

Name: \_\_\_\_\_ Date: \_\_\_\_\_

## Student Exploration: Microevolution

**Vocabulary:** allele, cystic fibrosis, deleterious, dominant allele, fitness, genotype, heterozygote superiority, heterozygous, homozygous, incompletely dominant, malaria, predator, recessive allele, sickle cell anemia

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

Many people from warm regions carry an **allele** that provides resistance to **malaria**. Two copies of this allele, however, causes a deadly blood disorder called **sickle cell anemia**.

- Suppose two parents are healthy carriers of the sickle-cell allele. The **genotype** of each parent is *AS* (*A* is the normal allele, and *S* is the sickle-cell allele).

How likely is it for a child of these parents to have sickle cell anemia (*SS*)? \_\_\_\_\_

- Do you think the allele for sickle cell anemia would be common in regions where malaria did not exist? Explain why or why not. \_\_\_\_\_

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### Gizmo Warm-up

If natural selection does not favor one trait over another, the frequencies of various alleles in a population will tend to be stable over long periods of time. But what happens when one allele confers an advantage or disadvantage to an individual? These scenarios and others can be explored with the *Microevolution* Gizmo™.



- The feather color of the parrots in the Gizmo is controlled by two alleles, *D* and *d*. The *D* allele is **incompletely dominant** over *d*. What is the feather color of each parrot genotype?


*DD* \_\_\_\_\_      *Dd* \_\_\_\_\_      *dd* \_\_\_\_\_

- The **fitness** of parrots is determined by how well they blend into the background trees. Set the **Fitness of *DD*** slider to 100% and the other fitness sliders to 60%.

The birds with which genotype blend into the background now? \_\_\_\_\_

- Click **Begin**, and then click **Predator**. Which parrots were killed by **predators**? \_\_\_\_\_

Why? \_\_\_\_\_

<b>Activity A:</b> <b>Deleterious dominant alleles</b>	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>• Click <b>Reset</b>.</li> <li>• Set the <b>DD</b> and <b>dd</b> sliders to 34%.</li> </ul>	
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**Introduction:** A **deleterious** allele is one that significantly lowers the fitness of an individual. If the deleterious allele is a **dominant allele** ( $D$ ), then both **homozygous**  $DD$  and **heterozygous**  $Dd$  individuals will be at a disadvantage.

**Question: How will allele frequencies change if a dominant allele is deleterious?**

1. **Observe:** To model the effects of a deleterious dominant allele, set the **Fitness of  $DD$**  and **Fitness of  $Dd$**  sliders to 60%. Set the **Fitness of  $dd$**  to 100%.

Based on the color of the trees, which parrots will be easiest for predators to spot and kill?

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2. **Predict:** How do you expect the proportions of  $D$  and  $d$  alleles to change in five generations?

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3. **Record:** Click **Begin** and **Predator**. Record the results of hawk predation in the table below.

	<b><math>DD</math></b>	<b><math>Dd</math></b>	<b><math>dd</math></b>	<b>Totals</b>
<b>Starting population</b>				
<b>Killed by hawks</b>				
<b>Ending population</b>				

4. **Calculate:** To calculate the percentage of survivors for each genotype, divide the **Ending population** by the **Starting population**. Multiply each result by 100 to convert to a percentage, and record the percentages below.

$DD$  \_\_\_\_\_  $Dd$  \_\_\_\_\_  $dd$  \_\_\_\_\_

5. **Analyze:** How do the percentages of survivors relate to the fitness of each parrot genotype?

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**(Activity A continued on next page)**



**Activity A (continued from previous page)**

6. Gather data: Click **Breed**, and then click **Hatch**. Click **Continue**, and then click **Predator**. Repeat this sequence to play the simulation for five generations. Select the TABLE tab and record the genotype populations over time in the spaces below.

Generation	<i>DD</i>	<i>Dd</i>	<i>dd</i>
0			
1			
2			
3			
4			
5			

7. Analyze: What patterns do you see in your data? \_\_\_\_\_

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8. Interpret: Select the ALLELE GRAPH tab. What does this graph show? \_\_\_\_\_

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9. Interpret: Select the GENOTYPE GRAPH tab. What does this graph show? \_\_\_\_\_

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10. Think and discuss: Why do you think deleterious dominant alleles are not very common?


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<b>Activity B:</b> <b>Deleterious recessive alleles</b>	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>• Click <b>Reset</b>.</li> <li>• If necessary, set <b>DD</b> and <b>dd</b> to 34%.</li> </ul>	
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**Introduction:** **Cystic fibrosis** is a genetic disease caused by a **recessive allele**. Individuals with one copy of this allele are healthy, but having two copies of the allele causes the production of abnormally thick mucus in the lungs and pancreas. This leads to breathing difficulty, frequent infections, and usually a shortened life span.

**Question: How will allele frequencies change if a recessive allele is deleterious?**

1. Observe: To model the effects of a deleterious recessive allele, set the **Fitness of DD** and **Fitness of Dd** to 100%. Set the **Fitness of dd** to 60%.

Based on the colors of the trees, which parrots will be easiest for predators to spot and kill?

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2. Predict: How do you expect the proportions of *D* and *d* alleles to change in five generations?

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3. Gather data: Click **Begin**. Play through the simulation for five generations. Select the TABLE tab and record the genotype populations over time in the spaces below.

Generation	<i>DD</i>	<i>Dd</i>	<i>dd</i>
0			
1			
2			
3			
4			
5			

4. Analyze: What patterns do you see in your data? \_\_\_\_\_

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**(Activity B continued on next page)**

**Activity B (continued from previous page)**

5. Interpret: Select the ALLELE GRAPH tab. What does this graph show? \_\_\_\_\_

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6. Interpret: Select the GENOTYPE GRAPH tab. What does this graph show? \_\_\_\_\_

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7. Compare: Compare the rate at which the deleterious *d* allele disappears in this activity to the rate at which the deleterious *D* allele disappeared in activity A.

A. Which disappears more rapidly from a population, a deleterious dominant allele or a deleterious recessive allele? \_\_\_\_\_

B. Why do you think this is so? \_\_\_\_\_

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8. Apply: Deleterious recessive alleles, such as the allele that causes cystic fibrosis, can persist in a population indefinitely. Why aren't these rare alleles eliminated completely?

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9. Think and discuss: Why are most genetic diseases caused by recessive alleles? If possible, discuss your answer with your classmates and teacher.

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<b>Activity C:</b> <b>Heterozygote superiority</b>	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>• Click <b>Reset</b>.</li> <li>• If necessary, set <b>DD</b> and <b>dd</b> to 34%.</li> </ul>	
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**Introduction:** In the case of **heterozygote superiority**, individuals who are heterozygous for a particular trait are more fit than either of the homozygous varieties. For example, individuals with one copy of the sickle cell allele are resistant to malaria but do not have sickle cell anemia.

**Question: How will allele frequencies change if heterozygous individuals have the greatest fitness?**

1. Observe: To model heterozygote superiority, set the **Fitness of DD** and the **Fitness of dd** to 60%. Set the **Fitness of Dd** to 100%.

Based on the color of the trees, which parrots will be easiest for predators to spot and kill?

\_\_\_\_\_

2. Predict: How do you expect the proportions of **DD**, **Dd**, and **dd** genotypes to change over the course of five generations? \_\_\_\_\_

\_\_\_\_\_

3. Gather data: Click **Begin**. Play through the simulation for five generations. Select the **TABLE** tab and record the genotype populations over time in the spaces below.

Generation	<b>DD</b>	<b>Dd</b>	<b>dd</b>
0			
1			
2			
3			
4			
5			

4. Analyze: What patterns do you see in your data? \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**(Activity C continued on next page)**

**Activity C (continued from previous page)**

5. Interpret: Select the ALLELE GRAPH tab. What does this graph show? \_\_\_\_\_

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6. Interpret: Select the GENOTYPE GRAPH tab. What does this graph show? \_\_\_\_\_

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7. Calculate: Suppose that the *dd* genotype represents a debilitating disease such as sickle cell anemia. In this population, what percentage of the offspring has sickle cell anemia?

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8. Think and discuss: Malaria is transmitted through mosquito bites. Symptoms include high fever, joint pain, and violent shivering. It can be deadly, especially in children or the elderly.

A. Why do you think the sickle cell allele is still common in tropical regions?

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B. How might the occurrence of sickle cell anemia change if anti-malaria drugs and preventative measures (such as the use of mosquito netting) become more widespread in tropical regions?

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