Gustavus Nobel Conference  
2014-15 Curriculum Materials

Document Overview:

This lesson is designed to provide an overview of natural selection and adaptation in a population as well as introduce the topic of evolutionary developmental biology, “evo devo”. It can be used to prepare students for Sean B. Carroll’s talk, and/or as an introduction to a Population Genetics Unit. This lesson contains copyrighted material, and material adapted and compiled from resources available from [HHMI Biointeractive](http://www.hhmi.org/reprints-and-permissions).

Minnesota State Academic Science Standards:

9.1.1.1.2. Understand that scientists conduct investigations for a variety of reasons, including: to discover new aspects of the natural world, to explain observed phenomena, to test the conclusions of prior investigations, or to test the predictions of current theories.

9.1.1.1.7. Explain how scientific and technological innovations ─as well as new evidence─ can challenge portions of, or entire accepted theories and models including, but not limited to: cell theory, atomic theory, theory of evolution, plate tectonic theory, germ theory of disease, and the big bang theory.

9.4.3.2.3. Explain how mutations like deletions, insertions, rearrangements or substitutions of DNA segments in gametes may have no effect, may harm, or rarely may be beneficial, and can result in genetic variation within a species.

9.4.3.3.4. Explain why genetic variation within a population is essential for evolution to occur.

9.4.3.3.6. Explain how genetic variation between two populations of a given species is due, in part, to different selective pressures acting independently on each population and how, over time, these differences can lead to the development of new species.

Next Generation Science Standards:

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| HS-LS3-2. | Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. |

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| HS-LS4-2. | Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. |

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| HS-LS4-5. | Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. |

Objectives:

Students will be able to

• explain how variation, selection, and time fuel the process of evolution; and

• analyze and organize data.

Type of Activity: Pre-Conference/Video Clip, Activity

Duration: 50 minute period

Connection to Nobel speakers: Evolutionary developmental biologist **Sean B. Carroll**, PhD, FRS – professor of molecular biology, genetics, and medical genetics, University of Wisconsin at Madison; investigator and vice president for science education, Howard Hughes Medical Institute.

Teacher Tips:

* Preview video clip and review [Lesson Teaching Material](http://media.hhmi.org/biointeractive/activities/pocketmouse/Mouse_ColorVariation_Teacher.pdf?download=true) and [Lesson Student Handout](http://media.hhmi.org/biointeractive/activities/pocketmouse/Mouse_ColorVariation_Student.pdf?download=true) and [In Depth Film Guide](http://media.hhmi.org/biointeractive/activities/pocketmouse/IDG_NaturalSelection.pdf?download=true)
* Print pages 5-8 from the Student Handout, single sided and in color, one set per group
* Laminate or put color pages in plastic sleeves and use whiteboard markers for counting so they can be used again
* Groups of 2 students works best
* You may want to assign video clip to be watched the evening before lesson, and then again during lesson, or be prepared to show it twice during the lesson

Concepts:

• 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.

Key Words: evolution, variation, natural selection, switches, evolutionary developmental biology, evo devo, mutation, adaptation, population,

Description of Lesson/Activity:

I. Engage - Pre-Video Clip Activity (Procedure #1-3 on Student Handout)

II. Explore - Video Clip/Analysis of Data (Procedure #4-6 on Student Handout)

III. Explain -

a. Class Discussion of Data Analysis (group Quick Present or amass class data on board and discuss)

b. Content Review

Overview:

The rock pocket mouse is an excellent model organism for studying geographic variation in phenotype within a single species. Rock pocket mice that live in areas with a light-colored granite substrate are usually sandy in color. Most rock pocket mice that live in areas covered by dark-colored lava rocks, however, are dark. Dark-colored rock pocket mice have uniformly pigmented hairs. Light-colored rock pocket mice have fur composed of banded hairs that have a dark-colored base and tip. Biologists have investigated and found the genetic mutations responsible for the dark-color mutation. Interestingly, different populations have different mutations that result in the same general dark-colored phenotype. Similar mutations are also responsible for dark-colored phenotypes in other species such as jaguars.

See discussion points on p. 3 in the [In Depth Film Guide](http://media.hhmi.org/biointeractive/activities/pocketmouse/IDG_NaturalSelection.pdf?download=true).

IV. Elaborate - Jigsaw lab groups for small group discussion of questions #1-4 from

p. 4 of Student Handout.

V. Evaluation - Ask students to journal on the following questions (adapted from [Student Quiz](http://media.hhmi.org/biointeractive/activities/pocketmouse/IDGquiz_NaturalSelection.pdf?download=true), HHMI Biointeractive):

1. As you saw in the film, rock pocket mice evolved to have dark-colored fur in certain habitats. In three to five sentences, explain how this trait increased in frequency in the population. Include the following key terms:

“fitness” (or “fit”), “survival” (or “survive”), “selection” (or “selective”), and “evolution” (or “evolve”)

2. Near the end of the film, Dr. Sean B. Carroll states that “while mutation is random, natural selection is not.” In your own words, explain how this is possible.

KEY

1. As you saw in the film, rock pocket mice evolved to have dark-colored fur in certain habitats. In three to five sentences, explain how this trait increased in frequency in the population. Include the following key terms:

“fitness” (or “fit”), “survival” (or “survive”), “selection” (or “selective”), and “evolution” (or “evolve”).

***A complete answer should resemble the following, with partial credit given to students who do not include all the key terms or concepts: “Rock pocket mice with dark-colored fur were more fit on dark-colored volcanic rock because visual predators could not see them well; that is, natural selection favored individuals with dark-colored fur. As a result, more of the dark-colored mice survived and reproduced. This caused the population of rock pocket mice to evolve to have more individuals with dark-colored fur.”***

2. Near the end of the film, Dr. Sean B. Carroll states that “while mutation is random, natural selection is not.” In your own words, explain how this is possible.

***A complete answer for this question should include the idea that natural selection acts on traits, which results in the mutations for those traits being more likely to be passed on to the next generation. However, it does not actually cause the mutations to appear in the population; many mutations appear randomly.***

Materials:

* Colored pencils
* 1 copy of pages 5-8 (single sided, color) for each group from [Lesson Student Handout](http://media.hhmi.org/biointeractive/activities/pocketmouse/Mouse_ColorVariation_Student.pdf?download=true)
* 1 copy of pages 1-4 (can be double sided, stapled) per student from [Lesson Student Handout](http://media.hhmi.org/biointeractive/activities/pocketmouse/Mouse_ColorVariation_Student.pdf?download=true)
* [Making of the Fittest: Natural Selection and Adaptation Video Clip](http://www.hhmi.org/biointeractive/making-fittest-natural-selection-and-adaptation) (can be shown via projector and internet access or using a computer/mobile lab)

Extension and Follow-up Activities:

Hardy-Weinberg Principle

Students will work through a [tutorial](http://www.phschool.com/science/biology_place/labbench/lab8/intro.html) on the Hardy-Weinberg equilibrium constant. Once they have a foundation in H-W, they will investigate how selective pressures can affect allele frequencies by completing the lab simulation. (The tutorial is copyrighted and was made by Teresa Knapp Holtzclaw for Pearson Education Inc. )

The Making of the Fittest: Evolving Switches, Evolving Bodies

Students will watch a [video clip](http://media.hhmi.org/fittest/HD/Evolving_Switches_Evolving_Bodies_HD.wmv?download=true) and work in groups on an [investigation](http://www.hhmi.org/biointeractive/modeling-regulatory-switches-pitx1-gene-stickleback-fish) of how evolutionary switches regulate gene expression. (This lesson contains copyrighted material and resources available from [HHMI Biointeractive](http://www.hhmi.org/reprints-and-permissions)).

Stickleback Evolution Virtual Lab

This [virtual lab](http://www.hhmi.org/biointeractive/stickleback-evolution-virtual-lab) teaches skills of data collection and analysis to study evolutionary processes using stickleback fish and fossil specimens. The following [worksheet](http://www.hhmi.org/biointeractive/worksheet-stickleback-evolution-virtual-lab) accompanies the lab. (This lesson contains copyrighted material and resources available from [HHMI Biointeractive](http://www.hhmi.org/reprints-and-permissions)).

Virtual Ant Lab

http://www.mhhe.com/biosci/genbio/virtual\_labs/BL\_12/BL\_12.html

This virtual lab teaches how selective pressures can change allele frequencies. There are data tables and reflection questions that can be printed out. I suggest making multiple copies of the data table.