COLOR VARIATION OVER TIME IN ROCK POCKET MOUSE POPULATIONS

OVERVIEW

KEY CONCEPTS AND LEARNING OBJECTIVES
- The environment contributes to determining whether a mutation is advantageous, deleterious, or neutral.
- Mutations that increase fitness of an organism increase in frequency in a population.

Students will be able to
- explain how variation, selection, and time fuel the process of evolution; and
- analyze and organize data.

CURRICULUM CONNECTIONS

<table>
<thead>
<tr>
<th>Curriculum</th>
<th>Standards</th>
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<tr>
<td>NGSS (April 2013)</td>
<td>MS-LS2-1, MS-LS2-2, MS-LS4-4, MS-LS4-6, MS-ESS2-2</td>
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<td>HS-LS2-2, HS-LS2-6, HS-LS3-3, HS-LS4-2, HS-LS4-4, HS-LS4-5</td>
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<td>CCSS.Math.Practice.MP.2, CCSS.Math.Practice.MP.3,</td>
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<td>CCSS.Math.Practice.MP.5</td>
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<td>CCSS.WHST.9-12.1</td>
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<td>IB Biology (2009)</td>
<td>5.4, D.2, G.1</td>
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KEY TERMS
adaptation, evolution, mutation, natural selection, trait, variation

TIME REQUIREMENTS
This lesson was designed to be completed within one 50-minute class period.

SUGGESTED AUDIENCE
This lesson is appropriate for middle school life science and high school biology (all levels including AP and IB).

PRIOR KNOWLEDGE
Students should know that traits are inherited and that some traits provide organisms with a greater chance to survive and reproduce. They should have a basic understanding of what a food web is and that organisms fill specific niches in their environments.
THE MAKING OF THE FITTEST: 
Natural Selection and Adaptation

MATERIALS
- colored pencils

TEACHING TIPS
- Print the illustrations on pages 5–8 of the student handout so that they are one sided.
- You may wish to have students work in pairs.
- Fill a few plastic sandwich bags with 15 grams of paper clips and pass them around so that students will have an idea of how much a rock pocket mouse weighs.
- Before watching the film, be sure that students write down initial thoughts about the sequence of the illustrations.
- You may want to show the film more than once so students can take notes. Encourage them to write down questions they have.
- Ask students to share how the data table and graph were helpful in confirming the order of the four illustrations.
- If you have access to computers, you may have students use graphing software to generate the bar graphs.
- Be sure to reinforce the concept that populations evolve over time; individuals do not evolve during their lifetimes.
- Address the common misconception that new traits arise “as needed.” The mutation for dark-colored fur did not evolve in response to the presence of dark-colored volcanic rock. You can make sure your students understand this by pointing out that there are dark-colored mutants on the sandy-colored substrate, too. Instead, the new trait arose—in both locations—due to random mutation.
- Discuss with students why the frequencies of the light-colored and dark-colored mice did not change significantly at location A but did at location B. In location A, the dark coloration was not adaptive, so it did not spread. In location B, however, mice with the dark coloration had a selective advantage over those with light coloration.
- Students may ask why the frequency of dark-colored mice changes slightly at location A. This represents the normal variation that is present even in a static environment.

ANSWER KEY

PROCEDURE STEP 2
Place the illustrations in what you think is the correct order from oldest to most recent. Indicate your order by circling the appropriate number under the illustration.

The illustrations are in this order: 2, 4, 3, 1.

PROCEDURE STEP 3
Explain how you decided which illustration represents the most recent rock pocket mouse population and why you positioned the others in the sequence as you did.

Any reasonable explanation is acceptable. Students might comment on the fact that the number of light-colored mice has decreased over time while the number of dark-colored mice has increased.

PROCEDURE STEP 6
Use colored pencils to prepare a bar graph based on the data that shows the distribution of the mice at locations A and B through time. Be sure to provide an appropriate title for the graph, and titles and labels for the x- and y-axes. You may record all of your data for each time period (A and B) on one bar graph or split A and B and make two graphs.

The graphs should represent the students’ data. Even if they miscounted, the trends should be apparent. Make sure that the axes are labeled and that the graphs have been given appropriate titles. A completed data table and sample graphs are shown below. Students may choose to keep A and B together for a single time period or they may plot A and B separately. Either is fine.
Color Variation over Time in Rock Pocket Mouse Populations

<table>
<thead>
<tr>
<th>Location</th>
<th>Sequence</th>
<th>First (oldest)</th>
<th>Second</th>
<th>Third</th>
<th>Fourth (most recent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location A</td>
<td>Number of mice with light fur</td>
<td>10</td>
<td>11</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Number of mice with dark fur</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Location B</td>
<td>Number of mice with light fur</td>
<td>10</td>
<td>9</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Number of mice with dark fur</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>10</td>
</tr>
</tbody>
</table>

Color distribution of pocket mice at Location B
QUESTIONS

1. Explain why a rock pocket mouse’s color influences its overall fitness. Remember that “fitness” is defined by an organism’s ability to survive and produce offspring.

Student explanations should include coat color as an important means of camouflage for the rock pocket mice.

2. Explain the presence of dark-colored mice at location A. Why didn’t this phenotype become more common in the population?

The dark-colored mice arose in the population at location A by random mutation. The phenotype did not increase because it did not afford a selective advantage to the mice.
3. Write a scientific summary that describes changes in the rock pocket mouse populations at location B. Your summary should include

- a description of how the population has changed over time;
- an explanation of what caused the changes; and
- a prediction that describes what the population will look like 100 years in the future. Base your prediction on trends in the data you have organized. You can assume that environmental conditions do not change over the 100 years.

Check that students have included the following points:

- Originally, location B had a sandy-colored substrate. Light-colored mice had a selective advantage because they could better avoid predation.
- Location B became covered in dark-colored volcanic rock, which means that dark-colored mice now had an advantage over light-colored mice in that environment.
- Over time, dark-colored mice became more common at location B because more of their offspring survived to reproduce and pass on their genes, including the gene for fur color.

4. Use the data and what you have learned about evolution to explain how mutation is a random process, but natural selection is not random.

Student answers should point out that the dark-colored mutation was present in the population before any volcanic activity, indicating that the mutation is random. However, the dark-colored phenotype became more common once there was a selective advantage for it, which indicates that selection is not random.

AUTHOR
Mary Colvard, Cobleskill-Richmondville High School (retired), New York

FIELD TESTERS
James Coleman, Newman High School; Marjorie Davis, Mount Saint Joseph Academy; Beth Dixon, Western Sierra Collegiate Academy; Christina McCoy-Crawford, First Baptist School; Tamara Pennington, Windsor High School