

## NATURAL SELECTION AND EVOLUTION OF ROCK POCKET MOUSE POPULATIONS

### OVERVIEW

This lesson serves as an extension to the short film [The Making of the Fittest: Natural Selection and Adaptation](http://www.hhmi.org/biointeractive/making-fittest-natural-selection-and-adaptation) (<http://www.hhmi.org/biointeractive/making-fittest-natural-selection-and-adaptation>). It provides an opportunity for students to analyze amino acid data and draw conclusions about the evolution of coat-color phenotypes in the rock pocket mouse. Students review key concepts and mechanisms of evolution, including mutation, gene flow (or migration), genetic drift, and natural selection. Students should come to understand that evolution can and does repeat itself.

### 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.
- Different mutations in the same gene, or even mutations in different genes, can result in the same phenotype.

Students will be able to

- analyze amino acid data in order to draw conclusions about the evolution of coat-color phenotypes in the rock pocket mouse.

### CURRICULUM CONNECTIONS

Curriculum	Standards
NGSS (April 2013)	HS-LS1-1, HS-LS3-1, HS-LS4-2, HS-LS4-4, HS-LS4-5 HS.LS1.A, HS.LS4.B, HS.LS4.C
Common Core (2010)	CCSS.ELA-Literacy.RH.9-10.2, CCSS.ELA-Literacy.RST.9-10.3, CCSS.ELA-Literacy.RST.9-10.4, CCSS.ELA-Literacy.RST.9-10.7
AP Biology (2012–13)	1.A.1, 1.A.2, 1.C.3, 3.C.1, 4.A.1, 4.B.1
IB Biology (2009)	4.1, 4.3, 5.4, D.2, G.1

### KEY TERMS

amino acids, evolution, gene expression, gene flow, genetic drift, mutations, natural selection, protein sequence

### TIME REQUIREMENTS

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

### SUGGESTED AUDIENCE

This lesson is appropriate for high school biology (all levels including AP and IB) and introductory college biology.

### PRIOR KNOWLEDGE

Students should be familiar with the mechanisms of evolution, including mutation, gene flow, genetic drift, and natural selection.

### MATERIALS

genetic code chart

### TEACHING TIPS

- After completing Step 1 of the procedure and before answering the analysis questions, show (or review) the Howard Hughes Medical Institute's short film titled *The Making of the Fittest: Natural Selection and Adaptation* at <http://www.hhmi.org/biointeractive/making-fittest-natural-selection-and-adaptation>.

# The Making of the Fittest: Natural Selection and Adaptation

## LESSON TEACHER MATERIALS

- Although this lesson can be completed as a stand-alone lesson, we recommend that students first complete the related lesson “Molecular Genetics of Color Mutations in Rock Pocket Mice” at <http://www.hhmi.org/biointeractive/molecular-genetics-color-mutations-rock-pocket-mice>. If they have already completed that lesson, then watch *The Making of the Fittest: Natural Selection and Adaptation* a second time, suggesting to the students that they focus on the evolution component of the rock pocket mouse coat coloration story.
- For an excellent resource on the basics of evolution and a review of evolutionary mechanisms, see the website Understanding Evolution at <http://evolution.berkeley.edu>.

### ANSWER KEY

#### PROCEDURE STEP 3

Using a genetic code chart, such as the one on page 4 [see the student handout], and the messenger RNA (mRNA) codons provided in the table below, fill in the appropriate amino acids in the boxes left blank. The columns from the Pinacate light-colored and dark-colored rock pocket mouse populations studied in the film have been filled in for you.

#### Mc1r Gene Mutations in Different Rock Pocket Mouse Populations

Mc1r Gene Missense Mutation Amino Acid Positions		Pinacate Light Mouse Population	Pinacate Dark Mouse Population	Kenzin Dark Mouse Population	Armendaris Dark Mouse Population	Carrizozo Dark Mouse Population
018	mRNA	CGC	UGC	CGC	CGC	CGC
	Amino acid	Arg	Cys	<b>Arg</b>	<b>Arg</b>	<b>Arg</b>
109	mRNA	CGG	UGG	CGG	CGG	CGG
	Amino acid	Arg	Trp	<b>Arg</b>	<b>Arg</b>	<b>Arg</b>
160	mRNA	CGG	UGG	CGG	CGG	CGG
	Amino acid	Arg	Trp	<b>Arg</b>	<b>Arg</b>	<b>Arg</b>
233	mRNA	CAA	CAC	CAA	CAA	CAA
	Amino acid	Gln	His	<b>Gln</b>	<b>Gln</b>	<b>Gln</b>

### QUESTIONS

1. Most rock pocket mouse populations have sandy-colored fur, which is consistent with the light color of the desert rocks and sand on which they live. On the other hand, dark-colored rock pocket mouse populations have been found living on black, basaltic rock formations caused by geologic lava flows. What is the best explanation for these facts? Discuss both.

**The dark-colored mouse has a selective advantage if it is living in a dark-colored habitat such as the Pinacate lava flow. Since rock pocket mice reproduce quickly and often, the frequency of this favored trait would quickly accumulate in the population. Any light-colored mice in the dark-colored habitat would have a selective disadvantage, as it would most likely be preyed upon by visual predators. This would decrease the frequency of its genes. Likewise, the light-colored mouse has a selective advantage if it is living in a light-colored habitat, and the dark-colored mice in that same light-colored habitat would have a selective disadvantage, therefore decreasing the frequency of their genes.**

2. The Mc1r gene encodes a protein called the melanocortin 1 receptor (MC1R). This receptor plays a role in the coat color of the rock pocket mouse. When the normal Mc1r gene is present, melanocytes, which are melanin-producing skin cells, decrease the

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production of the dark-colored pigment called eumelanin and increase the production of the light-colored pigment, pheomelanin. The mutated version of the *Mc1r* gene results in an increase in the production of eumelanin by melanocytes, resulting in the dark coat-color phenotype.

a. In the data provided in Step 3 of the procedure, the *MC1R* protein in the dark rock pocket mouse population from the Pinacate lava flow contains how many mutations? **The *MC1R* protein contains four mutations.**

b. Compare the amino acid data of dark-colored mice from the other three populations to that of the wild-type (light-colored) mice in the Pinacate region. What do you notice?

**The three additional dark-colored rock pocket mouse populations from lava flows other than the Pinacate flow do not have the mutated *Mc1r* gene. Instead, they have the normal *MC1R* receptor protein but the dark coat-color phenotype.**

c. Use the information in the excerpt on page 1 to explain the evolutionary significance of *MC1R* protein variations in the different mouse populations.

**This indicates that dark coat color in rock pocket mice from Arizona and New Mexico has evolved independently through changes in different genes. These discoveries reveal that the evolution of melanism (or the development of dark-colored pigment in skin or hair) is not some rare accident but a common, repeatable process. Evolution can and does repeat itself, and it has in the different dark-colored rock pocket mice studied in the southwestern United States.**

3. Charles Darwin proposed the mechanism of evolution called natural selection. Explain the theory of natural selection.

**Natural selection is the process by which individuals in a population who are best adapted to their environment survive and pass on their genes to the next generation more frequently than those individuals who are less well adapted. In this way, favorable traits will increase in frequency in a population, whereas unfavorable traits will decrease.**

4. Natural selection is just one mechanism of evolution. What are the others? Use your textbook or other Internet resources if necessary.

**Gene flow: Gene flow is commonly called migration. It is the movement of alleles into and out of a population's gene pool. This is a common source of genetic variation within a population.**

**Genetic drift: This mechanism causes a change in the gene pool of a small population and occurs strictly by chance. Genetic traits can be lost or become widespread in a population without regard to the survival or reproductive value of the alleles involved.**

**Mutation: Mutation is a random change in the DNA sequence of an organism and the main source of new alleles in a population. In some cases, as in the rock pocket mice, a mutant allele can actually make its bearer better suited for its environment, thus enhancing reproductive success.**

5. If two of the lava flows in New Mexico were near each other and included spans of rocky outcrops between them, what would be a possible mechanism, other than new mutations, to drive the decrease in the light coat-color gene frequency and the increase in the dark coat-color gene frequency in these rock pocket mouse populations? Explain your answer.

**Gene flow (migration) could be the mechanism in the described scenario. If the lava flows were indeed close to one another, rock pocket mice may be able to migrate from one population to another. Also, if spans of rocky outcrops are between the lava flows, then these habitats would provide suitable locations for migrating dark mice to "hide" in during the migration in order to avoid predators. Gene flow may introduce beneficial alleles into different populations experiencing similar selective pressures.**

### AUTHOR

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