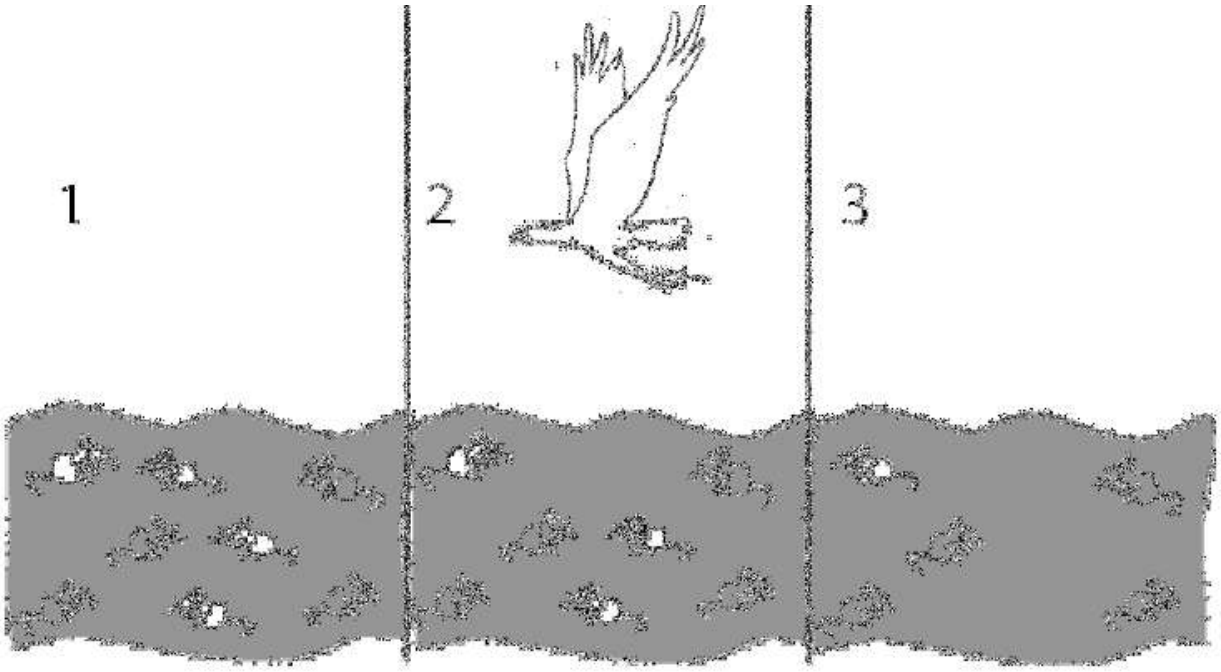
Evolution by Natural Selection

NAME_____ DATE _____

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



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. What characteristic of the mice is an adaptation that increased their fitness?

The table below gives descriptions of four female mice that live in a beach area which is mostly tan sand with scattered plants. According to the definition given for fitness, which mouse would biologists consider the fittest? Explain why this mouse would be the fittest.

Colour of fur	Black	Tan	Tan and Black	Cream
Age at Death	2 months	8 months	4 months	2 months
# of pups produced by each female	0	11	3	0
Running speed	8 cm/sec.	6 cm/sec.	7 cm/sec.	5 cm/sec.

If a mouse's fur colour is generally similar to its mother's colour, what colour fur would be most common among the pups?

A characteristic which is influenced by genes and passed from parents to offspring is called **heritable.** Over many generations heritable adaptive characteristics become more common in a population. This process is called **evolution by natural selection**. Evolution by natural selection takes place over many, many generations. 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 in the beach area with tan sand, none of the mice had a change in the colour of their fur; however, 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.

Questions

1. Explain why a 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.

2. Not all characteristics which contribute to longer life become more common in the population. Some characteristics contribute to long life, but not more offspring. For example, a female cat which is sterile and cannot have any offspring may live longer because she will not experience the biological stresses of repeated pregnancies. Explain why a characteristic like this which contributes to a long life, but with few or no offspring, would not become more common as a result of evolution by natural selection.

Simulation of Natural Selection

We will now play a **simulation** game to demonstrate how natural selection works. A simulation is a good way to simplify the problem in such a way that we can observe how evolution by natural selection may work in a real population. This simulation involves pompoms that can reproduce. These pompoms live out their lives on a Black Forest or Red Grassland habitat in the middle of the classroom. The only concern our pompom creatures have is the presence of ravenous hunters (that's you!). All we need is a system that has three necessary conditions for evolution by natural selection.

1. **Variation in characteristics**: For natural selection to occur, different individuals in a population must have different characteristics. In our simulation, pompoms vary in colour; they are black, red, and white. The hunters vary as well; hunters have three distinct types of feeding structures: forks, knives, 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 pompom colour may influence the probability that a pompom is snatched up by a hungry hunter. Also, different feeding types may vary in their success in capturing pompoms. 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 pompom that is born into the pompom population is the same colour as its parent and a hunter that is born into the hunter population has the same feeding structure as its parent.

Here is what we will do:

1. Your 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. Pompoms come in three colours: black, red, and white. Your teacher will "plant" an equal number of each colour on the Black Forest and on the Red Grassland at the beginning of the simulation. Which colour pompom do you think will be more likely to survive in each habitat?

Black Forest:

Red Grassland:

Why do you think that?

3. Now it is time to arm the hunters. There are three different feeding types: forks, knives, and spoons. 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 pompom, you must use only your fork, knife or spoon to lift the pompom from the habitat and put it into your cup. Which feeding structure do you think will do better in each habitat?

Black Forest:

Red Grassland:

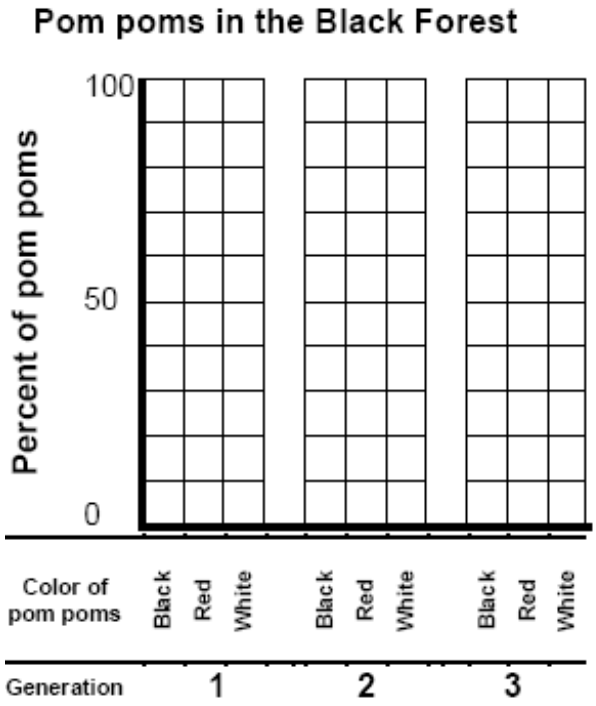
Why do you think that?

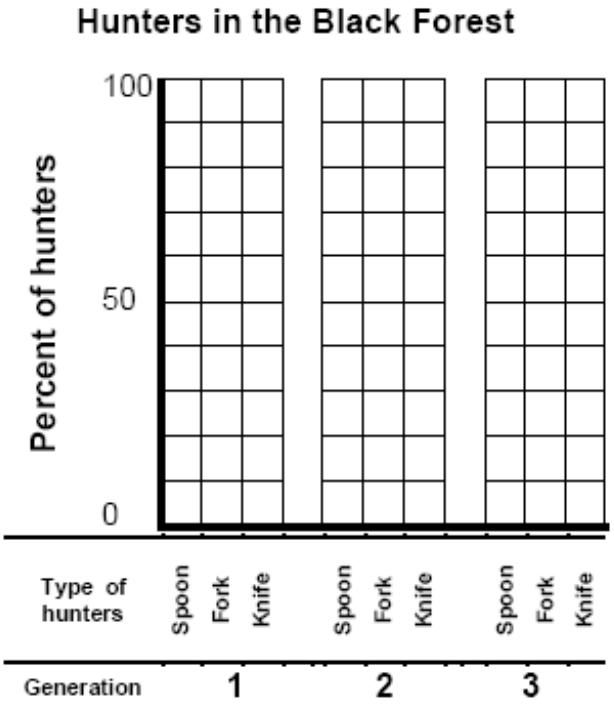
4. Your teacher will record the initial numbers of each type of pompom and each type of hunter in each habitat on the board.
5. At your teacher's signal, start feeding. Don't be shy about competing with your fellow hunters. However, once a pompom is on a fork, knife or spoon it is off limits. When your teacher calls time, **STOP** feeding.
6. Now count how many pompoms you have eaten and line up with your classmates who were feeding on the same habitat, from fewest pompoms eaten to most pompoms 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.
7. Count how many pompoms of each colour were eaten, calculate how many pompoms survived, and help the surviving pompoms reproduce. Only the pompoms that were not eaten will reproduce.
8. You will run through the simulation one more time. Your teacher will post on the board the numbers of pompoms of each colour 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 table on the next page. Then, for each generation of pompoms in each habitat, calculate the percent that are black, red, or white. Similarly, for each generation of hunters in each habitat, calculate the percent that have spoons, forks, or knives as their feeding implement

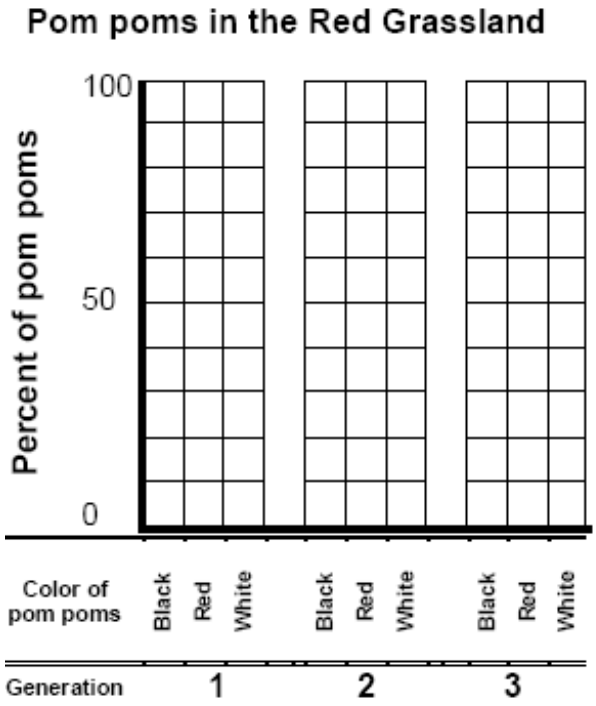
	Red Grassland				Black Forest			
	Pompoms				Pompoms			
	Black	Red	White	Total	Black	Red	White	Total
Generation 1 Number								
Percent				100%				100%
Generation 2 Number								
Percent				100%				100%
Generation 3 Number								
Percent				100%				100%

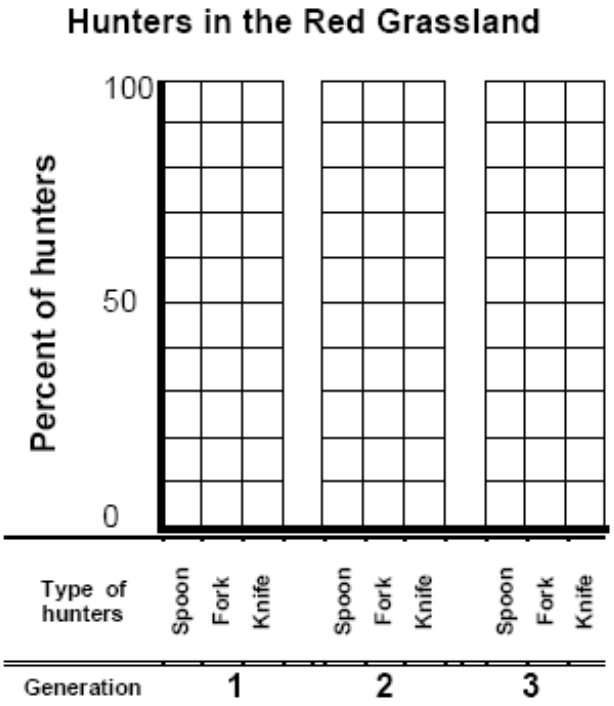
	Red Grassland				Black Forest			
	Hunters				Hunters			
	Spoon	Fork	Knife	Total	Spoon	Fork	Knife	Total
Generation 1 Number								
Percent				100%				100%
Generation 2 Number								
Percent				100%				100%
Generation 3 Number								
Percent				100%				100%

9. Use the data to complete the following 4 bar graphs. This will allow you to observe the changes in the percent of pompoms of each colour and hunters of each type over the three generations in each habitat









Questions

1. Did evolution by natural selection occur in each pompom population? In other words, did one pompom colour become more common over time while the other colours became

less common? What traits contributed to the survival of pompoms that survived to reproduce?

Black Forest:

Red Grassland:

Remember that the pompom 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 pompoms end up so different.

2. For each population of hunters, did one feeding type become more common while other feeding types became less common? What traits contributed to the survival of hunters that survived to reproduce?

Black Forest:

Red Grassland:

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

3. Did any individual pompoms change colour or adapt? If not, then why did the colours of the pompoms in the final population differ from the colours of the pompoms in the original populations?

4. If we ran the simulation for 50 more generations, what would you predict about the colours of the pompoms and the hunter types in each habitat?

Black Forest:

Red Grassland:

5. What do you think would happen to the pompom population if the black forest experienced a decade long drought and became red grassland? First, make your prediction of what would happen if the population of pompoms in the black forest at the beginning included red, white and black pompoms.

Next, suppose that natural selection over many generations had resulted in only black pompoms surviving in the black forest, and then a prolonged drought resulted in this habitat turning into a red grassland. Would natural selection for pompom colour occur?

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

6. Explain why evolution by natural selection cannot occur if the variation in a characteristic does not contribute to differences in fitness. Suppose, for example, that all the hunters in the simulation were blind-folded and could only find pompoms by touch. Would you expect evolution by natural selection in the colour of the pompoms?

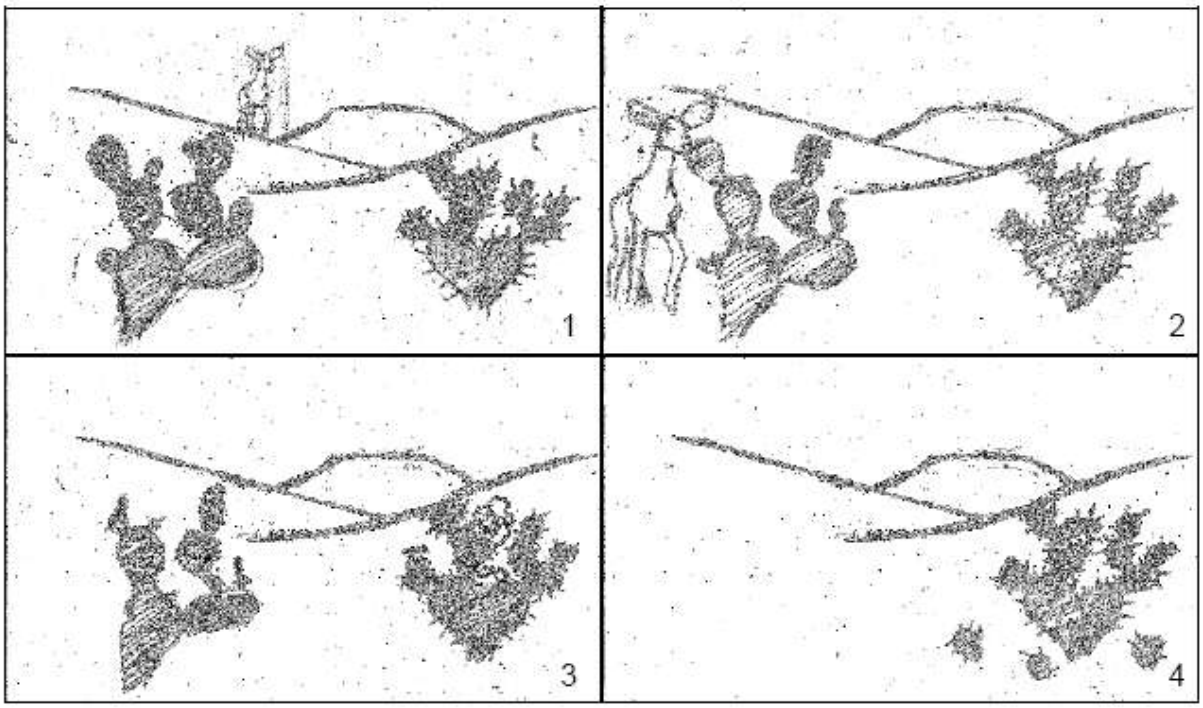
7. Which of the following scenarios would result in natural selection?
   a. Tyrone has heritable characteristics that increase resistance to infections and help cubs survive to adulthood.

b. Tyrone happens to live near a farmer who puts antibiotics in meat which he leaves out for Tyrone's lion cubs.

Explain why natural selection does not operate on characteristics which affect fitness but are not heritable.

8. "Survival of the fittest" is a common expression. What do you think most people mean by this expression? How would you explain this expression to help someone understand how natural election actually functions?

9. 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.

1. **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?

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

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

3. **Heritability of characteristics from parent to offspring:** The difference between the cacti is a heritable characteristic (see picture 4).
   Do you think that evolution by natural selection is occurring in this cactus population? Explain why or why not.