



# On-line Laboratories For Introductory Biology To Enhance Web-based Learning

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**Introduction:** Since 2007 we have offered distance education sections of courses in Introductory Biology. Students acquire the basic material from an interactive course web site; the non-synchronous "lecture" topics contain a mix of text, audio, interactive videos and animations to illustrate concepts and add interesting details. Concept checks are provided at the end of each subtopic to encourage students to think about the main points and synthesize important information. Weekly 15-point, web-based quizzes test student mastery of the week's material, and four major exams are given by computer at the NCSU proctoring center.

**The on-line laboratory:** In fall 2008, we began development of on-line laboratory components so that students could earn full credit for the course without attending campus laboratory sessions. The major disadvantage of an on-line laboratory is the lack of hands-on experience with the techniques and instrumentation commonly encountered in an introductory biology laboratory. We have attempted to minimize this drawback by using interactive features that show real-world lab protocols and enable students to interact with virtual equipment. Although it is not possible to recreate an entire "wet lab" experience, we have developed a combination of video, simulations, virtual microscopy, and game-like exercises that stress concepts and place students in the role of a working biologist. An advantage of the online laboratory approach is the ability to conduct experiments and take "field trips" that are not feasible in classroom sections due to financial and time constraints. We utilize weekly, graded assignments to assure that students spend time synthesizing information and solving problems based on the laboratory material.

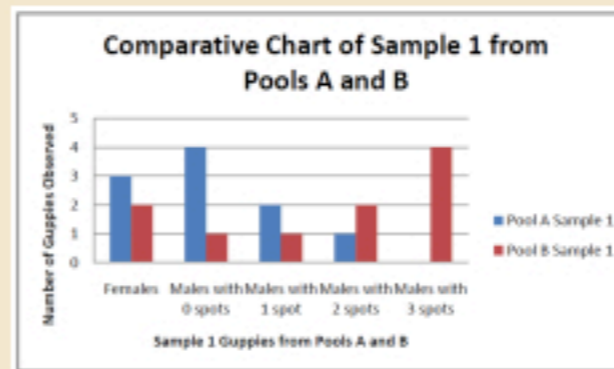
**WebAssign:** All homework assignments, as well as quizzes and exams, utilize WebAssign (<https://www.webassign.net/>). This Internet site provides a wide assortment of question types, including "file upload" which allows students to send files from their computers to WebAssign for grading. In various laboratory assignments, we require students to graph data, capture and label images from a virtual microscope, label bands in a gel image, etc. Students then perform a screen capture of the work and submit it as an image in jpg or png format to the appropriate WebAssign question. Graders can open each image from the website and record a score in the WebAssign grade book without downloading anything to their own computer. This allows an efficient and rapid method of grading which has allowed us to increase class size to 175 students. Grading image submissions requires an average of 30 sec or less for each image.

The adjacent figure shows part of a WebAssign page accessed by a grader. All student answers to a specific question have been selected. They appear in a column (only two are shown here). The question is at the top of each submission. The "choose file" button was used by the student to submit a file, in this case the image of a completed table. When the grader clicks the link, the image pops up. The grader can then record a score and enter comments. All scores are recorded in the WebAssign grade book. Comments and keys to correct answers are available to students after the assignment due date.

**Grade Essays and Files**  
 BIO 181 Lab Assignment 11 (1749720) - View | Edit | Schedule | Scores  
 Save | Reset  
 Submit your table of forest organisms here as a jpg or png image.  
 Choose file: no file selected [Link to student image](#)  
 Schenck Forest.png  
 Score: 3.6 out of 5  
 Comment:  
 Missing/misplaced 14 organisms, see key below:  
 Canopy: Woodpecker and owl (or birds)  
 Sapling layer: mosquito larva, caddisfly larva  
 Previously graded 3.6 on Friday, April, 8 2011 10:37 AM EDT.  
 Submit your table of forest organisms here as a jpg or png image.  
 Choose file: no file selected  
 raleigh forest table.jpg  
 Score: 3.8 out of 5  
 Comment:  
 Missing/misplaced 12 organisms, see key below:  
 Canopy: Woodpecker and owl (or birds)  
 Sapling layer: mosquito larva, caddisfly larva  
 Previously graded 3.8 on Friday, April, 8 2011 10:37 AM EDT.

**Interactive Laboratory Exercises:** The following exercises are utilized in BIO 181, a course for life science majors that covers the scientific method, evolution, biodiversity, and ecology. While we utilize these exercises to simulate a laboratory experience in distance education, they could also be used as homework extension of "wet labs" or as active learning/problem solving components in lecture-based courses.

**Case study using the scientific method:** This exercise utilizes the application Quandary (Half Baked Software) to provide an interactive in evolutionary ecology. Students play the role of a biologist in Trinidad using observation and experimentation to determine why guppies found in two pools differ in coloration. As the study progresses, students collect and analyze data on the guppies. They read a scientific article to gather more information, then interpret experiments performed both in a laboratory and in the field. Students must answer questions as the study proceeds to verify their understanding of the concepts.



The case study includes pictures of the pools and graphs of data that the student-researchers collect as they move through the study. At each step, there are several choices, but eventually the student will obtain data from 6 different experiments. After analyzing the data, a conclusion must be made as to why the male guppies in pool B are more colorful than those in pool A.

Conclude that Pool B has more colorful males and that further research is needed to determine why.  
 This observation is correct. You decide to design a laboratory experiment to further research why Pool B has more colorful males.  
 Go | Begin designing laboratory experiment  
 Go | Read research article on guppies  
 After reading the research article you feel you have enough information to conduct a laboratory experiment. Choose an experimental design from below and conduct your experiment.  
 Experiment 1: You set up a tank in your laboratory with one female from Pool A and one female from Pool B. You place several of the less colorful males from Pool A and several males from Pool B to determine if the females prefer the males from their natural environments.  
 Experiment 2: You set up a tank in your laboratory with several females and males of each level of coloration from both pools. After several generations of breeding you document your observations.  
 Experiment 3: You set up a tank in your laboratory with two clear divisions in it. In the center of the tank you place one female from each pool. In one division you place a dish made with 0 bright spots, you place a 1 brightly spotted female in the other divided section and observe which divided side the females attempt to enter.  
 Go | Conduct Experiment 1  
 Go | Conduct Experiment 2  
 Go | Conduct Experiment 3

**Student Response To the Case Study:** Students submitted an optional poll at the end of the course to express their opinions of the on-line labs. Out of the 12 laboratory assignments in the course, 12% of the students picked the case study as their favorite. When asked to select which of the following concepts that they understood better after performing the exercise, results were:

Concepts (select all that apply)	Number of students that selected each concept *
Natural selection	44 %
The scientific method	41 %
Designing laboratory experiments	60 %
Designing field experiments	24 %
Applying scientific literature to a research problem	54 %
Data analysis	35 %
None of these	6 %

\* Percent of the 111 students responding that selected the concept.

**Representative student comments on the case study**

The guppy coloration lab was my favorite because it forced me to think more complexly about the outcomes of the experiment and why they occurred.  
 I enjoyed this lab because it was simple, straightforward, and provided a well-rounded understanding to conducting experiments/labs. It also gave me a nice visual on how natural selection worked.  
 Scientific Method was my favorite because I feel like it was a "real world" experiment. I enjoyed trying to solve and understand the problem.

**Virtual field trip:** We are using panoramas with linked hot spots to simulate field trips to locations of ecological interest. The following exercise utilizes an interactive panorama of Schenck forest (Raleigh area) with video clips of plants and animals found there, including microscopic forms. Students open the panorama and locate habitats within the forest as indicated by hot spots. As they turn 360° within the panorama, more hot spots are found. They list the plants and animals that they find and place them in a table that indicates the forest strata or microhabitat in which each was found. To illustrate ecological concepts, students are required to construct a productivity pyramid that places each organism in their list at the appropriate trophic level. The completed table and pyramid are submitted to WebAssign for grading.

One view within the forest panorama with two hot spots indicated

When a hot spot is clicked, a page opens containing a narrated video that shows one or more organisms within the area. Clicking on the names beneath the video brings up additional video clips of animals too small to be easily seen. Most of these were videographed in our laboratory in samples taken from the forest using video microscopy equipment. The panorama contains 10 hotspots and 35 organisms.

**Student Response To the Forest Panorama:** Students who submitted the poll also evaluated the Ecosystems laboratory which contained the panorama and the game "Extinction" (adjacent poster). Out of the 12 laboratories in the course, 34% of students picked the Ecosystems lab as their favorite and chose panorama concepts as follows:

Concept (select all that apply)	Number of students that selected each concept *
Stratification of the forest	59 %
Trophic levels	31 %
Energy flow through an ecosystem	47 %
Microhabitats	61 %
Types of plants and animals found in a forest	23 %
None of these	4 %

**Representative student comments on the forest panorama**

Ecosystems was my favorite lab because of the interactive segments. By being "in" the area we are studying, I got a better visual.  
 My favorite was the ecosystems lab, where the game and forest panorama was utilized. It was nice to do something interactive rather than just read and answer questions.  
 I liked the forest panorama lab the best because I felt like I was actually in the field looking for plants and animals.