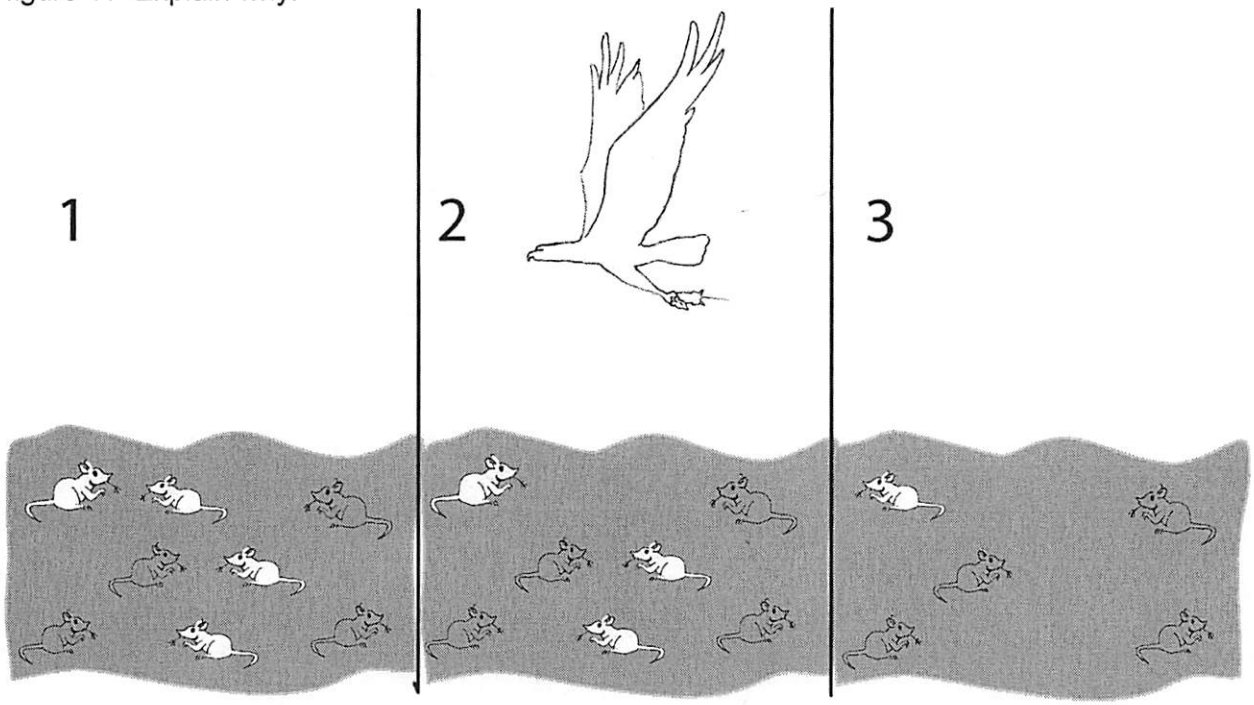
Evolution by Natural Selection

Adapted from the University of California, Los Angeles Life Sciences 1 Demonstration Manual

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?

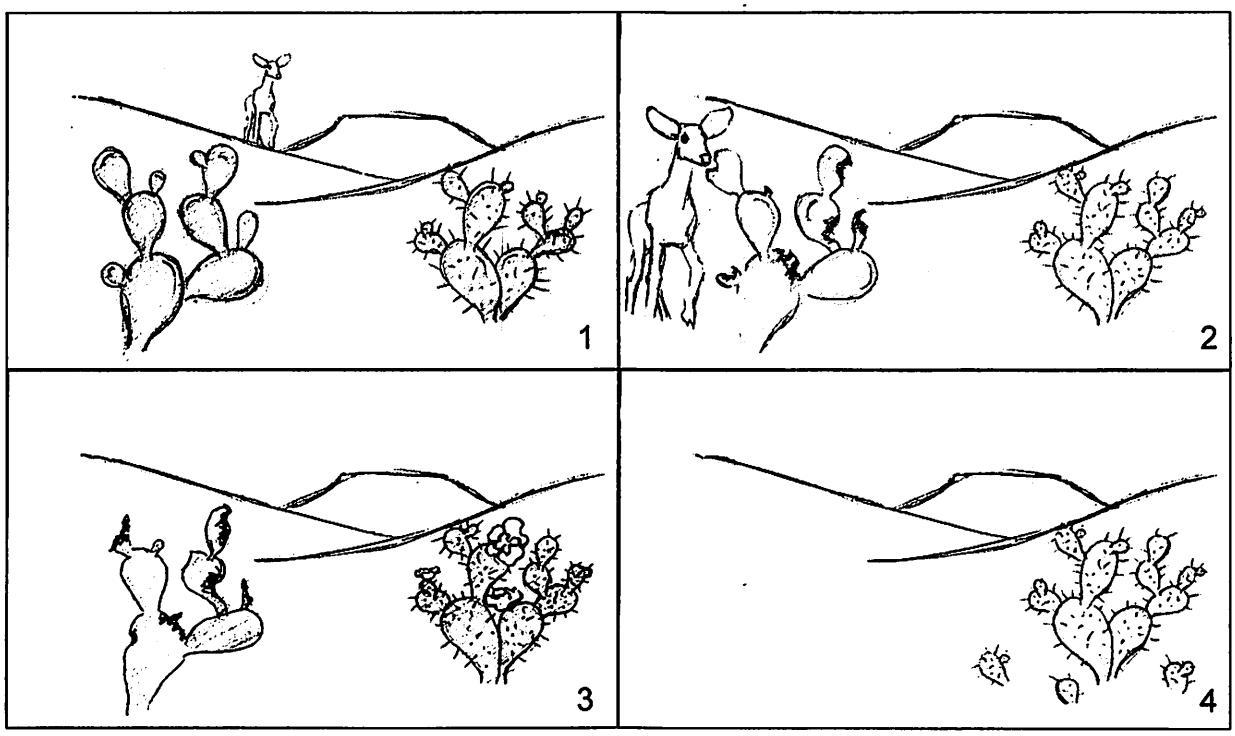
The table below gives descriptions of four female mice that live in a beach area which is mostly tan sand with scattered plants. According to the definition given for fitness, which mouse would biologists consider the fittest? Explain why this mouse would be the fittest.

Color of fur	Black	Tan	Tan and Black	Cream
Age at death	2 months	8 months	4 months	2 months
# 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 color is generally similar to its mother's color, what color 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.

8. 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 behavior 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.

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 in the beach area with tan sand, none of the mice had a change in the color 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 using colored cereals representing prey and you as the predator. These cereals (prey) can reproduce and live out their lives on a Black Forest or Red Grassland habitat in the middle of the classroom. The only concern these prey have is the presence of ravenous predators (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, our preys vary in color; they are blue, red, and white. The hunters vary as well; hunters have three distinct types of feeding structures: forks, chopsticks, 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 prey color may influence the probability that it is snatched up by a hungry predator. Also, different feeding types may vary in their success in capturing prey. 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 prey that is born into the 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.

Here is what we will do:

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 a dark table cloth and Red Grassland (represented by a red/checkered table cloth).

2. Preys come in three colors: blue, red, and white. Your teacher will "plant" an equal number of each color on the Black Forest and on the Red Grassland at the beginning of the simulation. Which color prey 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 predators (hunters). There are three different feeding types: forks, chopsticks, 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 prey, you must use only your fork, chopstick or spoon to lift the prey 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 prey and each type of predator 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 prey is on a fork, chopstick or spoon it is off limits. When your teacher calls time, **STOP** feeding.

6. Now count how many prey you have eaten and line up with your classmates who were feeding on the same habitat, from fewest prey eaten to most prey eaten. Only the top half of the predators 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. You and your teacher will count how many prey of each color were eaten, calculate how many prey survived, and help the surviving prey reproduce. Only the preys 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 prey of each color and predators 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 prey in each habitat,

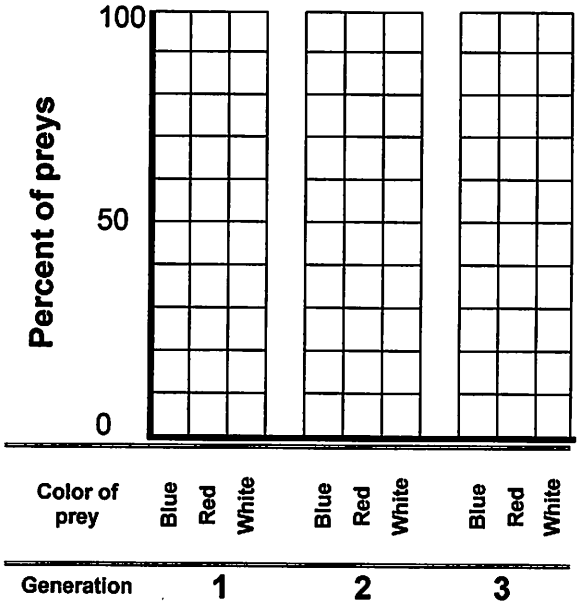
calculate the percent that are blue, red, or white. Similarly, for each generation of predator in each habitat, calculate the percent that have spoons, forks, or chopsticks as their feeding implement.

	Green Grassland				White Forest			
	Preys				Preys			
	Blue	Red	Green	Total	Blue	Red	Green	Total
Generation 1 Number								
Percent				100%				100%
Generation 2 Number								
Percent				100%				100%
Generation 3 Number								
Percent				100%				100%

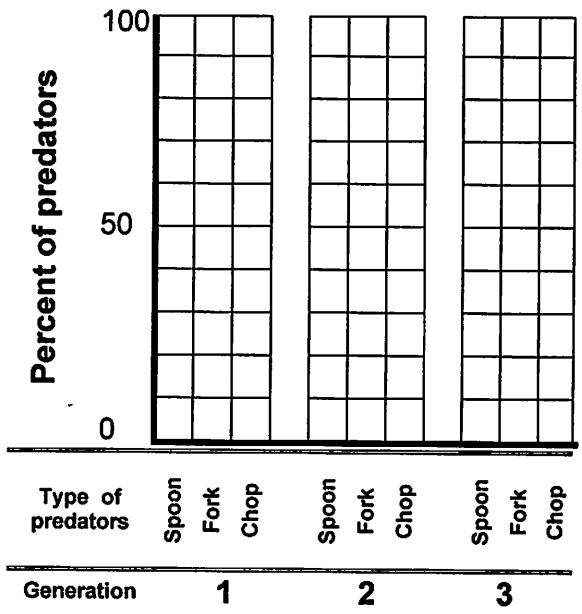
	Green Grassland				White Forest			
	Predators				Predators			
	Spoon	Fork	Chop	Total	Spoon	Fork	Chop	Total
Generation 1 Number								
Percent				100%				100%
Generation 2 Number								
Percent				100%				100%
Generation 3 Number								
Percent				100%				100%

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

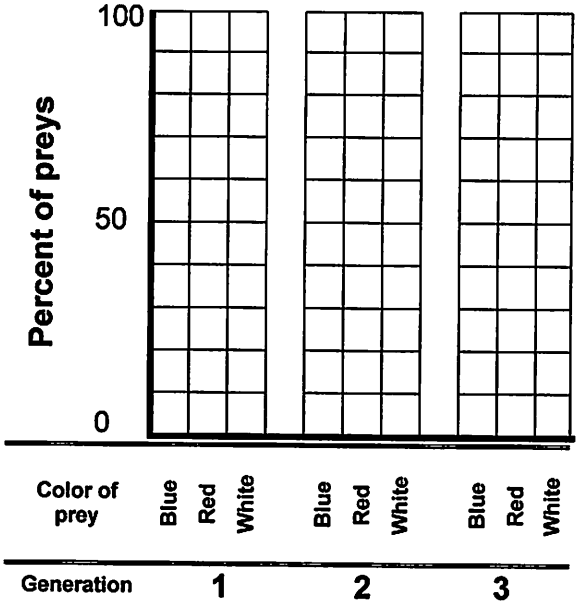
Preys in the Black Forest



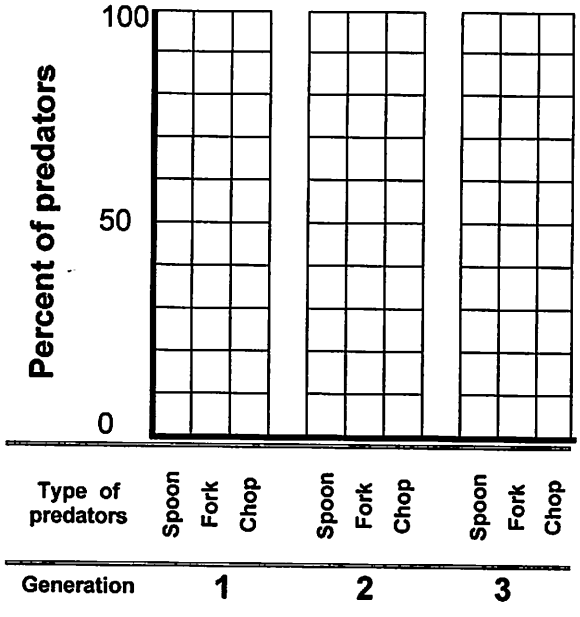
Predators in the Black Forest



Preys in the Red Grassland



Predators in the Red Grassland



Questions

1. Did evolution by natural selection occur in each prey population? In other words, did one prey color become more common over time while the other colors became less common? What traits contributed to the survival of prey that survived to reproduce?

Black Forest:

Red Grassland:

Remember that the prey 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 prey end up so different.

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

Black Forest:

Red Grassland:

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

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

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

Black Forest:

Red Grassland:

5. What do you think would happen to the prey 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 prey in the black forest at the beginning included red, white and black prey.

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

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

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

7. The following example will illustrate that evolution by natural selection can not 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. According to this definition of fitness, which of the four male lions described below would biologists consider the "fittest"?

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)

Explain why Dwayne is not the fittest even though he lived the longest and fathered the most cubs.

Circle 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 selection actually functions?

BIOLOGY 7
VIDEO: EVOLUTION

NAME _____

Answer the following questions thoroughly and neatly.

1. Darwin and Wallace proposed that all organisms are descendents of earlier forms that evolved over time through a process called?

2. What was Darwin's most significant contribution to the concept of evolution?

3. What was the name of the ship that Darwin sailed on?

4. Describe one of the observations that Darwin made during his voyage?

5. Why was Darwin's idea that species became modify over time so controversial?

6. What was the "missing piece" behind Darwin's evolving idea?

7. Who forged the modern synthesis of evolution?

Evolution in Action

8. What are vectors?

9. What disease is transmitted by *Anopheles* mosquitoes?

10. The sum total of all genes in a given population is called its?

11. Different versions of a specific gene is referred to an?

12. The proportion of the total gene pool represented by any single allele is called?

13. Without any evolutionary or disturbing forces, the gene frequency should remain?

14. Factors that can affect gene frequency include:

15. Which of the above factors was believed to be responsible for insecticide resistance in mosquitoes?

16. If the allele frequency changes in a specific direction, this is called?

17. Explain what is gene flow?

18. Why would the inflow of susceptible mosquitoes into the existing population slow down the evolution of resistant mosquitoes?

Isolation and Speciation

19. What is an endemic?

20. How do scientist define "species"?

21. What is speciation?

22. Explain how speciation can occur.

23. Explain what the founder's effect is?

24. Explain how speciation can arise from the founder's effect?

25. Isolating mechanisms prevent the interbreeding of non-related species. Describe a specific example of one such mechanism.

26. Is it important to protect endemic plants and animal? Why or why not?