Before coming to lab, you should read through this entire handout

Objectives

Upon completion of this exercise, you will be able to:

1. Identify the effects of natural selection in a population.
2. Identify the factors cause of any changes you observed in your populations.
3. Understand how scientists are able to build “family trees” that show the relationships among different species.
4. Be able to interpret family trees.
5. Be able to define the terms used in this handout and any other references that are used as part of the lab exercise..

Evolution is defined as a change in species over time (usually referring to changes in the genetic characteristics of a species). Charles Darwin (1809-1882) is generally credited as being the first person to develop a theory that was able to explain the diversity of life, although he was not the first person to actually propose such a theory. In fact, several evolutionary theories were developed before Darwin was even born. In 1859, Darwin published *On the Origin of Species by Means of Natural Selection*, a book detailing the evidence showing evolution has occurred, and giving his theory to explain the process that produced evolutionary change.

Darwin tied together ideas from a number of sources to develop his theory. He realized that any species was capable of producing far more offspring than the environment could support, and there needed to be some way to explain what happened to all the “extras”. He hypothesized that there was competition between individuals for the limited resources available in the environment. Darwin also knew that organisms varied (generally, no two organisms are identical) and that some of that variation could be passed on to their offspring (which is why we tend to resemble our parents more than strangers).

Darwin’s theory was composed of two main points:

1. **Natural selection** – this is the term Darwin used to describe the force that was responsible for making organisms better able to survive in their environment. Natural selection can only act on variation that exists in the population, it does not create that variation. Organisms with traits that allow them to survive in their

environment will tend to produce more offspring than other individuals. Since those offspring will resemble their parents, the traits that allowed the parents to survive will spread throughout the population (see Figure 1)

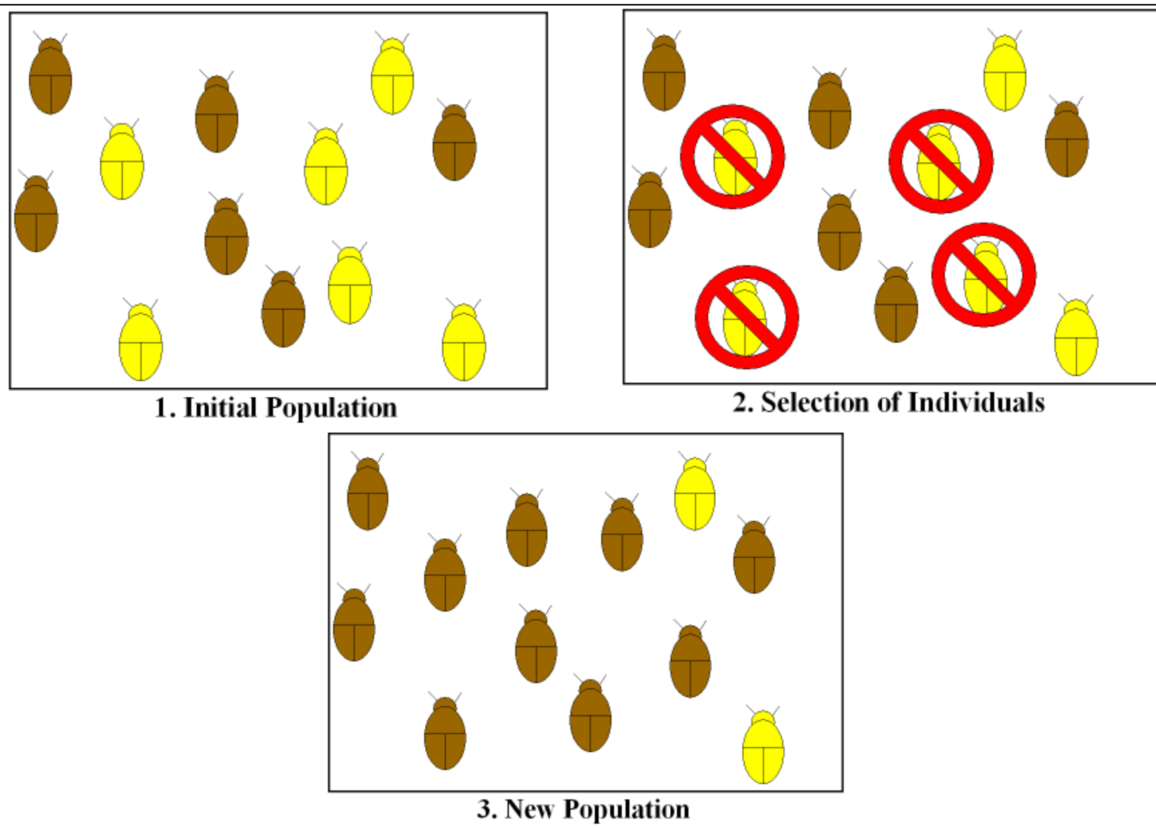


Figure 1 – Natural selection at work in a population of beetles. The force of selection in step 2 could be a predator that is able to catch the yellow beetles more easily or a disease to which the yellow beetles are more susceptible. After a generation of selection, the population has changed to contain more brown beetles, and very few yellow ones.

There are two main levels at which organisms can exhibit variation. They can vary in the physical makeup of their body structures (their **phenotype**) or they can vary in the makeup of their genetic material (their **genotype**). In general, natural selection can only act on phenotypic variation, since it can only affect the traits an organism actually expresses.

Selection can be divided into three different classes – directional, stabilizing, and diversifying. **Stabilizing selection** acts to eliminate the extremes of a population, which causes the population to stay at the average value for that trait (e.g., eliminating individuals who are too large or too small – figure 2a). **Directional selection** causes a species to change in some trait in one direction by eliminating individuals that are at one extreme for that trait (e.g., getting larger by selectively eliminating smaller individuals – figure 2b). **Diversifying selection** favors either extreme and eliminates the individuals at the average (e.g., favoring large or small individuals over medium-sized ones – figure 2c).

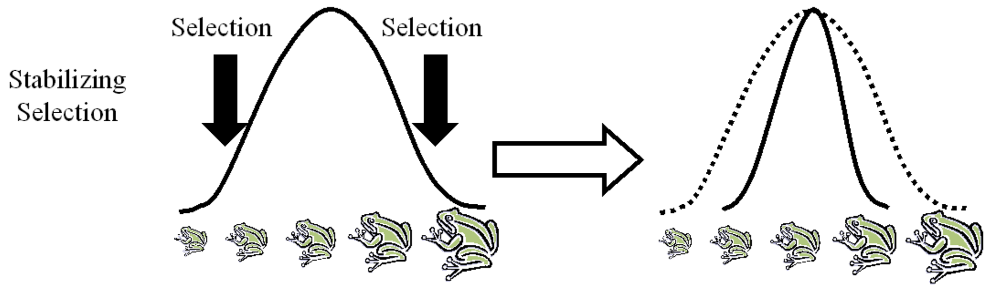


Figure 2a – Stabilizing selection. The original population is undergoing selection that eliminates large and small individuals. The resulting population will consist primarily of medium-sized individuals.

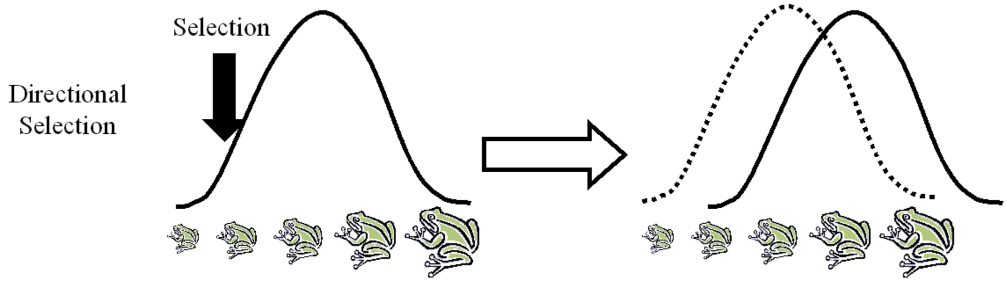


Figure 2b – Directional selection. The original population is undergoing selection that eliminates small individuals. The resulting population will contain more large individuals than were present previously.

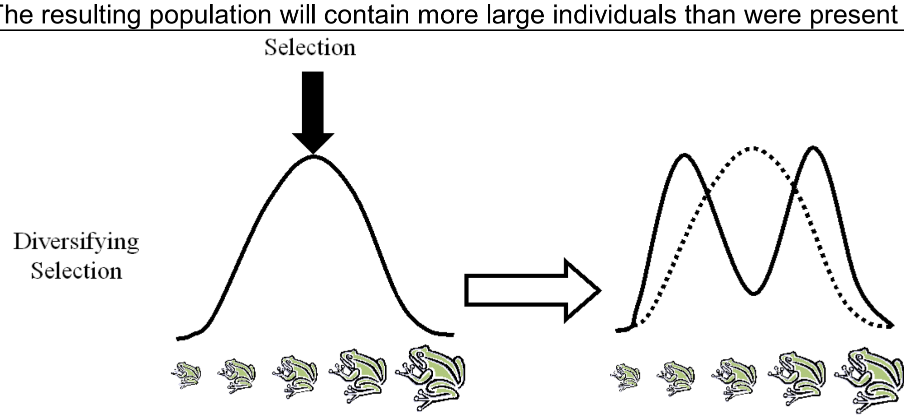
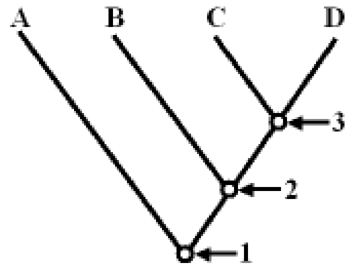


Figure 2c – Diversifying selection. The original population is experiencing selection that eliminates medium-sized individuals while favoring smaller and larger individuals.

2. **Common descent** – Darwin's second idea was that all living organisms were related to one another through a process called **descent with modification**. This idea is that species arise from a **common ancestor** and change over time, leading to the production of new species.

   Evolutionary relationships between species are generally represented using a type of "family tree" called a **cladogram** (figure 3). This type of diagram shows species as branches in the tree. At each branching point, the common ancestor's species (represented by the white circles) has diverged to produce two new species (represented by the letters at the end of the lines).

Figure 3 – Hypothetical cladogram for four species. The circles represent common ancestors to the species that branch from that point. 1 would represent the common ancestor of all four species, while 3 would only be a common ancestor for species C and D.



Exercise 1
Natural Selection

In this laboratory exercise you will be simulating the effects of selection on a population, and determine how selection causes that population to change.

Hypothesis: Develop a hypothesis based on the introduction to the lab and the experiment described below. Record this hypothesis on your report sheet.

Materials per group (4-5 students per group):

- ❑ 2 styrofoam bowls
- ❑ 5 cups of various sizes of beans

Part A:
To see how an initial population of "microbes" changes in response to its environment.

Procedure:

1. Obtain the materials listed above
2. Use a pencil or pen to make six holes in the bottom of **one** Styrofoam bowl. The holes should all differ in size.
3. Count out 5 of each type of bean and put them into the Styrofoam bowl with holes in it. Be sure to hold your hand over the holes so that no beans fall out. This represents your initial population of microbes. Each bean represents a single-celled organism.
4. Shake the bowl side to side 15 times (try not to vary how hard you shake the bowl each time) over the second bowl, so that you catch any beans that fall out of it.
5. The "microbes" that fall through the hole are considered dead. The ones that stay in the bowl are the parents for the next generation of microbes.
6. Count the number of beans that remain in the bowl. Record this information in table 1 on the report sheet.
7. For each bean remaining in the bowl, add another bean of the same type to represent the fact that the microbe divided. Only those that survive are able to reproduce. Record the doubled number in the appropriate column in table 1
8. Repeat steps 4-7 for until you have collected data for five generations of microbes.
9. Plot the appropriate data for each generation in figure 1 of the report sheet and answer the questions about the experiment.

Exercise 2
Computer Simulation – Darwinian Snails

In this exercise you will be using the "Darwinian Snails" software that was included with your laboratory bundle. You should read the instructions for the appropriate sections before coming to lab. For this exercise, we will be covering pages 1-13. Other pages might be used in later labs – check with your instructor for more information.

Run the experiments that start on page 3, and answer the appropriate questions on the report sheet. Be sure that you follow ALL the instructions in the manual or you may end up with results that are difficult to interpret.

Part I of the experiment is a "baseline" that you will use to compare the other experiments, so you will want to make careful observations of your results.

Part II will address the requirements for evolution to occur by natural selection, so you will be removing one of those requirements at a time and seeing how the populations change. These requirements are 1) variation in the trait, 2) inheritance of the trait, 3) survival is not random.

Part IV discusses the source of variation. In this experiment, you will add the possibility of mutation and see how that affects your population.

Exercise 3

Web Exercise - Relationships Among Species

Visit this web site from the University of California at Berkeley, entitled "What did *T. rex* taste like?"

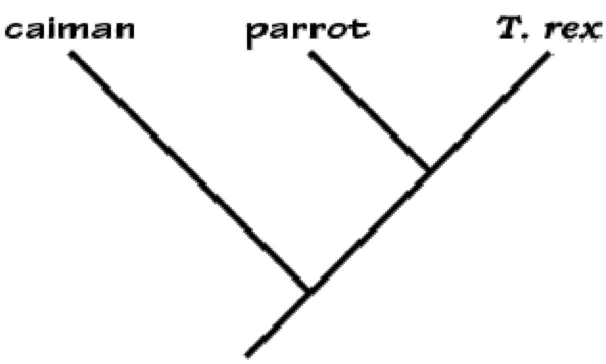
http://www.ucmp.berkeley.edu/education/explorations/tours/Trex/index.html

Click on the link labeled "Student start" and work your way through the exercises. You should be careful to note any vocabulary terms that are used through the exercises. You are expected to learn them and may be tested on them.

When you have finished the exercise, you will address two of these questions as chosen by your instructor.

1. Did *T. rex* have an amniotic egg?
2. Was *T. rex* warm- or cold-blooded?
3. Could *T. rex* have had feathers?
4. Did *T. rex* have color vision?
5. How many chambers were there in *T. rex's* heart?
6. Did *T. rex* sing to its offspring?

To answer these questions you will use the following cladogram and data



This data table indicates the presence or absence of eleven additional features for the caiman and the parrot. Notice that the information about the T. rex has not been filled in. You will need to make that determination based upon what you have learned.

	caiman	parrot	T. rex
color vision	+	+	
warm blooded	0	+	
feathers	0	+	
sing to young	+	+	
scaly skin	+	+	
melanin pigment in skin	+	+	
amniotic egg	+	+	
few glands in skin	+	+	
hole in hip socket	0	+	
3-chambered heart	+	0	
4-chambered heart	0	+	