Lab Activity: Evolution by Natural Selection **Name** _____

Biology 100 – K. Marr

Lab Section ____ Team No. ____Date _____

Prelab Assignment

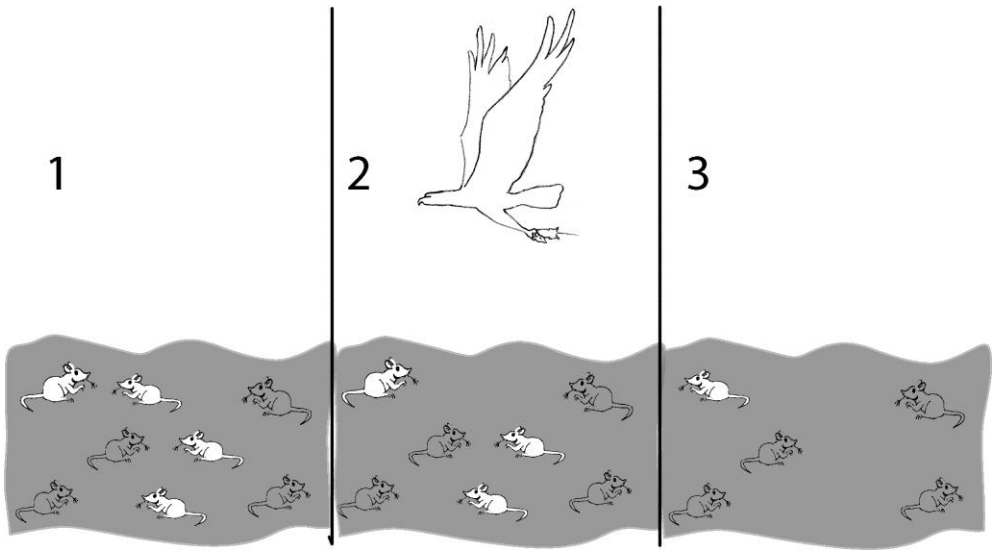
1. *Before* coming to lab, read all parts of this handout.
2. Answer the ***Prelab Questions 1 – 6 on pages 1 – 3*** and be prepared to hand them in at the start of your lab class.

Goals of this Activity

This activity involves a simulation of natural selection where you will graph and analyze the data collected. After completing this lab exercise you should be able to.....

1. Explain how natural selection works and the role it plays in evolution.
2. Apply what you have learned to interpret the results of experiments and understand how the results demonstrate the principles of natural selection.

Prelab Questions



1. Describe what is happening in figures 1-3, above. Is the population of mice different in figure 3 than in figure 1? *Explain why*.

Read This!!

Living things that are well adapted to their environment survive and reproduce. Those that are not well adapted don't survive and reproduce. An **adaptation** is any characteristic that increases **fitness**, which is defined as the ability to survive and reproduce.

2. What characteristic of the mice in figure 1 was an adaptation that increased fitness? *Be specific*.

Table 1. Data for four female mice that live in a beach area which is mostly tan sand with scattered plants.

Characteristics of each female mouse	Color of Fur			
	Black	Tan	Tan and Black	Cream
Running speed	8 cm/sec.	6 cm/sec.	7 cm/sec.	5 cm/sec.
# pups produced by each female	0	11	3	0
Age at death	2 months	8 months	4 months	2 months

3. According to the definition given for fitness, which mouse would biologists consider the fittest? Explain why this mouse would be the fittest. *Use specific numerical data in table 1 to support your explanation.*

4. If a mouse's fur color is generally similar to its mother's color, what color fur would be the most common among the pups? *Explain*.

Read This!!

A **heritable** characteristic is influenced by genes and passed from parents to offspring**.** In the mice on the tan sand, tan fur was a heritable adaptive characteristic, and you saw how this characteristic became more common in the pups than in the mothers. In nature, heritable adaptive characteristics become more common in a population over many generations. This process is called **evolution by natural selection**.

Evolution by natural selection leads to *adaptation within a population*. The term evolution by natural selection does *not* refer to individuals changing, only to changes in the frequency of adaptive characteristics in the *population* as a whole. For example, for the mice that lived on tan sand, none of the mice had a change in the color of their fur; rather, due to natural selection, tan fur was more common for the pups than for the mother mice.

In summary, a heritable characteristic that helps an animal or plant to have more offspring which survive to reproduce will tend to become more common in a population as a result of evolution by natural selection.

5. Explain why a heritable characteristic which helps an animal to live longer will generally tend to become more common in the population as a result of evolution by natural selection.

6. Suppose a different heritable characteristic helped animals to live longer but made them sterile so they could not have any offspring. Explain why this heritable characteristic would not become more common as a result of evolution by natural selection.

Lab Activity: Simulation of Natural Selection

Background Information

We will now play a simulation game to demonstrate how natural selection works. A **simulation** is a good way to mimic and simplify the process so we can observe how evolution by natural selection may work in a real population. This simulation involves pom-poms that can reproduce. These pom-poms live out their lives on a Black Forest or Red Grassland habitat in the classroom. The only concern our pom-pom creatures have is the presence of ravenous hunters (that's you!).

The simulation will have the <u>three necessary conditions for evolution by natural selection</u>.

1. **Variation in characteristics**: For natural selection to occur, different individuals in a population must have different characteristics. In our simulation, pom poms vary in color; they are black and red. The hunters vary as well; hunters have two distinct types of *<u>feeding structures</u>*: **forks** and **spoons**.
2. **Differences in fitness**: For natural selection to occur, the different characteristics of different individuals must contribute to differences in fitness (i.e. differences in ability to survive and reproduce). For example, variation in pom-pom color may influence the probability that a pom-pom is snatched up by a hungry hunter. Also, different feeding structures may vary in their success in capturing pom-poms. These differences contribute to survival and therefore success in reproducing.
3. **Heritability of characteristics**: For natural selection to occur, the characteristics that affect fitness must be heritable (i.e. passed by genes from one generation to the next). In our simulation, a pom-pom that is born into the pom-pom population is the same color as its parent and a hunter that is born into the hunter population has the same feeding structure as its parent.

Procedure for the Simulation of Natural Selection

1. Your class will be split into two groups which will carry out the simulation using two different habitats: **Black Forest** (represented by a rough black material such as faux fur) and **Red Grassland** (represented by a red fleece material).
2. Pom-poms come in two colors: **black** and **red**. Your teacher will scatter an equal number of each color on the Black Forest and on the Red Grassland. Develop a *<u>hypothesis</u>*, which color pom-pom do you think will be more likely to survive in each habitat?

   Black Forest: _____

   Red Grassland: _____

   <u>Explain your reasoning below</u>:

3. *There are two different types of feeding structures: forks and spoons*. To arm the hunters, your teacher will distribute the feeding structures so that there are equal numbers of each. You will also be given a cup. This cup will serve as your "stomach". To capture a pom-pom, you must use only your fork or spoon to lift the pom-pom from the habitat and put it into your cup. *It is against the rules to use the cup to scoop up the pom-poms*—***your cup must remain upright while "feeding***." Develop a hypothesis, which feeding structure do you think will do better in each habitat?

   Black Forest: _____

   Red Grassland: _____

   Explain your reasoning below:

4. *At your teacher's signal, start feeding*. Don't be shy about competing with your fellow hunters. However, once a pom-pom is on a fork or spoon it is off limits. When your teacher calls time, **STOP** feeding *immediately*.

5. Now count how many pom poms you have eaten and line up with your classmates who were feeding on the same habitat, from fewest pom poms eaten to most pom poms eaten. Only the top half of the hunters will survive and reproduce. Your teacher will tell you who lives ☺ and who dies☹. Those who die will be reborn as the children of the survivors and will now have the same type of feeding structure as their parents had.

6. Your teacher will count how many pom poms of each color were eaten, calculate how many pom poms survived, and help the surviving pom poms reproduce. Only the pom poms that were not eaten will reproduce.

7. While your teacher is busy preparing for the next round of feeding, discuss the following questions with your group and record your group's consensus response:

   a) Which feeding structure contributed to greater fitness (ability to survive and reproduce)?

   b) What characteristics of forks and spoons increased or decreased fitness?

8. You will run through the simulation one more time. Your teacher will post on the board the numbers of pom poms of each color and hunters of each type at the beginning of the simulation (generation 1) and at the end of each cycle (generations 2 and 3).

   - **Copy down the numbers on the board in the tables 2 and 3 on the next page**.
   - For each generation of pom poms in each habitat, calculate the percent that are black or red.
   - Similarly, for each generation of hunters in each habitat, calculate the percent that have spoons or forks as their feeding implement.

Results

Table 2. The number and percentage of black and red pom-poms that ***survive*** in the Red Grassland and Black Forest over three generations

	Red Grassland			**Black Forest**		
	Pom poms			Pom poms		
	Black	Red	**Total**	Black	Red	**Total**
Generation 1 Number (at start of generation)						
Percent			100%			100%
Generation 2 Number (at start of generation)						
Percent			100%			100%
Generation 3 Number (at start of generation)						
Percent			100%			100%

Table 3. The number and percentage spoon and fork "predators" that ***survive*** in the Red Grassland and Black Forest over three generations

	Red Grassland			**Black Forest**		
	Hunter Type			Hunter Type		
	Spoon	Fork	**Total**	Spoon	Fork	**Total**
Generation 1 Number (at start of generation)						
Percent			100%			100%
Generation 2 Number (at start of generation)						
Percent			100%			100%
Generation 3 Number (at start of generation)						
Percent			100%			100%

9. Use the data in tables 2 and 3 to complete the following ***bar graphs***. This will allow you to observe the changes in the percent of pom poms of each color and hunters with each type of feeding implement over the three generations in each habitat.

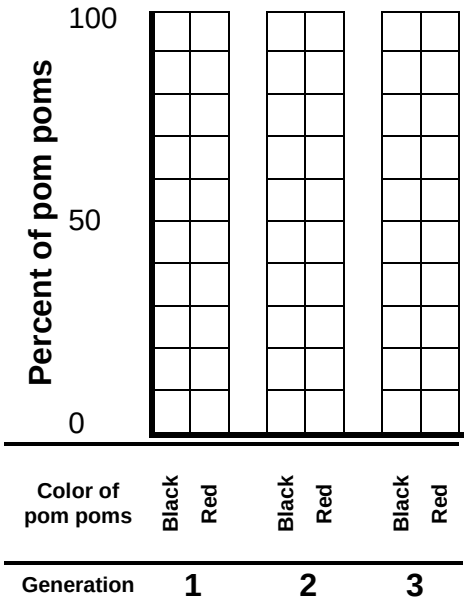


Figure 1. Pom-poms in the Black Forest

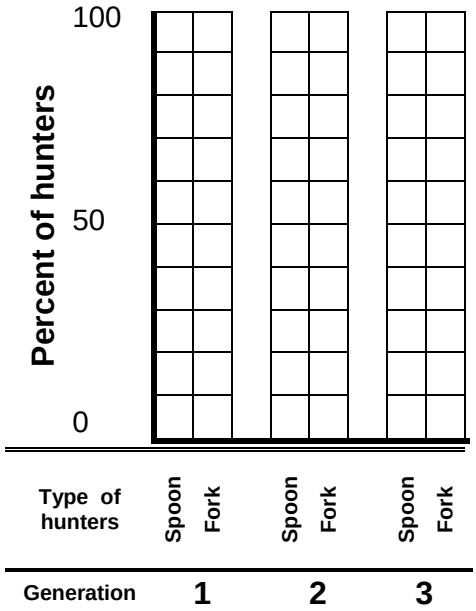


Figure 2. Hunters in the Black Forest

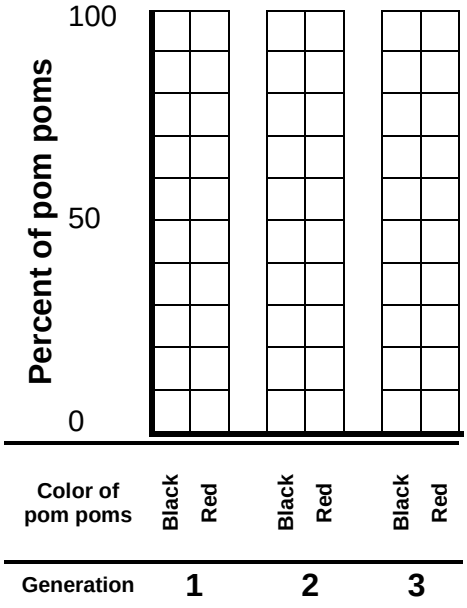


Figure 3. Pom-poms in the Red Grassland

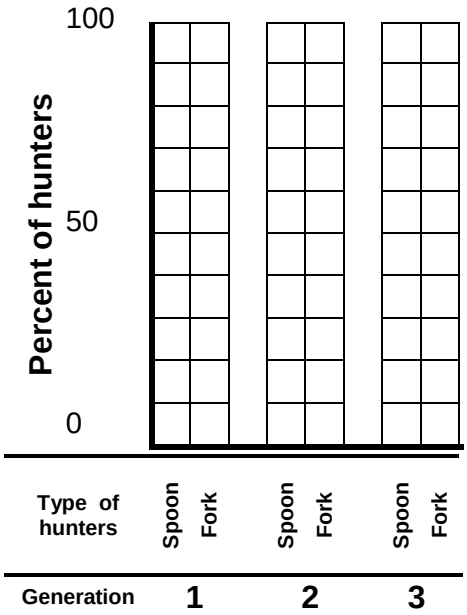


Figure 4. Hunters in the Red Grassland

Analysis of the Results

Answer the following questions for each "environment." *Use specific numerical data from tables 2 and 3 and figures 1 – 4 to support your responses.* No credit will be given unless you use specific numerical data from tables 2 and 3 and/or figures 1 – 4 to support your responses

1. Environment: **Black Forest**
   a) Did evolution by natural selection occur in each **pom-pom** population? In other words, did one pom -pom color become more common over time while the other color became less common? *Use the data to support your response*

   b) What traits contributed to the survival of **pom-poms** that survived to reproduce? *Use the data to support your response*.

2. Environment: **Red Grassland**
   a) Did evolution by natural selection occur in each **pom-pom** population? In other words, did one pom -pom color become more common over time while the other color became less common? *Use specific numerical data to support your response.*

   b) What traits contributed to the survival of **pom-poms** that survived to reproduce? *Use specific numerical data to support your response.*

3. Remember that the **pom-pom** populations were the same on the Black Forest and Red Grassland at the beginning. Explain why the trends differ in these two different habitats and the two populations of pom poms end up so different.

4. Environment: **Black Forest**
   a) For each population of **hunters**, did one feeding type become more common while the other feeding type became less common? *Use specific numerical data to support your response.*

   b) What traits contributed to the survival of **hunters** that survived to reproduce? *Use specific numerical data to support your response.*

5. Environment: **Red Grassland**
   a) For each population of **hunters**, did one feeding type become more common while the other feeding type became less common? *Use specific numerical data to support your response.*

   b) What traits contributed to the survival of **hunters** that survived to reproduce? *Use specific numerical data to support your response.*

6. Explain the differences in the trends in the feeding type of the hunters in the two habitats.

7. Did any individual pom-poms change color or adapt? **Yes** or **No** (*Circle your response*)

   If not, then why did the colors of the pom-poms in the final population differ from the colors of the pom poms in the original populations?

8. If we ran the simulation for 50 more generations, what would you predict about the colors of *the pom-poms and the hunter types* in each habitat? *Briefly explain your reasoning in each case.*

   Black Forest

   a) Pom-pom type after 50 generations:

   b) Hunter type after 50 generations

   Red Grassland

   c) Pom-pom type after 50 generations:

   d) Hunter type after 50 generations

9. What do you think would happen to the pom-pom population if the black forest experienced a prolonged drought so all the trees died and the habitat became red grassland? First, make your prediction of what would happen if the population of pom-poms in the black forest at the beginning included red and black pom poms. *Briefly explain your reasoning.*

10. Next, suppose that natural selection over many generations had resulted in only black pom poms surviving in the black forest, and then a prolonged drought resulted in this habitat turning into a red grassland. Would natural selection for pom-pom color occur? *Briefly explain your reasoning.*

11. Based on this example, explain why evolution by natural selection cannot occur if there is no variation in a characteristic.

12. Suppose that all the hunters in the simulation were blind-folded and could only find pom poms by touch. Would you expect evolution by natural selection in the color of the pom poms? *Briefly explain your reasoning.*

13. Explain why evolution by natural selection cannot occur if the variation in a characteristic does not contribute to differences in fitness.

Application Questions

Read This!!

The following example will illustrate that evolution by natural selection cannot occur if the variation in a characteristic is not heritable. This example also illustrates a more complete definition of ***fitness***, *which is the ability to survive and produce offspring who can also survive and reproduce*.

Table 3. Age at death, number of cubs fathered, number of cubs surviving to adulthood and size of 4 male lions (George, Dwayne, Spot and Tyrone)

Name	George	Dwayne	Spot	Tyrone
Age at death	13 years	16 years	12 years	10 years
# cubs fathered	19	25	20	20
# cubs surviving to adulthood	15	14	14	19
Size	10 feet	8.5 feet	9 feet	9 feet

(Adapted from Michigan State University, Occasional Paper No. 91, Evolution by Natural Selection: A Teaching Module by Beth Bishop and Charles Anderson, 1986)

14. According to the definition of fitness above, which of the four male lions described below would biologists consider the "fittest"? *Use specific numerical data to support your response.*

15. Explain why Dwayne was not the fittest even though he lived the longest and fathered the most cubs. *Use specific numerical data to support your response.*

16. Which of the following scenarios would result in natural selection? (*Circle the letter of your choice.)*

    a) Tyrone had heritable characteristics that increased resistance to infections, and the cubs that inherited these characteristics were more likely to survive to adulthood.

    b) Tyrone happened to live near a farmer who put antibiotics in meat which he left out for Tyrone's lion cubs.

    Use this example to explain why natural selection does not operate on a characteristic which affects fitness but is not heritable.

17. "Survival of the fittest" is a common expression.
    a) What do you think most people mean by this expression?

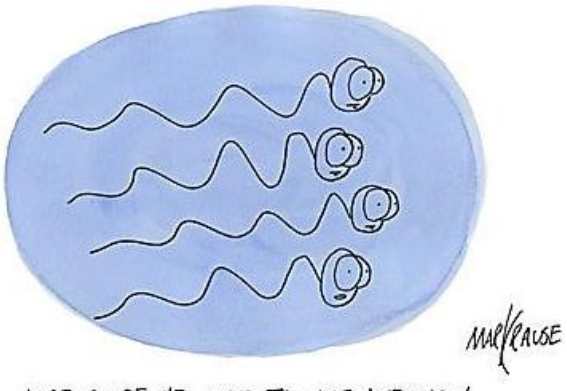
    b) How would you explain this expression to help someone understand how natural selection actually functions?

Natural selection does not grant organisms what they "need".

"Make it look like natural selection."

Ahh, the first day teaching Natural Selection is always the best day.

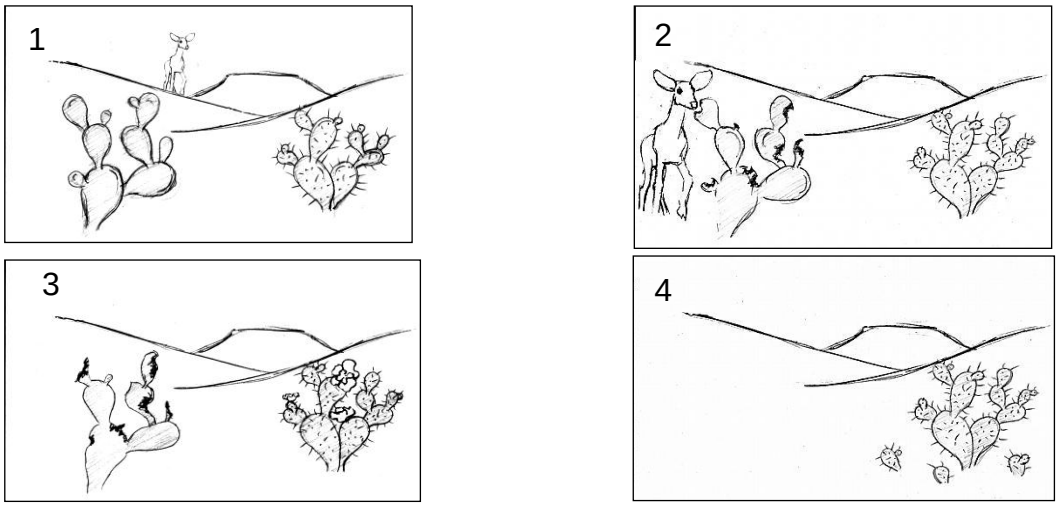
Survival of the Fittest…



JUST ONCE I'D LIKE TO NOT AUDITION.

Read This!!

Below is a series of pictures representing changes in a population of cacti. *Pictures 1 and 2* show what happened when a deer came to eat, *picture 3* shows the cacti a few weeks later (notice the flowers on the right-hand cactus), and *picture 4* shows the situation a few months later.



Recall that the *three conditions* listed below are necessary for natural selection to take place.

18. **Variation in characteristics within the population:** In *picture 1*, what is the main difference between the cactus on the left and the cactus on the right?

19. a) **Differences in fitness (survival and reproduction)**: Why would a deer be more likely to eat the cactus on the left than the cactus on the right?

    b) What effect does the deer's behavior have on the survival and reproduction of these two types of cactus?

20. a) **Heritability of characteristics from parent to offspring:** The difference between the cacti is a heritable characteristic (see *picture 4*).

    b) Do you think that evolution by natural selection is occurring in this cactus population? Explain why or why not.

Acknowledgement: Adapted from the University of California, Los Angeles Life Sciences Demonstration Manual by Drs. Jennifer Doherty and Ingrid Waldron, Department of Biology, University of Pennsylvania.