Faculty: Dr. Douglas Fudge (dfudge@uoguelph.ca)
       Dr. Denny Taylor (taylordj@hiram.edu)

TA:    Andrew Turko (aturko@uoguelph.ca)

Prerequisites: none

Class enrollment limit: 15 who are: a) matriculated students at Cornell, UNH or at any 4-year college or university; or b) incoming freshmen who will arrive at Cornell or UNH in fall 2014

Credit hours: 2

Course Overview: This course is an intensive, marine-based introduction to scientific method and experimental biology taught at the Shoals Marine Laboratory. The course takes advantage of the unique learning opportunities afforded by the pristine marine environment (especially the intertidal zone) around Appledore Island. The overall course philosophy is to allow students to learn the scientific method by doing it themselves under the guidance of veteran marine biologists. The course is structured around two class projects that are designed to expose students to concepts and techniques in marine ecophysiology and biomechanics.

The principle of science, the definition, almost, is the following: The test of all knowledge is experiment. Experiment is the sole judge of scientific 'truth'. But what is the source of knowledge? Where do the laws that are to be tested come from? Experiment, itself, helps to produce these laws, in the sense that it gives us hints. But also needed is imagination to create from these hints the great generalizations - to guess at the wonderful, simple, but very strange patterns beneath them all, and then to experiment to check again whether we have made the right guess.

-Richard Feynman
Course Objectives/Goals:
1. Scientific method. Students will:
   • appreciate the power and limitations of science as a way of knowing.
   • understand and apply the structure of the scientific method.
   • understand and apply principles of good experimental design and data collection.
   • learn how to carry out statistical testing, analysis, and graphing using R software.

2. Scientific information literacy. Students will:
   • learn how to use online research tools for scholarly literature and bioinformatics.
   • learn how to cite sources using proper format.

3. Scientific communication. Students will:
   • demonstrate understanding of the structure of scientific papers and their relationship to the scientific method via four writing assignments.
   • demonstrate principles of data analysis, slide design, and oral communication via participation in a scientific symposium at the end of the course.

4. Knowledge of and ability to use equipment in the lab and field. Students will:
   • understand the importance of measurement to the scientific process
   • demonstrate proper use of equipment such as pipets, calipers, micrometers, gel electrophoresis rigs, force transducers, and dissolved oxygen probes.
   • demonstrate proficiency with the use of remote sensing devices such as CTD probes, and HoboTemp temperature probes.
   • demonstrate proficiency with biological imaging using microscopes and cameras.
   • demonstrate proficiency with image processing using ImageJ software.

5. Conceptual knowledge pertaining to two laboratory modules. Students will master introductory concepts in three areas:
   • Marine Eco-physiology
   • Marine Eco-mechanics

6. Additional goals. Students will
   • be empowered to undertake their own scientific investigations.
   • practice critical thinking skills as background for MCAT and GRE.
   • take ownership of the material.
   • learn how to work cooperatively with others toward a common goal.

Course Content:
The course objectives will be met in the context of two modules that will engage students in active learning and research. These modules are as follows:

Module 1: Eco-physiology
In addition to mechanical forces, marine organisms are also subjected to physical stressors such as fluctuations of temperature, salinity, and oxygen content, and these factors can play important roles in determining their function and distribution. While much of the marine environment is known for its stability, the intertidal environment is one of the most challenging habitats on the planet. Intertidal organisms must be able to endure crashing waves, desiccation, and extremes of temperature, salinity, and dissolved oxygen that would kill most other organisms. In this module, students will be exposed to some of the physiological adaptations that intertidal organisms possess that allow them to survive and reproduce in such a stressful environment. The hands-on portion of the module will consist of students carrying out a research project whose goal will be to answer an “ecophysiological” question.
that emerges from observations they make in the field. As in the second module, students will engage in observation and question finding in addition to all the other steps of the scientific method. While the exact research project topic will be up to the class to decide, possible areas of inquiry include desiccation resistance, hypoxia tolerance, and thermal biology of intertidal animals and algae.

**Module 2: Eco-mechanics**
Organisms are routinely subjected to mechanical forces, both from other organisms, and from physical phenomena such as water flow, buoyancy, and gravity. Ecomechanics explores the roles that these forces play in determining the form, function, and ecological roles of organisms in their environment. In this module, students will be exposed to background information on how organisms are adapted to physical forces in their environment as well as general principles of biomechanics. Students will carry out a research project whose goal will be to answer an “ecomechanical” question that emerges from their explorations of the marine environment around Appledore Island. After a lecture on biomechanics, students will be given the opportunity to observe intertidal organisms in their natural habitats and generate ecomechanical questions about their distribution, behavior, or function. These questions will be discussed as a group until the class agrees on a question that they think they can answer in the time available in the course. Possible project topics include attachment of intertidal organisms (mussels, gastropods, algae, etc.), mechanics of suspension feeding (in mussels, barnacles, tunicates, bryozoans, etc.), and predator-prey mechanics (crabs feeding on armored prey such as bivalves, gastropods, etc.). Students will tackle the question posed by systematically applying the steps of the scientific method that they will learn at the beginning of the course.

**Course Materials:**
Required readings (provided as pdf files)

**Assignments & Grading:**
Required Assignments
- Assignment 1 (Sci Method - Observations & Questions) 5%
- Assignment 2 (Sci Method - Hypotheses & Predictions) 15%
- Assignment 3 (Sci Writing - Intro & Methods) 20%
- Assignment 4 (Sci Writing - Results & Discussion) 25%
- Oral Presentation (Research Proposal) 20%
- Participation 15%
Expectations and Conduct:
Students are responsible for fully understanding all of the information presented in this syllabus. If there are any questions regarding this information, it is the student’s responsibility to bring it to the instructor’s attention. In addition, students are responsible for attending all activities associated with this course and completing all assignments. Students are responsible for asking questions anytime they need clarification (remember, there is no such thing as a bad question).

Every student is responsible for their own behavior—specifically in being respectful and collegial to other students and with instructors. Students are responsible for fully understanding and adhering all of the information presented in the SML Appledore Handbook (http://www.sml.cornell.edu/sml_forms.html)

1. **Personal Technology.** Do not use cell phones, smart phones, iPads, mp3 players, headphones, or similar devices in the classroom or during course activities. If you take notes with your computer, disable wireless access during lecture.

2. The lab has a modest computer facility in Laighton Library; please treat this shared facility with respect. Printers are available, but please limit printing to your FINAL document (if required).

3. **Transmission of Course Materials.** Students are not authorized to replicate, reproduce, copy or transmit lectures and course materials presented, or derivative materials including class notes, for sale or free distribution to others without written consent of the instructors who are the original source of the materials.

4. **Academic Integrity.** Any work submitted must be your own. Uncredited use of another person’s words, data or images is considered plagiarism, a serious violation of the Code, whether the material comes from another student, a web site, or a published paper. Students must adhere to Cornell’s and UNH’s Policy for Academic Honesty/Plagiarism and Discrimination
   A. Cornell: [http://cuinfo.cornell.edu/aic.cfm](http://cuinfo.cornell.edu/aic.cfm)
   B. UNH: [http://www.unh.edu/vpsas/handbook/welcome-university-new-hampshire](http://www.unh.edu/vpsas/handbook/welcome-university-new-hampshire)

5. **Disabilities & ADA Accommodation:** Students with a disability must contact Cornell’s (420 CCC building; 607-254-4545) or UNH’s Student Disability Services [http://www.unh.edu/disabilityservices](http://www.unh.edu/disabilityservices) four weeks prior to start of class for confidential discussion of needs and for registration to verify eligibility for academic accommodations. No retroactive accommodations can be made.

6. **Mental Health:** Shoals Marine Laboratory cares about you and your well-being. If you experience unusual personal or academic stress during the course or need to talk with someone about a personal problem, seek support from your instructors as soon as possible. In addition, any SML staff is available for consultation 24/7. Find staff in the office in the Hamilton House between 8am – 7pm or knock on the door of Bartels House after hours.
Tentative Schedule:

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
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<tbody>
<tr>
<td>0730</td>
<td>Breakfast</td>
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<tr>
<td>0830</td>
<td>Observing and Asking Questions (DF)</td>
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<tr>
<td>1000</td>
<td>Hypotheses and Predictions (DF)</td>
</tr>
<tr>
<td>1130</td>
<td>Intro to Marine Eco-Physiology (AT)</td>
</tr>
<tr>
<td>1230</td>
<td>Lunch</td>
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<tr>
<td>1330</td>
<td>Measurement, Statistics, and R (DT)</td>
</tr>
<tr>
<td>1530</td>
<td>Intertidal Exploration</td>
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<tr>
<td>1800</td>
<td>Dinner</td>
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<tr>
<td>1930</td>
<td>Start Eco-Phys project planning</td>
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</tbody>
</table>

Thu July 2

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
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<tbody>
<tr>
<td>0730</td>
<td>Breakfast</td>
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<tr>
<td>0830</td>
<td>Assignment 2 due (Hypotheses and Predictions)</td>
</tr>
<tr>
<td>0830</td>
<td>Start Eco-Mechanics planning</td>
</tr>
<tr>
<td>1030</td>
<td>Set up and data collection for Eco-Phys project</td>
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<tr>
<td>1230</td>
<td>Lunch</td>
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<tr>
<td>1330</td>
<td>More Eco-Mechanics planning</td>
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<tr>
<td>1630</td>
<td>Collecting for Eco-Mechanics</td>
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<tr>
<td>1800</td>
<td>Dinner</td>
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<tr>
<td>1930</td>
<td>Eco-Mechanics data collection</td>
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<tr>
<td>2030</td>
<td>Rock Talk</td>
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Fri July 3

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<thead>
<tr>
<th>Time</th>
<th>Activity</th>
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<tbody>
<tr>
<td>0730</td>
<td>Breakfast</td>
</tr>
<tr>
<td>0830</td>
<td>How to write scientific papers (DF and DT)</td>
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<tr>
<td>0930</td>
<td>Data collection</td>
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<tr>
<td>1230</td>
<td>Lunch</td>
</tr>
<tr>
<td>1330</td>
<td>Data collection</td>
</tr>
<tr>
<td>1800</td>
<td>Dinner</td>
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</tbody>
</table>
1930 Data collection

**Sat July 4**
7:17 -1.0 19:29 -0.1  5:07 20:26
0730 Breakfast
0830 Assignment 3 due
0830 Data crunching
1230 Lunch
1330 Data crunching
1800 Dinner
1930 Data crunching

**Sun July 5**
8:05 -1.0 20:22 -0.1  5:08 20:26
1000 Brunch
1100 Assignment 4 due
1100 How to give a scientific talk (DT)
1200 Discussion of oral presentation topics
1700 Dinner

**Mon July 6**
8:55 -1.0 21:17 -0.1  5:08 20:25
0730 Breakfast
0830 Prep for oral presentations, symposium
1230 Lunch
1330 Prep for oral presentations, symposium
1800 Dinner
1730 Practice talks

**Tue July 7**
9:48 -0.8 22:16 -0.0  5:09 20:25
0730 Breakfast
1230 Lunch
1330 Start of student symposium
1800 Dinner

**Wed July 8**
10:43 -0.5 23:18 0.0  5:10 20:24
0730 Breakfast
0815 Luggage for dock - clean dorm
0900 Dock for Departure