Evolution: Natural and Artificial Selection

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 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?

   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

5. **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.

<table>
<thead>
<tr>
<th>Trial</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of generations to achieve 90% fitness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. **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.

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

   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

8. **Summarize:** How are the processes of natural selection and artificial selection similar? How are they different?

   __________________________________________________________________________
   __________________________________________________________________________
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.

<table>
<thead>
<tr>
<th>Mutation rate</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.0</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Mutation rate</th>
<th>Number of generations to 90% average fitness</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
<td>Trial 2</td>
</tr>
<tr>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

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. ____________________________

      _____________________________________________________________________

      _____________________________________________________________________