Survival of the Fittest
Variations in the Clam Species *Clamys sweetus*

Abstract
Survival of the Fittest: Variations in the Clam Species Clamys sweetus is a guided inquiry. This series of hands-on activities complements the HHMI DVD *Evolution: Constant Change and Common Threads* and requires simple materials such as M&Ms, Reese's Pieces, food storage bags, and paper cups. This activity has been designed to engage students in thinking about the mechanism of natural selection by encouraging them to formulate questions that can be answered through scientific investigation, data collection, and pattern recognition.

Appropriate Grade Level

Middle School — average and honors

High School Biology — average

Goals

This activity is designed to engage students in thinking about the following:

- How does natural selection preserve favorable traits?
- What evidence is there that variation exists within a population?
- What role does variation play in the evolution of a species?
- Why are some variations inherited and others eliminated?
- How do variation, selection, and time fuel the process of evolution?

Time Requirement

This lesson consists of three distinct activities. Each requires approximately one 45-minute block of time.

Required Student Background Information

Students should have a basic understanding of:

- evolution
- natural selection
- mutations
- variation within a species

Background Information

Variation, selection, and time fuel the process of evolution. Darwin observed that species are capable of producing more offspring than the environment can support. Individuals in a population of the same species exhibit variations in traits. Some members possess variations that increase their chance to survive and reproduce. These variations are due to both the recombination of genes during sexual reproduction and mutations. The selection of a survival type is a function of the environment in which the species lives and is referred to conceptually as natural selection. This is the driving force of evolution. It can also be thought of as a change in gene frequencies in a species over time.

The differential survival of organisms and consequently their ability to reproduce is due to a number of factors. These include changes in abiotic factors in the habitat such as temperature or pH changes, availability of resources such as nesting sites or food, and interspecies interactions such as predator-prey relationships. It is on these relationships that this series of activities focuses.

Implementing the Activity

There are two different ways to introduce this series of activities. The first probes prior conceptions through an interactive sharing of terms related to the concept of natural selection.

The second is a concept cartoon. Concept cartoons are designed to provoke discussion and stimulate scientific thinking. The cartoon can be used as a handout, on a SMART Board, or in a PowerPoint.

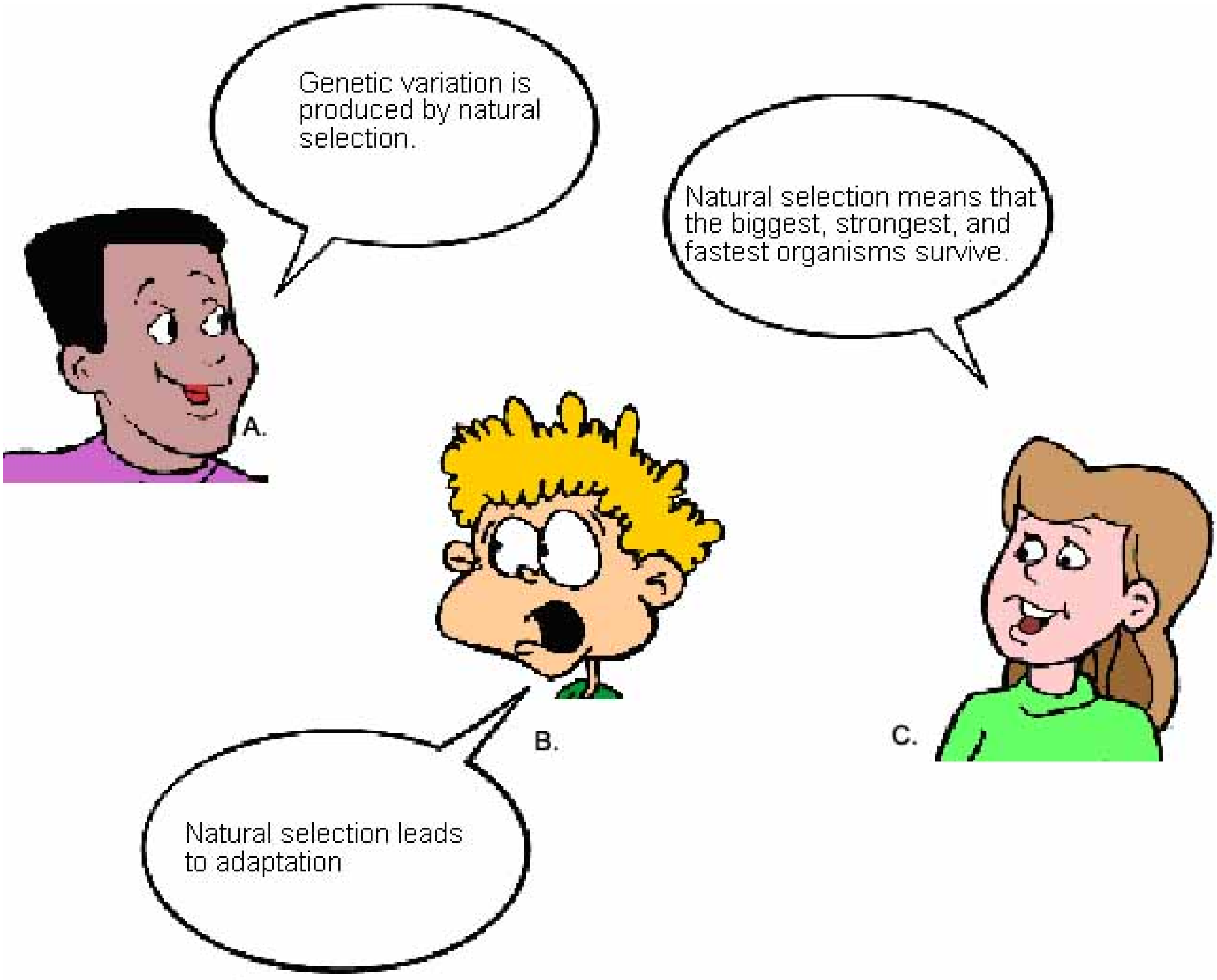
Term Share

1. Have each student make a list of words or phrases that come to mind when they hear the term "natural selection." Allow a few minutes for this but no more than three or four. The idea is to provide each student with ample time to compile a satisfactory list.
2. Organize students into cooperative groups of 3. Have one student act as the *Recorder*, another as the *Analyzer*, and the third as the *Reporter*. The *Analyzer* should examine the three lists and highlight the words that appear on all three lists. From this, the *Recorder* should compile two lists: one of the terms common to all three students and a second of terms not appearing on all three.
3. After the lists have been compiled, the group should discuss the words they chose and their reasons for including them. Each group should select two words from each of their lists for sharing with other groups. Next, the *Reporter* should report the two selected words from each list and explain to the class why their group included them. Members of other groups should make no comments about the inclusion of the words. This will provide a good idea of where students are in their conceptualization of natural selection in a nonjudgmental atmosphere.
4. The word lists can be held by the teacher or posted on the bulletin board for student reference.

Concept Cartoon

1. Give students a few minutes to look at the cartoon and then ask them to write their own reflection. (There is a clean copy at the end of the Teacher materials.) Ask them to comment on each statement. They should clearly indicate which one(s) they agree with and to give a reason for their choice.
2. Follow the individual reflection period with a pair-share and then a discussion that involves the entire class. Students should be asked to justify or adjudicate between the ideas expressed in the speech bubbles. This activity will allow you to identify areas of misconception and stimulate thinking. At this time, do not tell students the "right" answer. Let them use the activities as a way to find out which character in the cartoon has the best response. Tell them you will discuss the cartoon with them after the activity.

What is the role of natural selection in evolution?



For possible responses, see the answer to question #16.

<u>**Materials for Hands-on Activities**</u>

Part One—Materials for Hands-on Activities

Do not use any brown candies for this phase of the activity. You will have the option of using the brown candies for another experiment later in the activity. Or you can let your students eat them!

Per Class of 24

- 12 sealable storage bags* marked "*C. sweetus* strain M" (10 M&M candies minus the brown ones)
- 12 sealable storage bags* marked "*C. sweetus* strain R" (10 Reese's Pieces minus the brown ones)

- 12 paper cups or several paper towels marked "*Waste*"
- a copy of the activity for each student
- 12 small metric rulers
- optional: one or more electronic balances

Per student group of 2

- 1 sealable storage bag* marked "*C. sweetus* strain M" (10 M&M candies minus the brown)
- 1 sealable storage bag* marked "*C. sweetus* strain R" (10 Reese's Pieces minus the brown)
- 1 waste container (either a paper cup or paper towels)
- a copy of the activity for each student
- small metric ruler
- optional: electronic balance

* Use snack-size sealable food storage bags. These keep the candies contained so that during the observational phase of the activity, students do not even need to open the bags. The bags make it easy to store and transport the candies and can be reused.

Part Two—Materials for Hands-on Activities

Per Class of 24

- 12 sealable food storage bags* marked "*C. sweetus* strain M". Each bag should contain 4 each of the yellow, blue, green, orange, and red candies. There should be NO brown candies in the mix
- 12 waste containers (paper cups or paper towels)
- 12 sets of colored pencils/markers (red, blue, orange, green and yellow)
- a copy of the activity for each student

Per student group of 2

- 1 sealable food storage bag marked "*C. sweetus* strain M" containing 4 each of the yellow, blue, green, orange, and red candies. There should be NO brown candies in the mix
- 1 waste container
- 1 set of colored pencils/markers (red, blue, green, orange, and yellow)
- a copy of the activity for each student

Part Three—PowerPoint

You will need a copy of the HHMI DVD *Evolution: Constant Change and Common Threads,* a DVD player or computer with a DVD drive and an LCD projector or monitor.

<u>Safety Note:</u>

Students with peanut allergies should be informed that *C. sweetus* strain R contains peanuts. If necessary, they should be invited to leave the classroom and make observations only of strain M. Once the crushing phase is completed and the residue removed, these students can return and participate in the activity.

Another option is to provide students imitation M&Ms in place of Reese's Pieces. These can be purchased at a discount store and typically crush more easily than genuine M&Ms.

Caution students not to consume any of the candies they are provided with for this activity. Students in other classes may have handled the candies. Also, they should not eat in a science classroom.

Procedures

So that this series of activitues does not appear to be an overwhelming amount of work to students, it has been divided into three distinct parts. Provide students with only those pages and data sheets that are needed at the time. To facilitate this, all of the data sheets have been placed at the end of the student materials.

Part One

- Each group of two students should be provided with a set of materials and copies of the activity.
- Be sure to caution students not to squeeze *C. sweetus* through the bag.
- If using a balance, allow students to remove *C. sweetus* from the bag and determine the mass of both strains.
- At the appropriate point, demonstrate how to hold and crush the "clams".
- When teams have completed the trials for Part One, compile class data and make it available to all teams. This can be done using a SMART Board, newsprint, or projector.

Part Two

- Class results should be made available to the entire class for use in Part Two.
- Once students have completed Part Two, they should compile a list of questions they would like to ask other researchers about the brown clams. Have them share some of their questions with the entire class. Perhaps make a class list of the top 5 or 6 questions students would like to ask.

Part Three

- This final segment consists of the student-designed investigation and natural selection PowerPoint with video clips from the HHMI DVD *Evolution: Constant Change and Common Threads*. Students will likely replicate the type of crushing experiment they have already completed in Parts One and Two of this activity. You might want to encourage them to consider factors other than shell hardness. The experiments students design could address different variables such as feeding adaptations of the predator, environmental changes, whether different color alleles are dominant or recessive, and so on, You may elect to have students do the experiments they design as part of the activity, for extra credit, or not at all. There is no space provided for the results and a conclusion since students cannot presume to know the outcome of an experiment before conducting it. These can be added should they conduct their experiment.

  Before using the PowerPoint for the first time, select the Notes Page View for instructions on how to work through this part of the activity. In terms of making use of the PowerPoint, you have several options. They are:

  (1) Use the provided PowerPoint as is.
  (2) Integrate student questions into the existing PowerPoint.
  (3) Develop a new PowerPoint using only the questions your students asked and show the designated video clips at appropriate times.

  No matter which option you select, it is important for students to understand that what researchers have learned about the pocket mouse applies to the clam example and that what your students have learned through doing this activity has real world applications.

Answers to Questions

Part One

1. Four possible traits for *C. sweetus* strain M include but are not limited to:
   - come in a variety of colors (red, orange, green, blue, and yellow)
   - are round with a sort of flat top and bottom
   - have the letter "m" on one surface
   - about 1.2 cm wide and 0.5 cm tall
   - have a hard outer covering

2. Four possible traits for *C. sweetus* strain R include but are not limited to:
   - come in two colors (orange and yellow)
   - are round with a sort of flat top and bottom
   - about 1.2 cm wide and 0.5 cm tall
   - have a hard outer covering

3. Students may respond either "yes" or "no" to this question. The only major difference is that strain M has an "m" on one surface and strain R does not have an "R". All other traits are pretty much the same. Some students may detect differences in smell or mass.

Chart 1 *Relative shell strength*: The results will vary but the overall trend is that strain M is more resistant to cracking and has the stronger shell. Strain R will crack first in a majority of the trials.

Chart 2 *Percent frequency of C. sweetus M and C. sweetus R before and after crushing*: Results will vary. The frequency of strain R after crushing will be a very low number.

4. Students should provide a title for the bar graph.

   The "before crushing" bars have been shaded. Numbers will vary for "after crushing". Check to see that the bars reflect the data recorded in Chart 1.

5. Class results are more reliable since there are more trials. A larger sample size leads to increased precision and more accurate data.

6. There is a difference in shell strength. Strain R cracks more easily than strain M. Strain M possesses the strongest shell. Students should reference data from Chart 1 to support their answer.

7. (a) Class data shows that *C. sweetus R* generally has the weaker shell. The arthropod will seek out strain R since it will be easier to crack open.

   (b) After several generations, the frequency of *C. sweetus M* should be much greater than the frequency of *C. sweetus R*. Students may even predict that *C. sweetus R* will cease to exist.

Part Two

2-3. The data recorded in Chart 2 and Chart 3 varies. Red usually has the stronger shell and blue the weakest. If your class finds no real difference, that is OK.

8. Students should provide an appropriate title for the bar graph.

   The vertical axis should be labeled "Percent Frequency" with a range from 0% to 100%.

   The horizontal axis should be labeled "Shell Color." There should be two bars for each color. One bar represents the percent frequency of that color clam before crushing and the other bar after crushing. Both bars are based on team data.

   The key should make it clear what each bar indicates. Colored pencils or markers would be handy for this task.

9. (a) Answers will vary. The two colors experiencing the greatest change in frequency are likely the one that had the strongest shell (usually red) and the one with the weakest shell (generally blue).

   (b) Again, answers will vary when it comes to the color of the shells. That is fine as long as student answers are based on their results. Students should generally state that over several generations, the population would become mostly red (if that is the color they found to have the strongest shell). There would be some yellow, orange, and green clams present. There would be very few or no blue clams unless a favorable mutation occurred. The blue clams (if that is the color they found to have the weakest shell) would not survive to pass their genes on to future generations since they would be the food most preferred by the predatory arthropod.

10. Region A. This is because they have the weakest shells. The others may be strong enough to resist an arthropod attack.

11. (a) Answers should be based on class results.

    (b) Those with Color Two shells would most likely survive an attack. More of them have stronger shells than the Color One clams.

    (c) Both colors would have an equal chance of survival since their shells have the same strength.

12. One possible answer is that arthropods may vary in their ability to crack open *C. sweetus* shells. Over time, those with stronger pincers might feed more successfully resulting in them being less likely to starve and more likely to reproduce and pass along their favorable variation. Eventually the arthropods may be able to eat any *C. sweetus* clam.

Part Three

13. The hypothesis should be written in an acceptable form. Possible hypotheses include but are not limited to:

    -If they have hard shells, then brown-shelled clams will increase in number.

    -Brown-shelled clams have a selective advantage over other clams.

    Students should design a controlled experiment that tests only one variable. The experiment should consist of multiple trials.

14. Students should list a variety of questions. Possible lists might include, but are not limited to:

- Is there any survival advantage to having a brown shell?
- Has the environment changed?
- Could the presence of a few brown clams eventually lead to a population that is mostly brown clams?
- What caused the brown color to appear in the population?
- Are brown shells as strong as the shells of other colors?
- Do brown clams taste any different?
- Is there a predator that prefers brown shelled clams?

Summary

15. What students decide to select and draw varies widely. As long as the environmental change a student circles could lead to the evolutionary changes depicted in his/her drawing, the answer is correct. Each student's work should include a representation of *C. sweetus* in its present and future environment. The drawing should clearly show how the changed environment has selected

for specific variations. The arthropod should also be represented. It too may have evolved due to the change in the environment.

16. **"What is the role of natural selection in evolution?"**

Individual B. is correct. Natural selection does lead to adaptation. Adaptations are traits that are selected for by the environment. The genetic basis of a trait did not arise as a result of the environment. It already existed and provided the organism with some advantage that allowed it to survive and pass its favorable traits on to its offspring.

Individual A.* is *incorrect. Natural selection works on variations that are already present in a population. Natural selection does not produce the variation

Individual C incorrect and is expressing a common misconception. This is what is emphasized in nature movies but is not always the basis of natural selection Natural selection *can* cause the development of such traits. The very large, strong, fast lizards that once roamed Earth have not survived due to selection pressures.

Correlation to the National Science Education Standards

Unifying Concepts and Processes

- Systems, order, and organization
- Evidence, models, and explanation
- Change, constancy, and measurement
- Evolution and equilibrium
- Form and function

Content Standard A: Science as Inquiry

- Identify questions and concepts that guide scientific investigations
- Design and conduct scientific investigations
- Use technology and mathematics to improve investigations and communications
- Formulate and revise scientific explanations and models using logic and evidence
- Recognize and analyze alternative explanations and models
- Communicate and defend a scientific argument

Content Standard C: Life Science

- Biological evolution
- Interdependence of organisms
- Behavior of organisms

Content Standard F: Science in Personal and Social Perspectives

- Environmental quality

Content Standard G: History and Nature of Science

- Science as a human endeavor
- Nature of scientific knowledge

References

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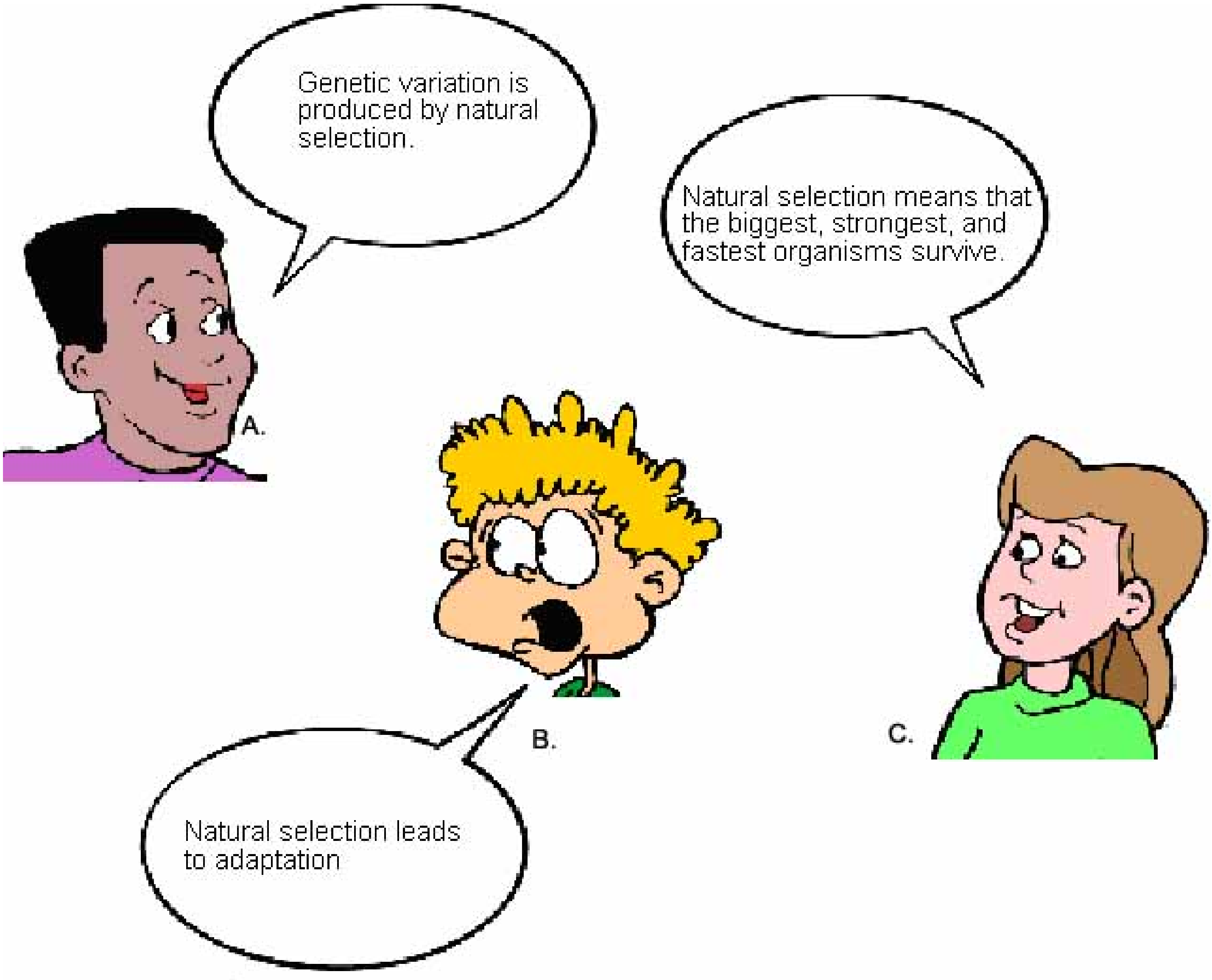
Genetic variation is produced by natural selection.
A.
Natural selection means that the biggest, strongest, and fastest organisms survive.
B.
C.
Natural selection leads to adaptation