OBJECTIVES:

- Help you develop an understanding of important factors that affect evolution of a species.
- Demonstrate important biological and environmental selection factors that influence evolution by natural selection.
- Simulate how changes in beak size and other characteristics of finch populations influence evolution of beak size and population numbers.

General Introduction:

EvolutionLab will allow you to study important principles of evolution by examining small populations of finches on two different islands, "Darwin Island" and "Wallace Island." You will manipulate important parameters that influence natural selection and then follow how your changes influence the evolution of beak size and population numbers for the two different populations of finches over selected time intervals. One obvious advantage of this simulation is that you can quickly and easily create new parameters and model evolutionary changes over long time periods.

The finches on Darwin and Wallace Islands feed on seeds produced by plants growing on these islands. There are three categories of seeds: soft seeds, produced by plants that do well under wet conditions; seeds that are intermediate in hardness, produced by plants that do best under moderate precipitation; and hard seeds, produced by plants that dominate in drought conditions. EvolutionLab is based on a model for the evolution of quantitative traits—characteristics of an individual that are controlled by large numbers of genes. These traits are studied by looking at its statistical distribution in a population and investigating how the distribution changes from one generation to the next. For the finches in EvolutionLab, the depth of the beak is the quantitative trait. You will investigate how this trait changes under different biological and environmental conditions.

You can manipulate various biological parameters (initial beak size, heritability of beak size, variation in beak size, clutch size, and population size) and two environmental parameters (precipitation, and island size) of the system, then observe changes in the distributions of beak size and population numbers over time.

Assignment 1: The Influence of Precipitation on Beak Size and Population Number

1. The first screen that will appear in EvolutionLab presents an initial summary (Input Summary) of the default values for each of the parameters that you can manipulate.

   Notice that default values on both islands are the same. Click on the Change Inputs button at the left of screen to begin an experiment. A view of initial beak size will now appear.

   In the Change Input view you can change the biological and environmental parameters in EvolutionLab to design an experiment. This first experiment is designed to study the influence of beak size on finch population numbers. For finches, deep beaks are strong beaks, ideally suited for cracking hard seeds, and shallow beaks are better suited for cracking soft seeds.

   Write down an hypothesis to predict how changes in beak size will affect population numbers for these finches.
Test your hypothesis as follows:

a. Begin by setting the initial beak size on the two islands to opposite extremes. Leave the initial beak size on Darwin Island at 12 mm and click and drag on the slider to change the initial beak size on Wallace Island to 28 mm. Note the change in beak size that appears on the graphic of each finch. Click on the Precipitation button to view the distribution of seed types on both islands. Click the Done button to return to the input summary view. Notice the new input value (28 mm) for beak size on Wallace Island while beak size on Darwin Island remains at the default value of 12 mm. Use the "revisit in" drop-down box in the lower left corner to select a value of 300 years, and run the simulation by clicking the Run Experiment button.

b. Once the experiment has run, you will be in the Beak Size view. **Look at the plots of average beak size over time. What do you observe? Do you notice any trends in beak size? Click on the Population tab at the top of the screen and look at the plots of population numbers over time. What changes do you see? Do the two islands differ? Does the data support or refute your hypothesis?**

Click on the Histograms tab. These are plots of surviving birds and total birds plotted against beak size. Click and drag the slider to advance the years of the plot and to see how beak size on each island may have changed over time. Note how the distributions of beak size change over time. **What happened to beak size on Darwin Island compared to Wallace Island over time? Is this what you expected? Why or why not?**

Click on the Input Summary button to see a table of your input values for this experiment.

2. This next experiment is designed to explore the effect of precipitation on finch beak size and population numbers. Click the New Experiment button, click the Change Inputs buttons then click the Precipitation button. Recall the relationship between precipitation and seed growth. There are three categories of seeds: soft seeds, produced by plants that do well under wet conditions; seeds that are intermediate in hardness, produced by plants that do best under moderate precipitation; and hard seeds, produced by plants that dominate in drought conditions.

3. **Write down an hypothesis to consider how a decrease in precipitation on Darwin Island might affect beak size and another hypothesis to explain how a decrease in precipitation might influence population numbers for these finches over time.**
Test your hypotheses as follows:

a. Leaving all other parameters at their default values, decrease precipitation on Darwin Island to 0 mm. Notice how the distribution of seeds produced on Darwin Island changes as you change precipitation. Click Done. Set the experiment to run for 100 years, then run the experiment. Compare beak size and population numbers for the finches on Darwin Island over 100 years. Scroll down the Field Notes view to observe the data recorded over 100 years. Use the Beak Size and Population buttons to view the effect of your experiment on each of these parameters.


Run another experiment for 200 years by clicking on the Revise Experiment button. Use the popup menu at the lower left corner of the screen to select a value of 200 years, then click the Run Experiment button. Repeat this experiment for 300 years.

What changes did you observe in beak size and population numbers? Do these results confirm or refute your hypothesis? If necessary, reformulate your hypothesis and test this hypothesis.

b. Repeat the above experiment now setting both Wallace Island and Darwin Island precipitation to 0 mm.

Did you notice any differences between precipitation, changes in beak size, and population numbers for the finches on Wallace Island compared with those on Darwin Island? Explain your answers.

c. Now develop an hypothesis to consider how an increase in precipitation on Darwin Island might influence the evolution of beak size.
Click the New Experiment button, return to the Change Inputs view then increase the precipitation on Darwin Island to 80 cm while leaving precipitation on Wallace Island at the default value. Run this experiment for 300 years to test your hypothesis.

**What did you observe?** After you have observed the data for this experiment, rerun this experiment by clicking on the Revise Expt. button, and then on the Run Experiment button. Look at the output results in the Beak Size and Population views. Do you notice any differences in this rerun compared with the previous run? Run and rerun each experiment for 100, 200, and 300 years. Are the general trends observed in each run the same as the previous run? Explain your answers.

Perform another experiment to test your hypothesis by increasing precipitation on Wallace Island to 50 cm/year and increasing beak size to 28 mm. **Run an experiment for 300 years and describe your results. Do these results support your hypothesis?**

d. Start a new experiment and decrease beak size on both of the islands to an intermediate value. Decrease rainfall on one island to a value close to zero. On the other island, increase rainfall close to the maximum value. Run the experiment for 300 years.

**Were the effects on each island the same or different?** What did you observe? Were these the results you expected? Explain your answers to justify what is happening to finches on each island. Be sure to provide explanations for any differences in beak size and population numbers that you observed when comparing finches on both islands.

**Assignment 2: Effect of Island Size**
The size of the living area for any population can strongly influence population numbers for organisms that live within that environment. The maximum number of organisms from a given population that an environment can support is known as the **carrying capacity** of that environment. Island size is one factor that can determine the carrying capacity of finches on each island. For the purposes of this simulation, the islands are assumed to be roughly circular and island size is represented as the radius of the island in kilometers. The size of each island remains constant throughout the simulation unless you choose to change this parameter. Although changing the entire size of an island is not something that could easily be done in real life, habitat changes and reducing the living environment for a population are real changes that occur through processes such as land development, and pollution. The following assignment is designed to help you learn about the influence of island size on the carrying capacity of finches on Darwin and Wallace Islands.
1. Develop a testable hypothesis to predict what effect an increase in island size will have on beak size and finch populations.

Test your hypothesis as follows: Begin your experiment by leaving all other parameters at their default values. Select the Island Size input and use the sliders to increase the size of either Darwin or Wallace Island. As you move the slider, the island image will change to reflect the values you have chosen. Run the experiment for 300 years.

What effect did this change in island size have on finch population? What effect did this change in island size have on beak size? Are the results what you expected? Explain your answers. Perform a new experiment to learn about the effects of a decrease in island size on beak size and finch populations.

2. Based on the previous experiments, consider possible parameters that you could manipulate which would prevent the changes in population size and beak size that you observed from occurring.

Test the effect of these parameters to influence population size and beak size by designing and running experiments to confirm or refute your answers.

Assignment 3: Variance

Variance is a measure of how different the phenotype is from one bird to the next. If the variance of a trait is large, then there will be large differences in phenotypes among birds for a given trait. If, on the other hand, variance is low (near zero), then all of the birds will be very similar to one another. You can use the sliders to change the variance for each island population. As you move the slider, the width of the bell-shaped probability distribution will change to reflect the value that you have chosen.

1. For the finches on one of the islands, develop a hypothesis to consider the effects of changes in variance on population numbers.

Begin by decreasing variance to a value close to zero. Run your experiment for 300 years.

Explain the results of this experiment. Perform a similar experiment for an increase in variance. Describe your results. Can you reverse any of the trends in population number by changing other variables such as precipitation?
Try another experiment in which you increase variance on Darwin Island to a value close to 2.0. Decrease variance on Wallace Island to a value close to 0.1. Equally change precipitation on both islands to a value close to zero. Run the experiment for 300 years.

What were the results of this experiment? Explain why the differences in variance on each island produced these results. What do these results tell you about the benefit of a population with a broad variance compared to a population with narrow variance? Which condition do you think is most desirable for maintaining a diverse population and for minimizing a population’s risk of extinction?

Assignment 4: Extinction
Now that you have manipulated many of the biological and environmental factors in EvolutionLab, consider how these factors could lead to extinction of the finch population on either island.

1. What conditions could lead to extinction of a finch population? Which parameter(s) is/are most important in determining whether a population goes extinct? Come up with three different hypotheses about sets of conditions that could lead to extinction.

2. Design and perform experiments that will confirm or refute your hypotheses. We will compare your answers with those of other classmates.

REFERENCE INFORMATION

- Much of the text for this lab was taken from “Evolution Lab” which is one of the simulations offered in the biologylabsonline.com packet (biologylabsonline.com). This is proprietary software that NSCC has paid to use.