Name ____ **Lab Section** _________________

Objectives: To gain an understanding of:

- How natural selection works to bring about evolutionary change.
- The key features of natural selection and the role they play in the selection process.
- How mutations introduce new variation into a population and their importance for evolutionary change.
- How changes in the environment can change the selection for or against a particular feature and how these changes can lead to evolution.

Background material can be found in Chapter 1.7 and Chapter 13.1-13.9 of *Biology: Concepts and Connections, 8th ed*

Evolution is the most important unifying principle in biology. Every living organism looks, functions, and behaves like it does because of evolution. This is true regardless of whether we are looking at cells, individuals, populations, or even entire ecosystems – all are (and have been) shaped by evolutionary processes.

B**iological evolution** is a change in the genetic make-up of a population over time. These genetic changes can result in visible changes among members of the population.

The primary mechanism of adaptive evolutionary change is **natural selection**. The following conditions are necessary for natural selection to occur:

1. **Genetic Variation**. Individuals within a population differ from each other. In order for Natural Selection to work, some of this variation must have a genetic basis. This is, traits must be passed down from parents to offspring.
2. **Overproduction of Offspring**. Within a population, more offspring are produced than can possibly survive.
3. **Struggle for Existence.** Individuals within a population compete for limited resources, such as food, space, and mates.
4. **Differential Survival and Reproduction**. Because of their different traits, some individuals are more likely to survive and reproduce than others. Over time, descendants of these survivors, having inherited **adaptive traits**, will be more abundant in the population.

Given these conditions, certain traits will gradually become more common in the population, while others will become less common. In effect, the environment, or nature, "selects" some traits over others. It is this process of natural selection that brings about evolutionary change.

Variation in Natural Populations

In this first exercise, you will be introduced to a small sample of the variation found in nature. Birds are highly variable for several, easily measured features such as bill length, height and width, tarsus (lower leg) length, and wing and tail length. To help illustrate this variation, you will measure the bill length and bill height of a series of individuals of the same species.

Series of 4-5 individuals of several species of birds are available in lab. You will choose **two** different species to measure. Please do not measure two very similar species. Using the calipers on the trays on your table, measure the bill length and bill height, **in millimeters**, of all the individuals in each of the two species you chose. Please wear gloves when handling birds, as the oil from your hands can damage the specimens. Record your measurements in tables 9.1 and 9.2 below. At the top of the table, write the common and scientific names of the species you are measuring. These can be found on the bird specimen tray.

After recording all your measurements, calculate the mean and range of values for each trait within each species. To calculate **mean**, add all the measurements and divide that sum by the number of measurements taken (you may know this calculation as the average). To calculate **range,** subtract the lowest measurement value from the highest value in the series.

Table 9.1

Variation in (Species name) ____
(provide both common and scientific names of your species)

	Bill Length (mm)	Bill Height (mm)
Individual 1		
Individual 2		
Individual 3		
Individual 4		
Individual 5		
Mean		
Range		

Table 9.2

Variation in (Species name) ____
(provide both common and scientific names of your species)

	Bill Length (mm)	Bill Height (mm)
Individual 1		
Individual 2		
Individual 3		
Individual 4		
Individual 5		
Mean		
Range		

✍ Within these samples, which trait exhibited the most variation?

✍ Why do you think this variation is important? (Hint: think in terms of the four conditions required for natural selection)

Natural Selection

Given that evolutionary theory is the most important unifying principle in biology, it is just as important to understand natural selection. The problem is that under most conditions the process of natural selection is slow, occurring over many generations. Fortunately, by using a simulation, we can speed up the process and study how natural selection works in a three-hour lab.

This exercise will demonstrate how natural selection works. As a group, we will simulate a situation in which individuals with different types of feeding structures are presented with a food source and allowed to “eat”. Some individuals will be more successful than others at obtaining food. Those that are most successful will survive and reproduce offspring just like themselves, and those that are less successful will die. After a few generations of this “natural selection”, we should see a change in the number of different types of individuals in the population – we should see that evolution has occurred.

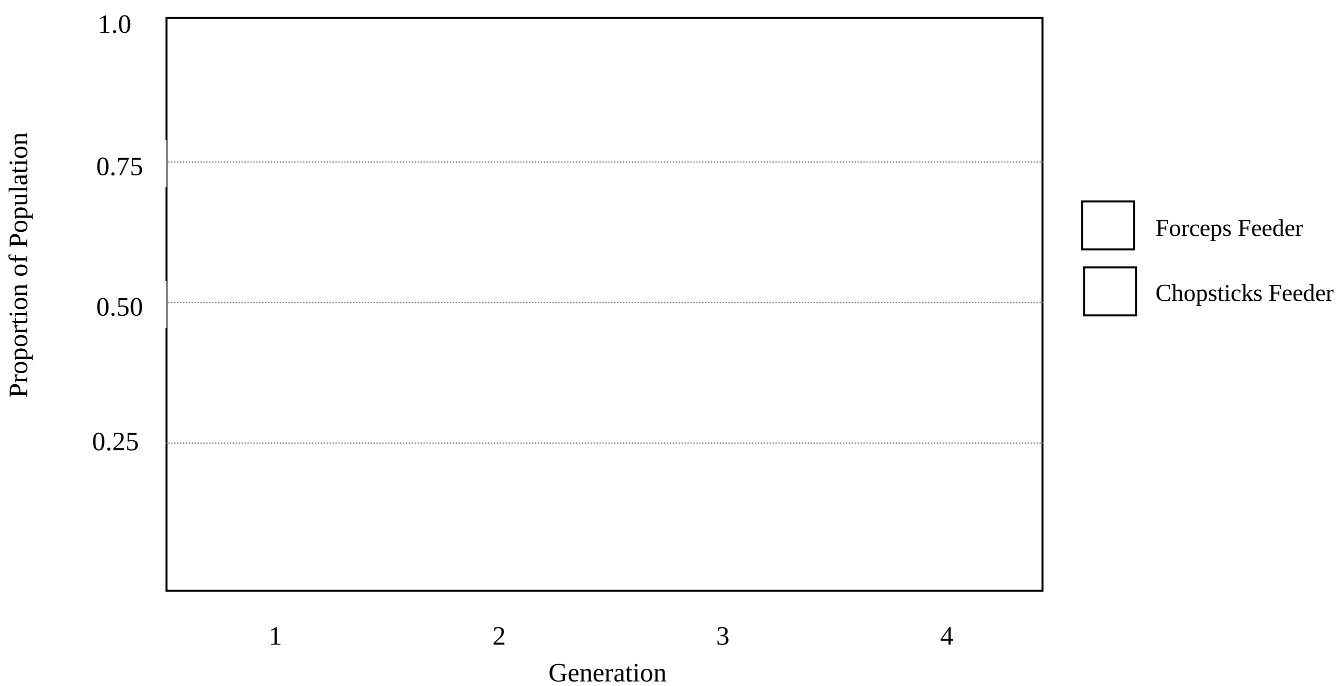
Note how this simulation includes all **four of the conditions necessary for natural selection** to work. **Genetic Variation** is represented by the different feeding structures and the fact that parents produce offspring just like themselves; **Overproduction of Offspring** is represented by the fact that not all individuals born will actually survive. Thus, there is a **Struggle for Existence** in which individuals compete for certain resources, in this case food. **Differential reproduction** is represented by the fact that only the best feeders will survive and reproduce.

The class will be evenly divided into two feeding types – “chopstick feeders” and “forceps feeders”. Evenly spread a layer of black and white beans on your fabric lined tray. The beans are your food. Using your assigned feeding structure, you will “eat” as many beans as you can in 30 seconds. “Eating” consists of picking up the bean and depositing it in your paper cup. At the end of the 30 second feeding session, you will count the number of beans you ate and record it on the board in lab. Only the top 50% of the population will survive and reproduce. Everyone else dies! (Don’t worry, you will be “reborn” as the offspring of one of the survivors.) The feeding sessions will be repeated for three more generations. Record the class data in table 9.3 below.

Table 9.3
Natural Selection Simulation: Class Data

	Number in Population		Proportion of Population	
	“Chopsticks”	“Forceps”	“Chopsticks”	“Forceps”
Generation 1				
Generation 2				
Generation 3				
Generation 4				

To more clearly illustrate the effect natural selection had on our population, you need to graph the data. On the graph below, plot the data from the last two columns (proportion of each feeding type) of table 9.3 for each generation.



✍ What happened to the proportion of "chopsticks feeders" in the population? Did it increase or decrease?

✍ What happened to the proportion of "forceps feeders" in the population? Did it increase or decrease?

✍ Why do you think the proportions of each feeding type changed the way they did?

Mutation

At the conclusion of the previous exercise our population was most likely composed entirely of "forceps feeders". Natural selection favored this type of feeding structure, and so it became more prevalent until it was the only feeding type left. As a result, there was no variation left in the population.

QUESTION ✍ What happens, with respect to evolution and natural selection, when there is no variation among the individuals of a population or species?

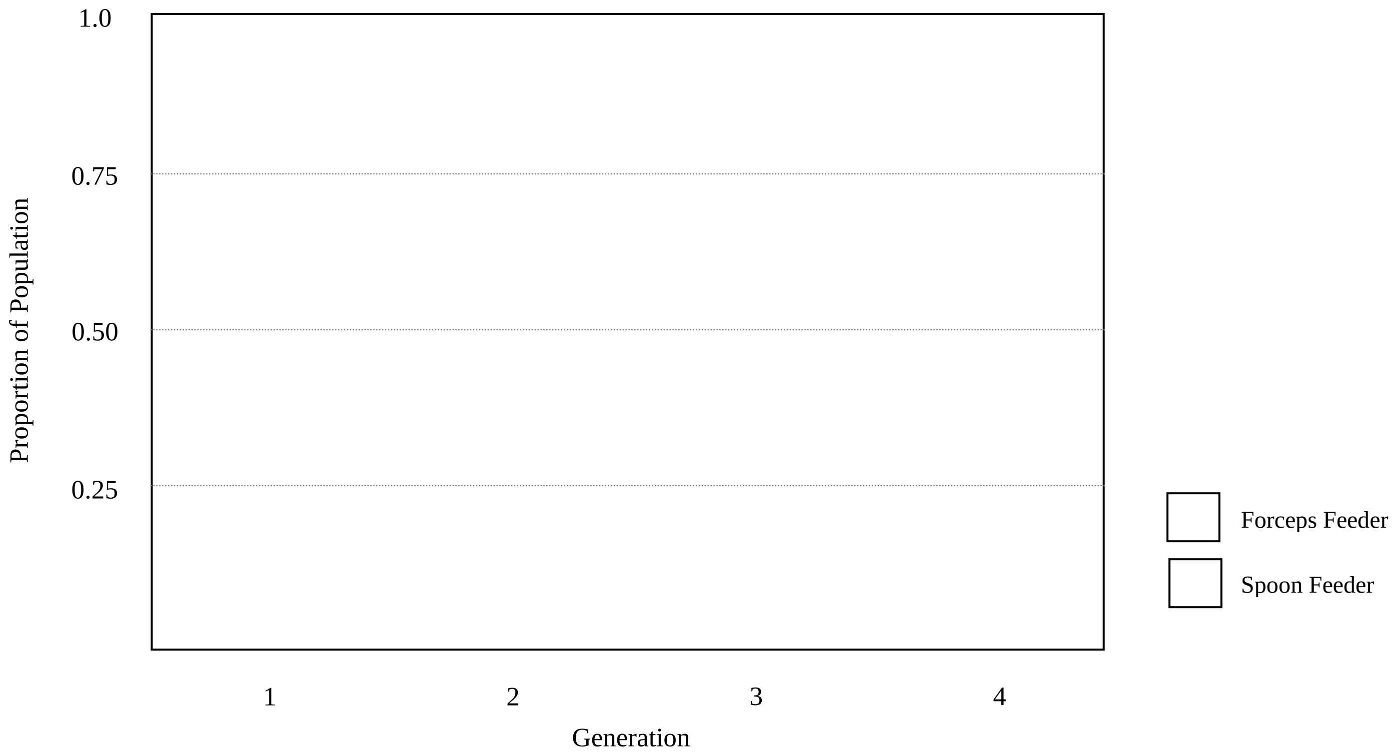
The next exercise will demonstrate the role **mutations** play in the evolutionary process. Mutations are defined as any change in the DNA of an individual. Mutations are a very important part of the evolutionary process and are **the only source of novel genetic types.** That is, mutations are the only source of new alleles.

For this exercise, we will introduce a "mutant" feeding type into our population of "forceps feeders" and watch how natural selection deals with this new form. To begin, everyone in the population remains a "forceps feeder" except two. Two people get to be the new "mutant" form, "spoon feeder". Just as in the previous exercise, everyone will get to feed for 30 seconds. Only the top 50% of food getters will live and reproduce, everyone else dies. We will run this simulation for four generations. Record the class data in table 9.4.

Table 9.4
Natural Selection Simulation: Class Data

	Number in population		Proportion of population	
	"Spoons"	"Forceps"	"Spoons"	"Forceps"
Generation 1				
Generation 2				
Generation 3				
Generation 4				

On the graph on the next page, plot the data from the last two columns (proportion of each feeding type) on table 9.4 for each generation.



✍ What happened to the proportion of “spoon feeders” in the population? Did it increase or decrease?

✍ Explain, with respect to natural selection, why you think the proportions changed like they did.

The previous exercise showed one outcome when a mutation introduces a new form into a population. However, not all mutations are beneficial and instead may be quite harmful. To illustrate what happens to a harmful mutation, we will re-run the mutation exercise using a different mutation, “probe feeder”. Again, only two members of the population will become the mutant type. We will run this simulation for only two generations. Record the class data in table 9.5.

Table 9.5
Natural Selection Simulation: Class Data

	Number in population		Proportion of population	
	“Probes”	“Forceps”	“Probes”	“Forceps”
Generation 1				
Generation 2				

✍ Explain, with respect to natural selection, what happened to the mutant form.

Environmental Change

The mutation exercise showed how a population with no variation for a particular trait (all individuals have the same trait) can obtain new variation through mutations. Further, it showed that the introduction of new forms can change the evolutionary path of a population. Mutations can be either selected for or against – either increasing or decreasing their numbers in the population. It is important to point out that mutations not only affect external structures or traits (things we can see directly), they can also affect internal structures such as organs, tissues, and biochemical pathways.

This exercise demonstrates the role that the environment plays in natural selection and evolution. A change in the environment can change the selective pressures on a population. A particular trait that was previously selected for in a population can become selected against if the environment changes (or vice versa).

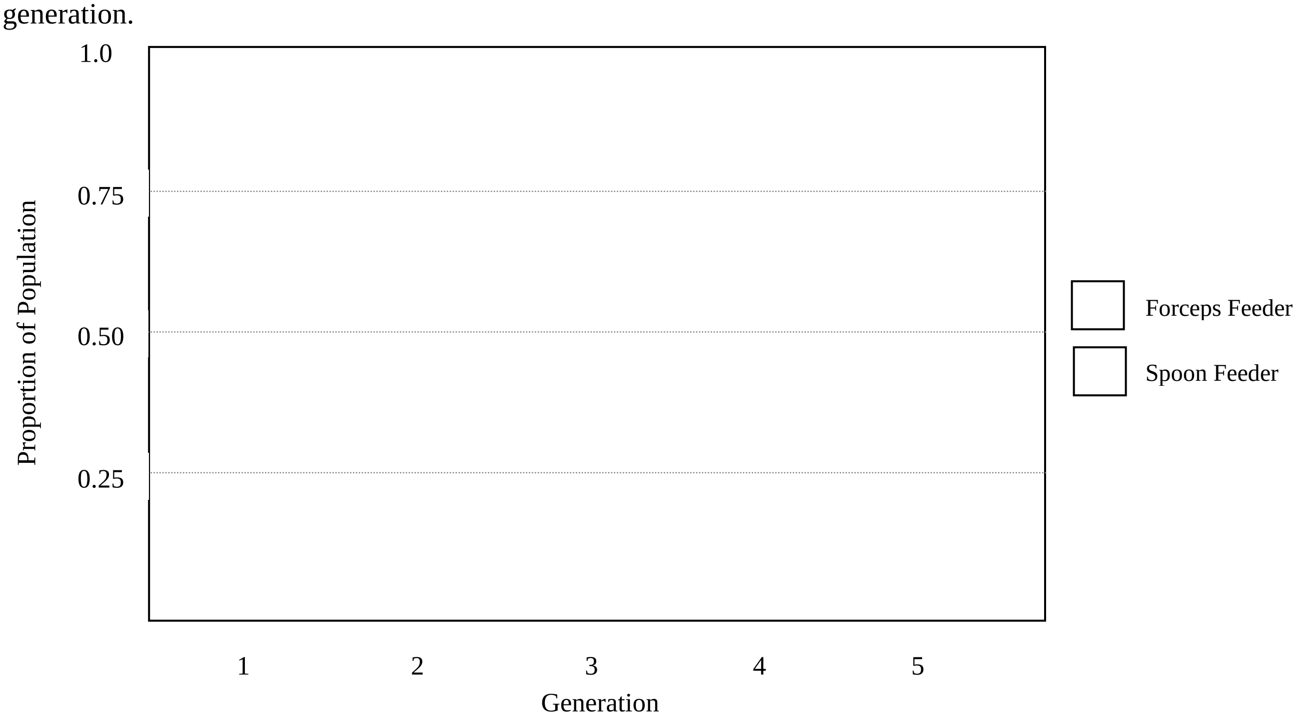
There is a change in our selection environment: The white beans experience a mutation that makes them poisonous and lethal if eaten. They occur in the same area and proportion as the black beans. The two feeding types for this simulation will be “forceps” and “spoons”. We will begin the simulation with equal numbers of each feeding type.

Feeding sessions will last for 30 seconds. However, in this simulation anyone that gets a black bean in his or her “mouth” dies immediately and stops feeding. At the end of the feeding session, the top 50% of feeders live and reproduce, the rest die. We will repeat this for four more generations. Record the class data in Table 9.6.

Table 9.6

	Number in population		Proportion of population	
	“Spoons”	“Forceps”	“Spoons”	“Forceps”
Generation 1				
Generation 2				
Generation 3				
Generation 4				
Generation 5				

On the graph below, plot the data from the last two columns (proportion of each feeding type) on Table 9.6 for each generation.



✍ What happened to the proportion of "spoon feeders" in the population? Did it increase or decrease?

✍ What happened to the proportion of "forceps feeders" in the population? Did it increase or decrease?

✍ Compare your results with the first mutation simulation (see pages 9.4 & 9.5). Explain why you think you got different results in the two simulations.

✍ **Questions and Summary for Natural Selection simulations**

1. What are the four conditions necessary for natural selection to work?

Given your newly acquired understanding of evolution and natural selection, answer the following:

2. Why are mutations important? What role do they play in the evolutionary process?

3. How can environmental change affect evolution?

Natural Selection Scenario:

For your final exercise in this lab, you will describe how natural selection can lead to evolution within a population.

Working in groups of three or four, come up with a scenario under which **natural selection** can result in evolution within a population. You can use real organisms, or make up organisms and an environment in which they are found. You may want to use drawings to supplement your description of the scenario you create.

✍ Your scenario should include:

- Description of a population with **genetic variation** in a given trait.
- **Differential survival and reproduction** within this population.
- Indication of what the population will look like after several generations.

✍ Finally, indicate how this scenario might change if the environment changes:

Using your Natural Selection scenarios as examples, your instructor will review how the process of natural selection works.