This fall I reviewed the Evobeaker labs from Simbiotic Software and considered their potential use for future Evolution 4974 courses. Simbiotic had seven labs available for review. I chose to review the three labs that were designed for advanced courses: "How the Guppy Got Its Spots", "The HIV Clock", and "Hardy, Weinberg, and Kuru". I considered how well each lab reinforced the concepts covered in class, their challenges, time commitment, and finally, their potential benefits for deeper student learning.

How the Guppy Got its Spots:

Summary

The goal of this lab is to design an experiment that documents evolution by natural selection in the wild. Students are able to simulate work done by Endler in 1980 on a natural population of guppies.

The simulation begins with four wild populations of guppies that are geographically isolated. In the first exercise, students observe that male guppies vary in "spot brightness" or number of spots, while females have neutral colors and lack spots. Three of the pools have different assortments of predatory fish, either *Rivulus*, cichlids, or both; the fourth pool has no predators.

In the beginning of the lab, students make observations about variations between the pools and are asked to hypothesize about the cause of variation in showiness among males. Next, students design an experiment in which they are able to transplant guppies into tanks or into field sites and observe the populations through multiple generations. Predatory fish may also be added to tanks. Students summarize their hypotheses, experimental design, observations and data.

After students have designed and run their own experiments, they learn the details of Endler's study and his results. The lab includes the actual graphs from Endler's experiments.

Concept Reinforcement

This lab reinforces the concept of **natural selection** and changes in a population over time due to **variation** and **differential reproduction**. Students can observe **geographic variation** and can design a **common garden experiment**. This lab would fit best between Lecture #9 (Geographic variation) and Lecture #11 (Natural Selection).

Benefits

The concepts covered in this lab are not difficult. Many students will already be familiar with Endler's work from general biology, animal behavior or ecology courses. The real challenge in this lab is the use of the scientific method and experimental design. While I was already familiar with Endler's studies, I still found it challenging to design a successful experiment. Thus, while this lab is not likely to challenge most students conceptually, it does require critical thinking and can promote a deeper understanding of the methodologies used to document evolution. Since the lab does not specifically discuss common garden experiments, it may be beneficial to require students to use this method as part of their experimental design. This would promote deeper understanding of a methodology that students are likely to be less familiar with.

A highlight of this lab is that it is visually engaging. Pop-up windows allow students to see pictures of the real individual fish that they are studying. The lab does not require excessive student time and can be placed in the middle of the semester when student workloads are not overwhelming.

Challenges

The main downside to this lab may be in the time required for assessing student work. I recommend placing specific guidelines around what students should turn in and making expectations clear.

Time commitment

This lab, including write-up, should not take more than 2 hours of student time. This may vary depending on what the expectations are for the write-up. I would suggest that students skip #9 (Exercise #1) which requires creating histograms of spot brightness, and read ahead to #12, which creates histograms for you.

The HIV Clock:

Summary

This lab investigates a hypothesis, put forth by reporter Edward Hooper in 1999, that HIV originated in patients that were vaccinated for polio with chimpanzee cells. Hooper contended that these cells were infected with SIV (the simian immunodeficiency virus). The lab is based on work by Korber, who dated the last common ancestor of HIV to the late 1950s using a molecular clock.

The lab begins with a model of HIV evolution, in which students observe genetic drift in a population of virions. Next, the lab simulates rates of change for populations in which new mutations are deleterious or beneficial. In the third exercise, two populations of virions become genetically distinctive through time after they are geographically separated into two different infected hosts.

Exercises four and five are the critical thinking sections of the lab. In exercise four, students “grow” two populations of virions. At intervals of 50 generations, they compare differences in RNA sequences between random virions selected from each of the populations. After 500 generations, students use a best-fit line to extrapolate how long ago the populations diverged. Students can check the validity of their results as the computer program knows the "truth".

In exercise five, students sample virions from an infected chimpanzee and seven infected humans. Using virions from the infected chimp as a reference point, students can "grow" several generations of virions, and determine when the first human was infected. Again, the simulation calculates a best-fit line, and students extrapolate the infection time. After several of the exercises, data from real experiments are used to validate the time of the simulation's findings. The lab concludes by explaining how Korber used similar methods to date the last common ancestor of HIV to the late 1950s.

Concept Reinforcement

The learning objectives of this lab have a high correlation with the course material. The HIV Clock emphasizes **non-adaptive evolution** and shows population change over time due to **random mutations**. It shows that natural selection tends to **reduce genetic variation.** The simulation also emphasizes the genetic divergence of two populations due to **geographic isolation.** Finally, the simulation illustrates the methodology used to create molecular clocks.

This lab would fit well immediately following Lecture # 15 (Molecular Phylogenies and Clocks) and ideally before the Albert and Vigilant papers.

Benefits

Beyond the relevance of this lab to course material, "The HIV Clock" has several benefits. Namely, the subject matter is beyond interesting--it's truly fascinating. The evolution of HIV is a current topic with a medical slant. This lab is especially engaging because it is designed around unraveling the mystery of HIV's origins and solving a puzzle. Additionally, the authors have interspersed the results of several real-life studies throughout the lab, which validates the simulations.

The concepts presented in this lab are high-level. The lab requires students to actively engage and use quantitative skills. This engagement should not only deepen their understanding but also make their learning more long-term. Finally, this lab should clarify the methods used by Vigilant and Albert in the assigned readings. Completing this lab prior to these assignments, should make the readings less difficult.

Challenges

Exercise four and five raised more questions for me than answers. After completing the lab, I wondered about the validity of Korber's estimate. I especially wanted confirmation that I had a correct understanding of the methods being used in Exercise five. For students to truly benefit from this simulation, there would have to be class discussion in which conclusions can be confirmed in a group setting, and questions can be addressed.

The math in this lab could be challenging for some students, depending on the comfort level with basic linear algebra. In exercise four and five, students must use the slope-intercept form to solve for x.

Time commitment

This lab can be completed in two hours. I would recommend at least 20 minutes of class discussion time for students to validate their conclusions. Discussion questions: 7c,21, 28, 31, 32, 44, 56, 58, 59, 68, 77, 79.

Hardy, Weinberg and Kuru

Summary

This lab investigates an epidemic of Kuru, a spongy brain disease that broke out among the Fore people in Papua New Guinea, as a result of a ritual in which people ate the remains of dead relatives. The lab simulates a study by Mead on the genetic basis for differential survivorship among the Fore people.

In this lab, students calculate genotype frequencies and allelic frequencies. They observe change in allelic frequency due randomness and the effects of genetic drift in small populations as compared to large populations. The lab emphasizes the assumptions of the Hardy-Weinberg equilibrium and allows students to test the effects of immigration, unequal survival rates and genetic mutations on a population. The final exercises introduce the idea of a "null model" and show how scientists use chi-square value in populations to determine whether a population may be useful to investigate. Finally, the hypothesis of heterozygote advantage among the Fore people is examined.

Concepts

This lab covers the assumptions of **Hardy-Weinberg Equilibrium**, **genetic drift**, and the calculation of **allele and genotype frequencies**. The lab would fit well after lecture #10 (Population Equilibrium and Inbreeding).

Benefits

This lab investigates a highly interesting topic, and is extremely relevant in light of recent mad cow disease outbreaks. Like the HIV clock, the simulation is engaging, as it involves solving a real-life puzzle. The concepts had a high correlation with the learning objectives of the course.

Challenges

While the concepts of this lab are fundamental to understanding population genetics, the workload for me did not justify the learning. I found this lab to be highly tedious in certain exercises, especially as I had to move generations through their entire life cycles. I spent more time trying to understand the direction in this lab, than in other labs. The topic was engaging, but I lost interest in the middle. By the time I reached the fundamental concepts in the final exercise, my patience was low and I was not as committed to investing more time to fully understand the exercises.

I especially needed more direction and confirmation through Exercise four. Did I calculate the chi-square correctly? How do I calculate the chi-square for the Fore people? Because there is not complete clarity here, I did not feel confident about my assertions and my learning was not as significant.

This lab could be worthwhile in other classes, especially population genetics. In the evolution class, I quickly learned to calculate allele and genotype frequencies from lecture, and did not need to invest much more time learning these concepts outside of class.

Time commitment

I spent almost three hours on this lab and did not complete the final exercise.

Final Recommendations

I recommend the addition of "How the Guppies Got Their Spots" and "The HIV Clock" for the Evolution 4974 class. While these labs do not require excessive student time commitment, they can deeply enhance concepts presented in lecture. More importantly, they challenge students to think critically and to understand current methodologies in studying evolution. The simulations are based on real experiments which makes them relevant and credible. They help students gain insight into the scientific process, and should promote understanding of the assigned technical papers. Finally, the active learning required in these labs should promote the long-term retention of new concepts for all students, and especially for students for whom reading and listening are not their primary modes of learning.

A Review of *Evobeaker*

and its potential use in the Evolution 4974 course

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December 11, 2007