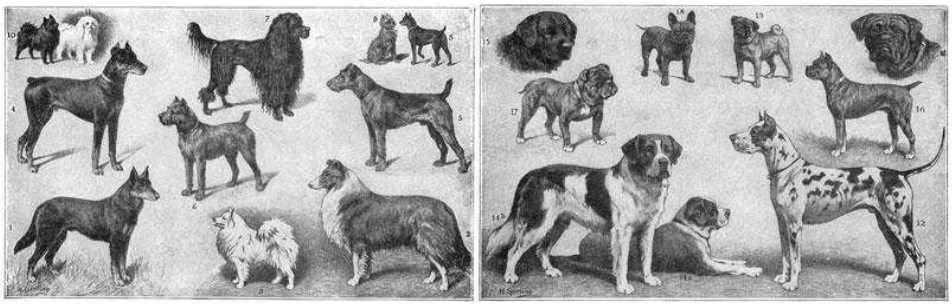
Name: _____ Date: _____

Student Exploration: Evolution: Natural and Artificial Selection

Vocabulary: artificial selection, breed, chromosome, evolution, fitness, genotype, mutation, natural selection, phenotype

[Note to teachers and students: This Gizmo™ was designed as a follow-up to the Evolution: Mutation and Selection *Gizmo. We recommend doing that activity before trying this one.]*

Prior Knowledge Question (Do this BEFORE using the Gizmo.)



This illustration from an old textbook shows some of the over 150 different dog **breeds** that can be seen around the world today. How do you think all of these different breeds were developed?

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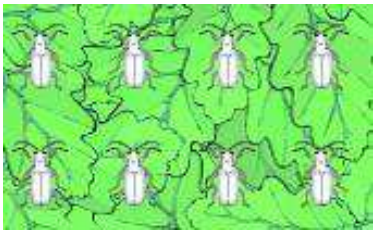
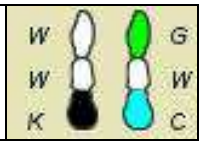
Gizmo Warm-up



Dog breeds and other varieties of domesticated animals were developed through **artificial selection**. Over many generations, breeders selected which animals to mate in order to select for desired traits. The *Evolution: Natural and Artificial Selection* Gizmo allows you to try your hand at breeding insects with a variety of colors. To begin, select the **Artificial selection** option.

1. Drag the 10 insects into the breeding alcoves on the left side of the Gizmo.
   A. How many breeding pairs are there? _____
   B. How many offspring are produced? _____

2. Circled insects have **mutations**, or changes to their DNA. How many of the offspring insects in this generation have mutations? _____

Activity A: **Genotype and phenotype**	Get the Gizmo ready: • Select **Natural selection**.	

Question: How are genes inherited and modified over many generations?

1. Observe: The **fitness** of an insect is a measure of how well it is adapted to its environment.

   A. What is the initial **Average fitness** of these insects? _____

   B. Click **Play** (▶), and observe the simulation for several generations. What occurs in each generation? _____

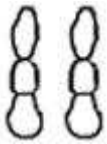
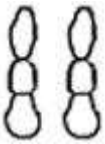
   _____

   _____

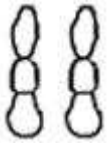
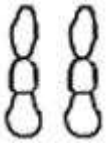
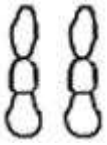
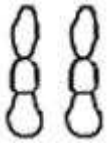
   C. Increase the **Sim. speed** by one level. Click **Pause** (⏸) after 30 generations. What is the **Average fitness** now? _____

2. Analyze: Set the **Sim. speed** to its slowest level. Click **Play**, and then **Pause** when the offspring appear. Choose a pair of parents in which both parents have a different color.

   A. Move your cursor over a parent insect. The genes that control color make up an insect's **genotype**, while its actual color is its **phenotype**. Fill in the genotypes and phenotypes of each parent below.

Parent 1 genotype	**Parent 1 phenotype**	**Parent 2 genotype**	**Parent 2 phenotype**
	red = _____ green = _____ blue = _____		red = _____ green = _____ blue = _____

   Now list the genotypes of each of the four offspring below.

Offspring 1	**Offspring 2**	**Offspring 3**	**Offspring 4**
			

(Activity A continued on next page)

Activity A (continued from previous page)

3. Explain: Each rod-shaped structure is a **chromosome**. Real chromosomes contain hundreds or even thousands of genes. The simplified chromosomes shown in this Gizmo only contain genes that determine the insects' colors.

   How are the chromosomes of the offspring related to the chromosomes of the parents?

   _____

   _____

   _____

4. Investigate: Any insect that has a mutation will be circled. Place your cursor on an insect with a mutation to examine its genotype. (If there are none in this generation, click **Play** and then **Pause** when a mutation appears.)

   A. Examine the genotype of the mutated insect as well as the genotypes of its parents to determine what the mutation is. What new gene appeared? _____

   B. Do you think this mutation is helpful, harmful, or neutral for the insect? Explain.

      _____

   C. Click **Play**, and then click **Pause** after the birds have finished eating. Did the mutated insect survive? _____

5. Observe: Increase the **Sim. speed** by two levels. Click **Play**, and wait for a while. What occurs as time goes by? _____

   _____

   _____

6. Explain: In wild populations, **evolution** is often caused by **natural selection**. Based on what you have observed, how does natural selection occur? _____

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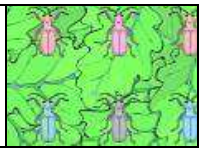
Activity B: **Artificial selection**	Get the Gizmo ready: • Select **Artificial selection**. • Set the **mutation rate** to 2.0.	

Question: How can a species be changed through artificial selection?

1. Set a goal: In this activity, your goal is to develop insects that are any color you would like.

   What color do you want your insects to be? _____

2. Make a plan: Follow the directions in the Gizmo to produce five generations of insects.

   A. How would you describe the process of artificial selection? _____

   _____

   _____

   B. How will mutations be useful in achieving your goal color? _____

   _____

   _____

   C. What strategy will you use to produce insects of your desired color? _____

   _____

   _____

3. Run Gizmo: Use the Gizmo to produce insects that match your goal color. (This will take patience!) When you are satisfied, click the **camera** ( ) to take a snapshot. Paste the snapshot into a blank document that you will turn in with this worksheet.

   How many generations did it take for you to develop your insects? _____

4. Compare: If possible, compare your insects to the insects developed by your classmates.

   What different colors of insects can be developed using artificial selection? _____

   _____

   _____

(Activity B continued on next page)

Activity B (continued from previous page)

5. Explain: One of the tallest dog breeds is the Great Dane, which stands over a meter tall. One of the shortest is the Pomeranian, which stands about 20 centimeters tall. Based on what you have learned about artificial selection, how were these two breeds developed?

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_____

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_____

6. Collect data: Use the **red**, **green**, and **blue** sliders to match the **Background color** as closely as possible to phenotype of the insects. Select **Natural selection**.

   Click **Play**, and then click **Pause** when the **Average fitness** first exceeds 90%. Record the number of generations in the table below, and then repeat for a total of five trials.

Trial	1	2	3	4	5	Mean
Number of generations to achieve 90% fitness						

7. Calculate: Add up the number of generations and divide by five to find the mean number of generations required to reach at least 90% fitness. Fill in the last column of the table.

8. Analyze: Which process tends to occur more quickly, natural selection or artificial selection? Why do you think this is so?

_____

_____

9. Summarize: How are the processes of natural selection and artificial selection similar? How are they different? If possible, discuss your answer with your classmates and teacher.

_____

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Activity C: **Mutation rates**	Get the Gizmo ready: • Click **Reset** (↺). Be sure **Natural selection** is selected. • Set **red** to 100, **green** to 255, and **blue** to 50.	

Question: How does the mutation rate affect a population's ability to adapt to its environment?

1. Gather data: Change the **mutation rate** to 0.1 and the **Sim. speed** slider to its lowest setting. Click **Play**, and then click **Pause** when the offspring appear. Record the number of mutations (circled offspring), and then repeat for two more trials. Do this for each mutation rate listed in the table, then calculate the mean number of mutations for each mutation rate.

Mutation rate	Trial 1	Trial 2	Trial 3	Mean
0.1				
1.0				
10.0				

How does the mutation rate relate to the number of mutations in each generation?

_____

2. Form hypothesis: How do you expect the rate of mutations to affect the ability of the bug population to adapt to its environment? _____

_____

3. Gather data: Click **Reset**. Set the **mutation rate** to 0.1, and move the **Sim. speed** slider to a faster setting. Click **Play**, and then click **Pause** when the **Average fitness** is 90% or greater. Record the number of generations required to reach 90% fitness in the table below.

Mutation rate	Number of generations to 90% average fitness			Mean
	Trial 1	Trial 2	Trial 3	
0.1				
0.3				
0.5				
1.0				
3.0				
5.0				
10.0				

(Activity C continued on next page)

Activity C (continued from previous page)

4. Analyze: How does the mutation rate affect the speed at which a population adapts to its environment? _____

_____

_____

5. Think and discuss: You may have noticed that above a certain mutation rate the time required for a population to adapt to its background may increase. Why do you think this is so? If possible, discuss your answer with your classmates and teacher.

_____

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_____

6. Apply: Scientists doing artificial breeding experiments often use radiation or other methods to increase the mutation rate. Why is a high mutation rate useful? _____

_____

_____

7. Investigate: Use the Gizmo to develop a population of insects that are well adapted to their environment. (**Average fitness** is above 90%.) Change the **mutation rate** to 0.1, and run the simulation. Then, observe the population with a **mutation rate** of 10.0.

   A. What do you notice? _____

   _____

   _____

   B. If a population is already well-adapted to its environment, will most mutations be helpful or harmful? Explain. _____

   _____

   _____