BIOLOGY 1101
LAB 6: MICROEVOLUTION (NATURAL SELECTION AND GENETIC DRIFT)

READING: Please read chapter 13 in your text.

INTRODUCTION: **Evolution** can be defined as a change in allele frequencies in a population over time. **Natural selection** and **genetic drift** are two different mechanisms of evolution, and because they deal with generation to generation changes in alleles (small protein coding regions of DNA), are sometimes referred to as mechanisms of **microevolution**.

Natural selection is defined as differential survival and reproduction of organisms. In this process, alleles that make a population better able to survive and reproduce are "selected for" – in other words, they become more common. Alleles that do not confer fitness are selected against – that is, individuals that are not as good at finding food, shelter, mates, etc. do not pass on as many copies of their genes to future generations as more "fit" individuals, because they are less successful at reproducing. "Survival of the fittest", as the outcome of natural selection is sometimes called, is fairly easy to comprehend. **Fitness**, in terms of natural selection, is defined as the number of offspring an individual produces. Natural selection is an important process underlying the theory of evolution as proposed by Darwin and Wallace. You may also be familiar with the term "**artificial selection**," which happens when humans artificially select for the traits (alleles) they want in the population. There are many examples of artificial selection, especially if we think of the success in breeding dogs, most livestock (like horses and cattle), or many kinds of plants to suit our purposes. Natural selection is sometimes harder to imagine than artificial selection, although both are fairly straightforward concepts. What is more difficult is an appreciation for the effects of natural selection within a population over time, resulting in evolution.

While a change in allele frequencies due to natural selection is determined by environmental effects, **genetic drift** is random change in allele frequencies in a population due to chance events. Because genetic drift is a random process, it does not result in adaptive evolution, and "good" and "bad" alleles (in terms of the fitness they confer) are equally likely to become more common. The smaller the population is the more likely random changes in allele frequencies are to occur. For example, if an individual is accidentally killed by a falling tree, the loss of those two alleles is more likely to alter overall allele frequencies in a population of ten individuals than in a population of one million.

LABORATORY OBJECTIVES: The purpose of this set of laboratory exercises is to provide you with a better understanding of evolutionary mechanisms. In this lab, and from your readings, you should learn to describe the basics of natural selection and genetic drift and their importance in evolution.

EXERCISES:

A. Natural Selection

Materials:

- A plastic “habitat” in which to forage
- Roughly 200 beads of any single color
- A different foraging tool for each member of the group (forceps, plastic fork, etc.)
- A plastic cup for each member of the group
- A stopwatch or wristwatch to track foraging time

Procedure: (Read the entire section before you start.)

1. Work in groups of 4-5. In your group, designate one person to keep track of time. Each of the remaining students will be “predators” and should pick one of the foraging tools; that is, predators which feed using forceps, spoon, fork, etc. There should be no more than two foragers with the same tool at the start, and ideally everyone should have a different tool. These variations represent genetically fixed, species differences in the population. All individuals have identical mouths (cups).

2. The time keeper should pour the beads into the plastic foraging tray and spread them out relatively evenly. Each foraging bout should last 1 minute. The rest of the group will begin hunting when the timekeeper says to begin and continue until the time keeper says to stop. The prey (beads) must be picked up ***one at a time*** with the feeding apparatus and placed in the mouth (cup, please don't really eat the beads). No scraping or pushing of the prey into the mouth is allowed. You must hold the bottom of the cup flat against the table. You may, however, dash in and pick up any prey being pursued by another predator or make a grab at prey already “captured” by another predator. Don't hesitate to intrude…any hungry natural predator would "go for it!" Remember, this is survival of the fittest! There are no particular rules; all we ask is that no one gets stabbed…

3. When told to stop hunting, count and record the number of prey you captured (in the table on the next page). This will allow us to see which predators were most successful. Return the prey items to the foraging habitat for the next round. Conduct a second foraging round like the first and again record the number of prey each forager captured in the table on the next page.

4. Stop for a moment and check your capture results. There is a good chance that the foraging group will have to be reconstructed for the next generation. Predators which capture less prey are not successful hunters and natural selection will remove them from the population. Any forager that captures the fewest prey two generations in a row will go extinct. One of the remaining foragers will then reproduce (the person who was least successful with their tool

can now pick any foraging tool they want, as long as it is identical to one of the tools already being used, and continue foraging as the "offspring" of a successful forager). Repeat these steps until only one predator type remains in the population (yes, even if it takes more than ten generations – just keep track on a separate piece of paper).

Generation 1		Generation 2		Generation 3		Generation 4		Generation 5	
Predator type	# Kills	Predator type	# Kills	Predator type	# Kills	Predator type	# Kills	Predator type	# Kills

Generation 6		Generation 7		Generation 8		Generation 9		Generation 10	
Predator type	# Kills	Predator type	# Kills	Predator type	# Kills	Predator type	# Kills	Predator type	# Kills

Discussion Questions.

1) What was the only surviving predator type at the end of your simulation? Why do you believe this was the most successful type and the other types went extinct?

2) If the prey items had been tater tots instead of beads, do you think your results would have been different? If so, how? What other modifications to the prey items could change the results? Think about color and patterns, movement, etc.

B. Genetic Drift

Materials:

- Two plastic foraging trays
- 55 beads each of four different colors
- A plastic cup for each member of the group

Procedure: (Read the entire section before you start.)

1. Establish two different populations of organisms, using the beads to represent alleles (remember that every *individual* has two *alleles*). Different colored beads represent different color alleles in the population. Both populations will begin the simulation composed of equal proportions of four different alleles, but one population will be small and one will be large. Create the small population by adding 5 beads of each of the four colors to one of the plastic trays. Create the large population by adding 50 beads of each of the four colors to the other tray.

2. The members in your group will now take turns acting as random mortality agents on the population (e.g., the effects of a tsunami). First, take turns removing two beads at a time from the large population. Do not look while you remove beads from the tray so the process is random. Keep going until you have removed 160 beads from the tray (leaving 40, or 20% of the original population). Record the percentage of each color remaining in the table below.

3. Have the remaining 40 beads "reproduce," by adding 4 beads back to the tray for each one remaining of that color (for example, if you have 5 blue beads left, add 5X4 = 20 blue beads to the tray, giving you a total of 25 blue beads). This should restore your population to the beginning number of 200 beads. Yes, we know it's tedious, but do it anyway. You will see why at the end. Repeat this process, of mortality and reproduction, 3 more times (for a total of 4 rounds), recording your data in the table below.

Percentage of Each Color Allele Remaining in Large Population

Color	Generation 1	Generation 2	Generation 3	Generation 4

4. Now take turns removing beads from the small population. Have group members remove a total of 16 beads (leaving 4 – again, 20% of the original population). Record the percentage of each color left in the table below. As before, have the remaining 4 beads "reproduce," by adding 4 beads back to the tray for each one remaining of that color (for example, if you have 2 blue beads left, add 2X4 = 8 blue beads to the tray, giving you a total of 10 blue beads). This should restore your population to 20 beads. Repeat this process, of mortality and reproduction, 3 more times (for a total of 4 rounds), recording your data in the table below.

Percentage of Each Color Allele Remaining in Small Population

Color	Generation 1	Generation 2	Generation 3	Generation 4

Discussion Questions

1) Were any color alleles eliminated from your large population? How about from your small population? After four generations of genetic drift, which population had the most diversity left, as illustrated by alleles for color?

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2) If you were protecting land to help preserve an endangered species, how might you design your preserve? Suppose you were given two options; protect three small pieces of habitat, or one large piece of habitat. Assume all habitat area is of equal quality for the species. Defend your answer in terms of the impacts of <u>both</u> approaches on the genetics of the species.

3) Match the Evolutionary Mechanism: In the following list of scenarios, what do you think is most likely to be responsible for the trait in the population, natural selection or genetic drift?

   a) The bright coloration of a poisonous snake, where coloration is unrelated to mating success: ____________________

   b) Albino coloration in a small, isolated population of the endangered kangaroo rat: ____________________

   c) The production of increasingly large, sweet fruits by a tree: ____________________

   d) A small, isolated population of indigenous people in a remote tropic forest, where all have the same blood type: ____________________

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