What Is Happening To The Spotted Salamander In Georgia?

Overview: Students will conduct a population genetics simulation lab and relate it to mutations, adaptations and natural selection. The students will also be introduced to the Hardy-Weinberg principle and its conditions and calculations. At the end of the activity, students should be able to calculate and use allelic frequencies and see the relationships to both natural selection and population genetics.

Standards (Content and Characteristics):

SB2. Students will analyze how biological traits are passed on to successive generations.
   c. Using Mendel’s laws, explain the role of meiosis in reproductive variability.
   d. Describe the relationships between changes in DNA and potential appearance of new traits including: alterations during replications and mutagenic factors that can alter DNA.

SB5. Students will evaluate the role of natural selection in the development of the theory of evolution.
   d. Relate natural selection to changes in organisms.

SCSh1. Students will evaluate the importance of curiosity, honesty, openness, and skepticism in science.
   a. Exhibit the above traits in their own scientific activities.

SCSh3. Students will identify and investigate problems scientifically.
   c. Collect, organize and record appropriate data.
   e. Develop reasonable conclusions based on data collected.

SCSh6. Students will communicate scientific investigations and information clearly.
   a. Write clear, coherent laboratory reports related to scientific investigations.

SCSh8. Students will understand important features of the process of scientific inquiry.
   Students will apply the following to inquiry learning practices:
   a. Scientific investigators control the conditions of their experiments in order to produce valuable data.
   f. Science disciplines and traditions differ from one another in what is studied, techniques used, and outcomes sought.
Enduring Understandings:

- Changes in DNA occur spontaneously at low rates, some of these changes make no difference to the organism whereas others can change cells and organisms.
- Favorable variations among individuals that increase the chance of survival tend to be passed onto successive generations.
- Hereditary information, coded by DNA, is passed down from generation to generation in a predictable way.
- Only mutations in germ cells can contribute to the variation that changes an organism's offspring.

Essential Question(s):

1. How can a change in DNA in one organism affect future generations of a population?
2. How can mutation and meiosis result in a new trait appearing in an organism?
3. What impact do lethal genetic recombinations have on populations?
4. What is the relationship between natural selection and allelic frequencies in a population?

Pre-Assessment:

Have students write a paragraph using terms from a word splash such as: meiosis, mutation, DNA, adaptation, population, natural selection.

OR

Watch video clips from United Streaming concerning the Hardy-Weinberg principles:

- What are Populations and Gene Pools?
- 5 conditions of the Hardy-Weinberg Principle
- Applying the Hardy-Weinberg principle to predict coat color in a population of fuzz balls

Practice one or two problems for mathematically attaining these frequencies.

<table>
<thead>
<tr>
<th>Outcome/Performance Level Indicator</th>
<th>Explain how mutations may produce adaptations that are the basis of natural selection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Identify agents responsible for genetic alterations</td>
</tr>
<tr>
<td></td>
<td>Relate adaptation to natural selection</td>
</tr>
</tbody>
</table>

Georgia Department of Education
Kathy Cox, State Superintendent of Schools
Biology • 9-12 • Equilibrium
August 12, 2007 • Page 2 of 9
Copyright 2007 © All Rights Reserved
### Performance Task Directions for Differentiated Groups

All groups conduct the Population Genetics Activity. Background information, student directions and data tables are attached at the end of this task. See [PopGenetics](#) attached below

<table>
<thead>
<tr>
<th>BASIC</th>
<th>INTERMEDIATE</th>
<th>ADVANCED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Follow this procedure which is also given in the framework. All data tables are given as a hand out for this group. This level of students will need group discussion and direction to answer the concluding questions at the end of the activity.</td>
<td><em>(Teacher note: you will need to have a clear understanding of the Hardy-Weinberg equation in order to do this activity and its extension. The video clips from Unitedstreaming are very well done and all levels of students can understand them.)</em> Using the Hardy-Weinberg equation, have students calculate the gene frequencies and the allelic frequencies using their own data. Using the five conditions of the Hardy-Weinberg principle, explain the results of your data. Which condition(s) must have been affected to cause the change in the population? What condition(s) has affected the spotted salamander population in Georgia?</td>
<td><em>(Teacher note: you will need to have a clear understanding of the Hardy-Weinberg equation in order to do this activity and its extension. The video clips from Unitedstreaming are very well done and all levels of students can understand them.)</em> Using the Hardy-Weinberg equation, have students calculate the gene frequencies and the allelic frequencies using given data (from the teacher)</td>
</tr>
</tbody>
</table>
### Resources

Use video clips about Hardy-Weinberg principles to illustrate the allelic and gene frequencies:
- *What are Populations and Gene Pools?* · 5 conditions of the Hardy-Weinberg Principle; Applying the Hardy-Weinberg principle to predict coat color in a population of fuzz balls;

### Homework/Extension

- On the Internet, have students look up the natural history of the spotted salamanders in Georgia and illustrate the life cycle of the salamander.
- Create a pedigree analysis of this fatal allele in salamanders showing at least 5 generations of salamanders and show how a recessive lethal allele is inherited.
- Using Internet sources, students need to find recent examples of lethal alleles occurring in nature or previously in the past 100 years.

### Instructional Tasks Accommodations for ELL Students

- Modify language requirements for written assessments
- Pair with more advanced native language speaking partner (allow for translation in native language for comprehension) as needed
- Provide paragraph summary template (fill in the blank format)
- Provide bilingual support using word to word translation such as dictionaries, and glossaries
- Provide native language text books and support material whenever possible
- Use simpler vocabulary or paraphrase
- Use sentence starters for student responses
- Provide list of Internet sites for homework that have lower level reading
- Create a word wall for vocabulary; word wall can be an interactive whereby students use yarn to make connections with key vocabulary
- Include illustrations with the word wall
- Use KIM vocabulary strategy (Key word, Illustration, and Meaning  student in students own words)
### Instructional Tasks Accommodations for Students with Specific Disabilities

- **Review and Implement IEP accommodations for specific student needs**

  Other possible accommodations may include:

  - Modify language requirements for written assessments
  - Pair with more advanced native language speaking partner (allow for translation in native language for comprehension) as needed
  - Provide paragraph summary template (fill in the blank format)
  - Create a word wall for vocabulary; word wall can be an interactive whereby students use yarn to make connections with key vocabulary
  - Include illustrations with the word wall
  - Use KIM vocabulary strategy (Key word, Illustration, and Meaning student in students own words)
  - Give written examples of math calculations as well as oral
  - Use of multi-media or allow students give oral responses
  - Provide list of Internet sites for homework that have lower level reading
  - Break work into manageable parts

### Instructional Tasks Accommodations for Gifted Students

- Use multi-media to design a presentation to find recent examples of lethal alleles occurring in nature or previously in the past 100 years
Population Genetics

Materials (for each student group)
- Closed container (cigar boxes, brown paper lunch bags, opaque plastic containers, etc)
- 50 white beads and 50 red beads in the container
- Sandwich bag with an additional 50 red beads

Background
A fatal genetic disease has been observed in a population of Spotted salamanders commonly found throughout the state of Georgia. You are a wildlife biologist who has been charged with monitoring changes in the population. You have determined that the fatal disease is the result of a recessive trait and that the affected salamanders typically die in their second year of life. Male and female salamanders are equally likely to be affected by the disease.

You have decided to use beads to simulate the salamanders’ gene pool. You are using red beads to represent normal alleles and white beads to represent the allele for the fatal gene. A container will hold the gene pool of the salamanders. (Note: this exercise simulates the change in allele frequencies under selection. It involves procedural shortcuts that simplify the calculations. These shortcuts do not affect the validity of the simulation or the conclusions you can draw from it.)

Procedure
Remove the bag of extra red beads from the opaque bag. The opaque bag will contain the “gene pool”. Reseal the opaque bag of red and white beads and thoroughly mix the tubes in the opaque bag. Without looking, withdraw 2 beads from the opaque bag. Tally the beads’ colors (red-red, red-white, or white-white) in the table below, and return the two beads to the bag. Thoroughly mix the beads. Continue withdrawing beads two at a time, tallying their colors, and returning the beads to the container, until you have drawn 50 pairs of beads. Find the frequency of each color combination using the following formula:

\[ \text{Frequency of a color combination} = \frac{\text{number drawn of the combination}}{50}. \]
Now you will simulate the removal of individuals with the fatal white/white gene pair from the population.
Determine the total number of white beads you withdrew in white/white pairs. Remove this number of white beads from the gene pool (the bag) and replace them with red beads from the bag of extra red beads. For example, if you drew 13 white/white pairs, replace 26 white beads with 26 red beads.
From the new “gene pool”, randomly draw another 50 pairs of beads, tally their color combinations (red-red, red-white, white-white) as before, and return them to the opaque bag before you draw the next set.

<table>
<thead>
<tr>
<th>Color combination</th>
<th>Red-red</th>
<th>Red-white</th>
<th>White-white</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tally</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of pairs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>with color combination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency of color combination</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Color combination Tally</th>
<th>Red-red</th>
<th>Red-white</th>
<th>White-white</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of pairs with color combination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency of color combination</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Determine the total number of white beads you withdrew from the opaque bag in white/white pairs. Remove this number of white beads from the gene pool and replace them with red beads from the bag containing the extra red beads as before. Repeat the counting procedure a third time, and tally your results below.

**Generation 3**

<table>
<thead>
<tr>
<th>Color combination</th>
<th>Red-red</th>
<th>Red-white</th>
<th>White-white</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tally</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of pairs with color combination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency of color combination</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Questions**

1. Assign a letter to each of the normal and lethal alleles, and use the letters to form the genotypes of the salamanders. Produce a Punnett square showing the cross of two salamanders, both of which are heterozygous for the lethal gene. Provide a key to the symbols you use in the cross and identify the phenotype for each genotype derived from the cross.
2. Tally the red and white alleles in each generation. Find the percentage of the alleles in each generation. Why are some alleles favored by natural selection and others are less frequently seen?
3. What could have caused the mutation that led to the fatal gene condition?
4. Defend the statement: “Only mutations that occur in germ cells can be passed on to successive generations.”
5. What affect would migration have on this population? Are there other conditions that could impact reproductive survival rates?
6. How could calculating allelic frequencies provide evidence that evolution by natural selection is occurring?
7. Predict what might occur if a mutation arose that caused a “super salamander” that had a higher survival rate than the general population. Design an experimental model that will support your prediction.
Extension:

1. Using the Hardy-Weinberg equation $p^2 + 2pq + q^2 = 1$, calculate both the gene and allelic frequencies for the following data: In a population a dominant gene occurs at the rate of 70% and the recessive trait at a rate of 30%.

2. Calculate the frequencies using the Hardy-Weinberg principle for the data of each of the three generations of spotted salamanders from your data.

3. Account for the change in the frequencies from one generation to the next. As a population geneticist, decide how you will save the spotted salamander in Georgia using the data you have gathered as the basis for your actions. Use the idea that survival of a species occurs when favorable variation occur within the population.