Name: _____ Date: _____

Student Exploration: Evolution: Mutation and Selection

Vocabulary: adaptation, allele, allele sequence, chromosome, evolution, fitness, gene, genotype, mutation, natural selection, phenotype, trait

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)

1. Imagine a white lizard and a brown lizard sitting on a brown rock. A hawk is circling overhead hunting for its next meal. Which lizard do you think the hawk would most likely try to catch? Explain your choice.

   _____

   _____

2. Now imagine that the same two lizards were sitting on a dune of white sand. Which lizard do you think the hawk would then most likely try to catch? Why?

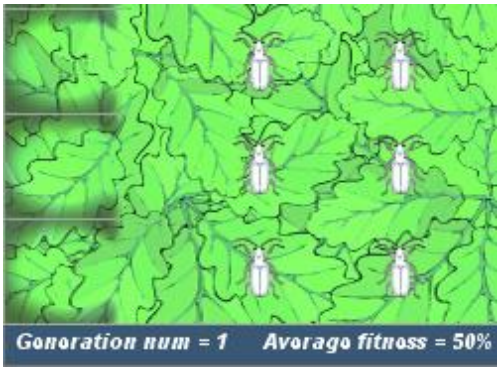
   _____

   _____

Gizmo Warm-up

How long could a parrot survive in Antarctica? It would probably not survive long. Parrots do not have **adaptations**—or helpful characteristics—to survive icy cold weather. Because of this, a parrot is not fit for Antarctica. **Fitness** describes how well an organism can survive and reproduce in an environment.

In the *Evolution: Mutation and Selection* Gizmo™, you will see how a species' fitness can change over time as it becomes better adapted to its environment.

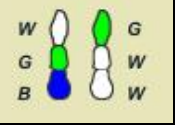


1. On the SIMULATION pane, what is the **Average fitness** of the population? _____

2. On the CONTROLS pane, experiment with the **Background color** sliders.

   A. Which background color results in the highest fitness? _____

   B. Which background color results in the lowest fitness? _____

Activity A: **Inherited variation**	Get the Gizmo ready: • Set the **red** value to 100, the **green** value to 255, and the **blue** value to 50 on the CONTROLS panel.	

Introduction: An organism's **traits**, or characteristics, are controlled by **genes**. Genes are located on rod-like structures called **chromosomes**. Different versions of genes that code for the same trait are called **alleles**. In this Gizmo, there are 3 genes on each chromosome. For each gene there are eight possible alleles: *W* (white), *R* (red), *G* (green), *B* (blue), *C* (cyan), *M* (magenta), *Y* (yellow), and *K* (black).

Question: Where does variation in a population come from?

1. Observe: Hold your cursor over one of the insects on the SIMULATION pane. The two rod-like structures under **Genotype** on the CONTROLS pane represent chromosomes. The three letters next to each chromosome represent alleles.

   Which alleles does the insect have? _____

   The alleles carried on an organism's chromosomes make up the organism's **genotype**.

2. Observe: An organism's alleles combine to produce a trait. The physical expression of that trait is a **phenotype**. In the Gizmo, phenotype is expressed in red, green, and blue values.

   A. What is the phenotype of the insect? Red: _____ Green: _____ Blue: _____

   B. What color is the insect? _____

3. Run Gizmo: Move the **Sim. speed** slider all the way to the left. Click **Play** (▶). You will see the insects move to the left in pairs. The pairs mate and produce a set of four offspring. As soon as you see at least one offspring with an oval around it, click **Pause** (⏸). Move your cursor over the circled offspring.

   A. What is its genotype and phenotype? _____

   B. How does its genotype and phenotype differ from the non-circled offspring?

   _____

4. Explain: The change in the circled offspring's genotype was caused by a **mutation**. A mutation is a change in a gene. Mutations happen when a mistake is made when a cell's chromosomes are copied. How might mutations introduce variation into a population?

   _____

   _____

(Activity A continued on next page)

Activity A (continued from previous page)

5. Collect data: Move the **mutation rate** slider to 3.0, and click **Play**. Allow the Gizmo to run for another 10–15 generations. (You can see the generation number below the insects.)

   Click **Pause** when the parents are ready to have offspring. Find a set of two parents that has four *different* chromosomes. (If you can't find any, allow the Gizmo to run a few more generations and try again.) Write the allele sequences for these parents in the table below. Note the labels for each of these chromosomes: A1, A2, B1, and B2.

Organism:	**Parent A**	**Parent B**
Allele sequence of chromosome 1:	(A1)	(B1)
Allele sequence of chromosome 2:	(A2)	(B2)

   Click **Play**, and then click **Pause** immediately after the offspring are produced. Write the allele sequences of chromosomes 1 and 2 for each of the offspring of your selected parents.

Offspring	**Allele sequence of chromosome 1**	**Allele sequence of chromosome 2**
Offspring 1	( )	( )
Offspring 2	( )	( )
Offspring 3	( )	( )
Offspring 4	( )	( )

   Label the offspring chromosomes A1, A2, B1, or B2. Circle any mutated chromosomes.

6. Analyze: Study the completed table.

   A. Look at the inheritance patterns. What do you notice? _____

   _____

   B. Can a single offspring inherit both chromosomes from one parent? _____

      Explain: _____

   C. Did any mutations occur in this set of offspring? _____

      If so, which chromosome mutated? _____

7. Challenge yourself: You have already learned that mutation is one source of variation in a population. Based on what you have just seen, what is a second source of variation?

   _____

   _____

Activity B: **Survival of the fittest**	Get the Gizmo ready: • Click **Reset** ( ). • Set **red** to 255, **green** to 0, and **blue** to 130. • Move the **mutation rate** slider to 1.0.	

Question: Are some organisms more likely to survive and reproduce than others?

1. Count: Move the **Sim. speed** slider all the way to the left. Click **Play**.

   A. After the parents mate, click **Pause**. How many offspring are there? _____

   B. Click **Play**. After the birds eat, click **Pause**. How many offspring are left? _____

   In nature, as in the Gizmo, more offspring are born than can survive long enough to reproduce. Because of this, the offspring must compete with one another for survival. In this Gizmo, the insect offspring compete to avoid being eaten by birds.

2. Observe: Move the **Sim. speed** slider one notch to the right. Click **Play**, and wait for about 20 generations to pass. You should see a variety of insect phenotypes. (If not, click **Play** and wait until you do.)

   A. What different colors of insects do you see? _____

   _____

   B. How do you think this variation might affect the competition between the offspring?

   _____

   _____

3. Analyze: Scroll over the insects and note their fitness (shown under the **Phenotype**). The fitness of an organism reflects how likely it is to survive and produce offspring. Each insect is given a percentage that reflects its chances of surviving to reproduce.

   Compare the fitness percentages to the insect colors. How does fitness relate to the color of the insects? _____

   _____

4. Predict: How do you think an insect's fitness will affect is chances of being eaten by birds?

   _____

   _____

(Activity B continued on next page)

Activity B (continued from previous page)

5. Collect data: In nature, chance alone can affect whether an individual survives. However, general trends in survival rates can be seen by studying a larger group of individuals.

   Move the **Sim. speed** slider all the way to the left. Click **Play**, and then click **Pause** when all the offspring are visible. Write the generation number and the average fitness of all the offspring in the first two spaces of the table below.

   Next, click **Play**, and then click **Pause** immediately after the birds have fed and the 10 survivors are visible. Mouse over each survivor and record its fitness. Find the average fitness of the survivors by adding these values and dividing by 10.

   Repeat this experiment two more times, recording your results in the table.

Generation	Ave. fitness	Survivor fitness values	Ave. survivor fitness

6. Recognize trends: Study the table above. What trends do you see? _____

   _____

   _____

7. Analyze: In most situations, were the fittest insects or the least fit insects most likely to survive? Explain how the data from your experiment supports your answer.

   _____

   _____

8. Think and discuss: The principle of **natural selection** states that the best adapted organisms are most likely to survive and reproduce. Was this demonstrated in your experiment? Explain.

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Activity C: Evolution	Get the Gizmo ready: • Click **Reset**. Set **red** to 100, **green** to 255, and **blue** to 50.	

Introduction: You learned in activity B that fit individuals have a better chance of surviving and reproducing than individuals that are less fit. In this activity, you will observe how natural selection affects a population over time.

Question: How does a population change over time?

1. Experiment: Set the **Background color** to the values shown in the last column of the table below. Record the **Average fitness** of generation 1 in the second column of the table. Move your cursor over the insects and find the individual with the greatest fitness. (In the first generation, all the insects will have the same fitness). Record that individual's phenotype in the table's third column.

   Move the **Sim. speed** slider a quarter of the way to the right. Run the Gizmo, and complete the table for each listed generation. (The generation number does not have to be exact.)

Generation number	Average Fitness	Fitness of Fittest Individual	Phenotype of Fittest Individual (R, G, B)	Background color
1				red = 100 green = 255 blue = 50
25				
50				
75				
100				
150				
200				
300				

2. Describe: Examine the data collected for trends.

   A. How did the phenotype of the fittest individual change over time? _____

   _____

   B. How did the population's fitness change over time? _____

   _____

   The process by which populations change over time is known as **evolution**. This Gizmo only demonstrates how one trait—body color—can evolve.

(Activity C continued on next page)

Activity C (continued from previous page)

3. Predict: Based on what you have just seen, how do you think the population will evolve if you made the **Background color** purple?

   _____

4. Test: Set **red** to 120, **green** to 0, and **blue** to 160 to make a purple background. Click **Play**. After 300 more generations have passed, click **Pause**.

   Was your prediction correct? Explain. _____

   _____

5. Make connections: Why do you think it is necessary for there to be variation in a population in order for evolution by natural selection to occur?

   _____

   _____

6. Make connections: Why is it necessary for traits to be inherited for evolution to take place?

   _____

   _____

   _____

7. Apply: Look carefully at the picture below and you will see an insect called a katydid. Katydids evolved from grasshoppers through natural selection. Use what you have learned to explain how this could have happened.

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