Lab Section: ____________________ **Name:** ______________________________________

Pre-lab Homework Lab 8: Natural Selection

1. This week's lab uses a mathematical model to simulate the interactions of populations. What is an advantage of using a model like this over doing research on real-world populations?

2. How can you be sure that the results of your model are telling you something about the real world?

3. In your own words, describe what natural selection is.

4. How are we going to model natural selection this week in lab? Explain briefly.

Name: ______________________________________ **Date/Lab time:** ___________________

Lab 8: Natural Selection

OBJECTIVES: After successfully completing this lab, a student will be able to:

- Explain how predation can affect prey species.
- Describe how populations can change depending on the environment.
- Discuss strategies that both predators and prey use to improve their chances of survival.
- Relate all of these ideas to the idea of natural selection.

Overview:

Phenotypic variability exists in all natural populations: some zebra are faster than others, some plants grow broader leaves, and so on. For a wide variety of reasons, some **phenotypes** (or **morphs**) survive and reproduce better than others (for example, faster zebra may survive and reproduce better than slower zebra). These phenotypes then become more common over many generations. This is the concept of **natural selection**. One of the common reasons some organisms have more success than others is because of how they interact with other species. In lab this week, we will look at how one type of interaction, the predator-prey interaction, can alter a population.

Today we will use a game to help model how predator and prey populations interact. Using games to model behavior is a commonly-used tactic in many situations, since it can allow scientists to experiment with the different variables that are thought to affect the behavior. Each different version of the game, with slightly altered variables, is like a hypothesis about how these behaviors occur. As the variables are altered, the results of the game change and can be compared to data about the real world. The goal is to create a game that seems most like the real world. The closer the match between the results of real world research and the game, the better the hypothesis, and therefore the better we understand the mechanisms that cause the behavior.

Today, we will simulate predator-prey interactions where individual prey are represented by various types of beans (pintos, lentils, etc.) and different predators are represented by different utensils (knife, fork, spoon). Each different type represents different phenotypes or morphs of the same species (e.g. a lima bean may be a big slow zebra while a lentil is a tiny fast zebra).

The Predator-Prey Game:

General Rules:

- Environment must have at least 4 predators (combine groups if necessary)
- Predators can use only one hand and must lift the prey into their cups. No scooping!
- After every round, you will recalculate the proportion of each phenotype in the populations.
- The sizes of predator and prey populations does not change, just the proportion of each morph in the population. Think of the population as being at its **carrying capacity**.
- Always try to think about the game you are playing in terms of the how populations interact in the world outside of the lab.

Exercise 1: The Most Wily Prey in the Carpet!

Predators of the same phenotype (knives) will “feed” on a variety of prey phenotypes scattered over a small piece of carpet. We will then track the changes in our populations.

Starting conditions: there are 5 different prey phenotypes, with 10 individuals of each phenotype, for a total population size of 50 individuals. This information is already filled out for you in Table 1 below. You will then fill out the rest of the table during the trial.

Trial 1
Up to four students armed with knives eat for 15 seconds on each round.
Start with your prediction: What type of prey do you think is the least likely to be "eaten"? Why?

Table 1.Trial 1: Changes in prey phenotype frequencies over 3 rounds of predation.

Prey Morph (name)	Starting Population (number of each)	Starting frequency	Pop. after One round	New frequency in pop.	Number at begin. of rnd. 2	Pop. after Round 2	New Frequency in pop.	Number at begin. of rnd 3	Pop. after Round 3	New Frequency In pop.
	10	.2								
	10	.2								
	10	.2								
	10	.2								
	10	.2								
total	50	1.0		1.0	50		1.0	50		1.0

Frequency = number of individuals of this type alive / total number of individuals alive

Procedure:

1. Set up your prey population. Select a piece of carpet for your background environment. Then place 10 of each of the 5 different bean types (phenotypes) randomly on the carpet. Strew the beans around so that they are spread out, but do not deliberately arrange the beans.

2. Assign each of the phenotypes (bean types) to a row (in column A) in Table 1 above (e.g. 1 = limas, 2 = lentils, etc.). Also fill out column C.

   Make a prediction: Which prey type will be the least likely to be “eaten”? Why?

3. Each student in your group should arm themselves with a knife and gather around the carpet.

4. Start a stopwatch, and “eat” for 15 seconds. Remember, no scooping! You should skim the prey off of the surface of the carpet.

5. After feeding time is over, count many of each prey type remain. Fill out columns D through F in Table 1 above.

6. Reset your prey population based on your results from Round 1. Make sure that your total population size is 50 individuals. Then repeat another round of predation, count the remaining prey, and fill out columns G through I of Table 1 above.

7. Reset your prey population based on your results from Round 2. Make sure that your total population size is 50 individuals. Then repeat another round of predation, count the remaining prey, and fill out column J of Table 1 above.

<u>Questions:</u>

1. Was your prediction about the "most fit" phenotype correct? If not, why do you think the results were different from what you thought would happen?

2. Did any type of prey disappear? What does this mean is happening to the population? How does this illustrate natural selection? Remember these are all members of the same species so the species is not going extinct!

3. Imagine that the phenotype of these prey are not determined by their genetics but only by their environment. How would this affect the ability of natural selection to change the population?

4. Do you think this simulation has taught you anything about natural selection in the "real world"? If yes: what? If no: what could be done to make a lab setting more like the "real world"?

Exercise 2: The Best Predator in the Carpet!

A new predator phenotype has appeared: the fork! Now 4 predators of two morphs (replace one knife predator with a fork) will "feed" on prey species scattered over a small piece of carpet. You will need to create a data table to track the predator populations over time and you will need to develop rules to control predator populations.

Starting conditions: Fill in the starting conditions in Table 2 below based on the information from Round 3 of the previous exercise. You will then fill out the rest of the table during the trial.

Up to four students armed with knives or forks eat for 15 seconds on each round. Round one includes one fork and the rest knives.

Start with your prediction: How do you think the pattern of prey consumption will change with the presence of this new predator?

How will you reset the population of predators on rounds two and three? (Do predators have to eat a certain amount to survive? How many prey must they eat to reproduce?) Write your rule here.

Trial 2: Changes in prey phenotype frequencies over 3 rounds of predation

Prey frequencies

Prey Morph (name)	Starting Population (number of each)*	Starting Frequency from trial 1	Pop. after One round	New frequency in pop.	Number at begin. of rnd. 2	Pop. after Round 2	New Frequency in pop.	Number at begin. of rnd 3	Pop. after Round 3	New Frequency In pop.
total	50	1.0		1.0	50		1.0	50		1.0

* from round three of trial 1

Predator frequencies

Predator	Starting Pop.	Starting frequency	Pop. after One round	New frequency in pop.	Number at begin. of rnd. 2	Pop. after Round 2	New Frequency in pop.	Number at begin. of rnd 3	Pop. after Round 3	New Frequency In pop.
knives										
forks	1									
total		1.0		1.0			1.0			1.0

*** Frequency = number of individuals of phenotype / total number of individuals**

**** # at start of round = frequency of phenotype x total number of individuals in starting pop.**

Procedure:

1. Set up your prey population based on the information from Round 3 of the last exercise (i.e. set your population using the frequencies from last column of Trail 1).

   Make a prediction: Which predator (knife or fork) will be the most successful? Why?

2. Replace one of your knife predators with a fork. Each student in your group should arm themselves and then gather around the carpet environment. Start a stopwatch, and "eat" for 15 seconds. Remember, no scooping! Skim the prey off of the surface of the carpet.

3. After feeding time is over, fill out columns in the Table 2 above.

4. Now you must reset the predator population. To do this, you must decide how many knives and forks there will be in the next generation of predators. Remember that in general, the more a predator eats, the more offspring it can produce.

   An example of a rule could be that the proportion of prey eaten by a predator morph contributes directly to the phenotype's frequency in the next generation (e.g. if a fork "ate" 26 of 50 beans, half of the next generation of predators would be forks.

   Note that if you are feeling adventurous, you could incorporate the spoon phenotype as well (you may need more than 3 rounds for this!).

   Write your new rule here:

5. Now, draw a data table so that you can track your predator population over time. You should be sure to include columns for starting phenotype frequencies as well as frequencies at the end of each of three rounds of predation. You will fill in this table as you complete this trial. There is space on the next page to draw this table. Don't forget to give it a title!

Table 3:

6. Reset your prey population based on your results from Round 1 and your predator population based on your new rule. Then repeat another round of predation and update your data tables (Table 2 and the one you drew above).

7. Reset your prey population based on your results from Round 2 and your predator population based on your rule. Then repeat another round of predation and update your data tables (Table 2 and the one you drew above).

Questions:

1. Was your prediction about the "most successful" phenotype correct? If not, why do you think the results were different from what you thought would happen?

2. You set up a rule to determine how many predators you had of each type for each round. How well did your new rule work out? Think of examples in the "real world" that work the same way that your rule does.

3. Using the provided graph paper or on a separate piece of paper, sketch a graph of predator and prey frequency over the rounds of the trial you conducted. Make sure to label your axes, and include a legend to distinguish between the various predator and prey phenotypes.

Exercise 3: Natural Selection and Adaption to the Environment

Not every population of the same species is subject to the same selective forces. In this exercise, you will visit other lab groups and examine how their populations evolved. As you do this, keep in mind how the environment is a very important selective force for natural selection.

An alternative method to this exercise is to pick a new piece of carpet, and repeat the procedure from Exercise 1 above. You can then compare your two environments and form conclusions about differences or similarities that you observe in phenotype frequencies.

Procedure:

1. Pick another lab group to visit. Observe their carpet environment, but do not ask them for their results just yet.

   Make a prediction: which prey type will be the least likely to be "eaten"? Why?

   Make another prediction: which predator type will be the most successful? Why?

2. Now ask the other lab group for their results for Exercise 1. How did phenotype frequencies of their prey population change over time? Was your prediction right? If not, why do you think the results were different from what you thought would happen?

3. Ask this lab group for their results for Exercise 2. Which was the most successful predator phenotype in their population? Was your prediction right? If not, why do you think the results were different from what you thought would happen?

Exercise 4: The Evolutionary Arms Race

We will watch a video about how the interactions of different organisms can drive evolution. We will start by looking at the interaction of predator and prey species, including a “predator” on humans. Then we will look at other types of interactions that can drive evolution.

Read these questions prior to watching the video and answer them during the video.

1. What is special about the newts that Edmund Brody studies?

2. What seems to be causing this trait in the newts? Why?

3. What is the one type of predator that humans should still fear?

4. In the middle of the last century, the surgeon general said it was time to close the book on infectious disease. Was he right? Why or why not?

5. What disease is running rampant in the Russian prison system?

6. What seems to have happened to the microbes causing the infection in Sasha?

7. MDRTB stands for “multi-drug resistant tuberculosis”. How is natural selection driving the evolution of this type of TB? Think about how this relates to the activity you did in the first part of the lab.

8. What conditions caused cholera to become more toxic?

9. What conditions caused cholera to become less toxic?

10. What seems to have happened to all the big cats who are infected with FIV (feline immunosuppressive virus)?

11. Do you think a similar thing will happen with humans who are at risk for HIV infection? Why or why not?

12. Leafcutter ants are an example of a symbiotic relationship with what other organism?

13. How do these ants keep pests out of their gardens?

14. What is the most interesting thing that you learned from this video?