help early and often!** Small problems are easier to cope with than waiting until the end of the semester when the issue has escalated. While we sincerely hope that you will let us know when things are not going well, here are other campus resources you can turn to, as well:

* **Dean of Students:** If at any time during the semester you experience a personal or family illness, loss, financial stress, academic access, living issues, interpersonal violence response, alcohol or similar substance related issues, and other forces that may interfere with your well-being and success and/or academic retention please contact the Dean of Students immediately (or contact your professors and we will do so for you). <http://deanofstudents.unc.edu>
* **Academic Advising**: Your academic advisers are familiar with all of the campus policies, procedures and requirements. <http://advising.unc.edu>
* **UNC Learning Center:** A variety of services are offered at this center, located in the Student Academic Success Building (SASB). The resources include the writing center, academic coaching, study skills information, etc. Learn more about these free resources**.** <http://learningcenter.unc.edu>
* **Counseling and Psychological Services (CAPS):** If you are experiencing any distress please speak with a medical professional in a confidential setting. The CAPS office has daily drop in hours or you may call them for an appointment (919-966-2281) or schedule online (healthyheels.unc.edu). <http://campushealth.unc.edu/services/counseling-and-psychological-services>
* **LGBT Center:** Provides educational services, resources and advocacy. <http://lgbtq.unc.edu>
* **Carolina Women's Center:** Aims to provide an equitable working and educational environment regardless of gender. Provides assistance to all individuals regardless of gender orientation. <http://womenscenter.unc.edu>
* **International Student and Scholar Services:** offers services to help international students adjust to life in North Carolina and UNC. <http://isss.unc.edu>
* **Accessibility Resources:** UNC-Chapel Hill facilitates the implementation of reasonable accommodations for students with learning disabilities, physical disabilities, mental health struggles, chronic medical conditions, temporary disability, or pregnancy complications, all of which can impair student success. See the ARS website for contact and registration information: <https://ars.unc.edu/about-ars/contact-us>