INTRODUCTION

Rock pocket mice live in the Sonoran Desert in the southwestern United States and Mexico. Over time, volcanic eruptions affected the environments where the mice live. These eruptions covered parts of the ground in dark volcanic rock.

In this activity, you will explore how this change impacted rock pocket mouse populations. You will make observations, analyze and interpret data, and support claims with evidence. These skills are essential in science and many other fields.

MATERIALS

- the "DNA Evidence Sheet"
- the "Genetic Code Chart"
- access to the short film *The Making of the Fittest: Natural Selection and Adaptation*

PART 1: How Are Rock Pocket Mouse Populations Different?

Figure 1 shows images of rock pocket mice in different environments. You will use these images to make observations, ask questions, and make predictions.

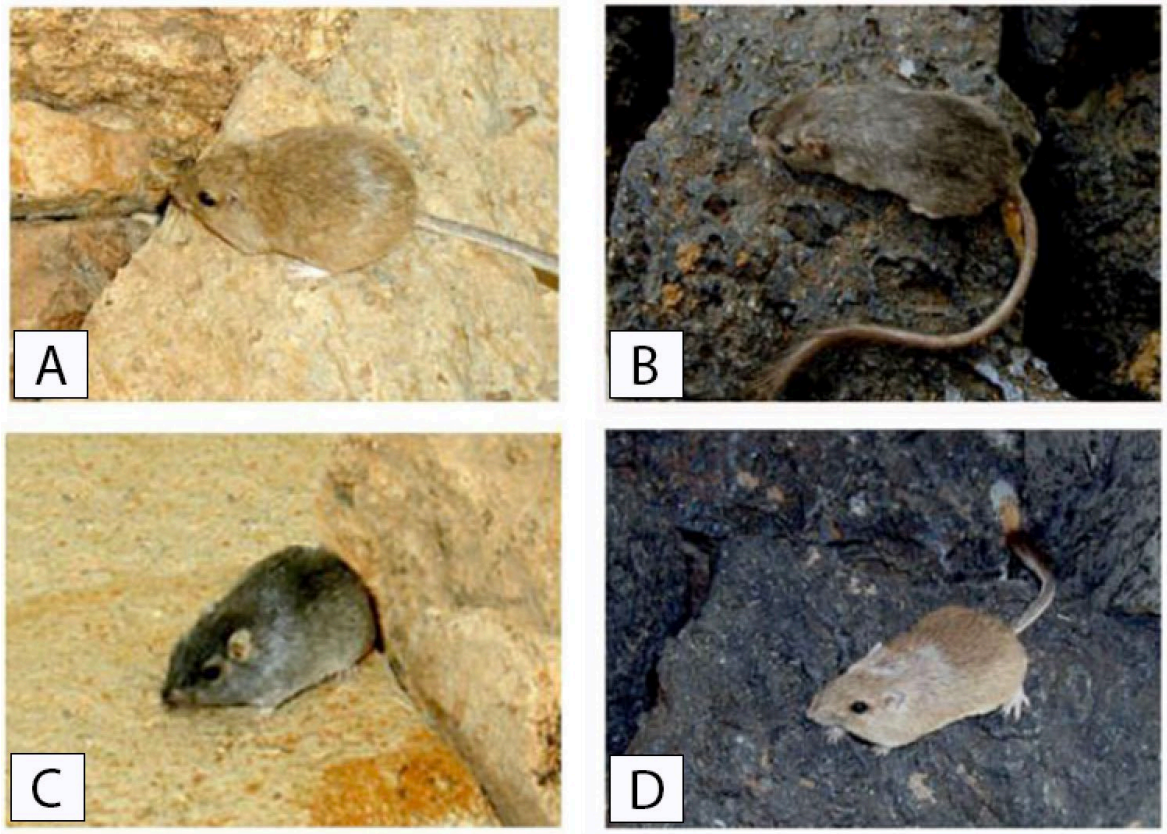

Figure 1. Four different rock pocket mice living in their natural environments.

1. What do you notice about the four images in Figure 1?

2. What questions do you have about your observations of these images?

3. Predict how likely each mouse is to survive in the environment where they live.
   a. Mouse A:

   b. Mouse B:

   c. Mouse C:

   d. Mouse D:

4. What type(s) of data would help you explain why these mice have different fur colors?

PART 2: Are There Genetic Differences Between Mice with Different Fur Colors?

A rock pocket mouse's fur color is affected by a protein called **MC1R**, which stands for melanocortin 1 receptor. The MC1R protein is encoded by a gene called ***Mc1r***. Your instructor will give you a **"DNA Evidence Sheet,"** which shows the *Mc1r* gene nucleotide sequence in mice from two different populations:

- a population of mostly **light**-colored mice living on light-colored desert rock
- a population of mostly **dark**-colored mice living on the Pinacate lava flow (an area covered by dark volcanic rock)

You will analyze these *Mc1r* gene sequences to identify differences between the two mouse populations. You will then determine how these differences affect the MC1R protein.

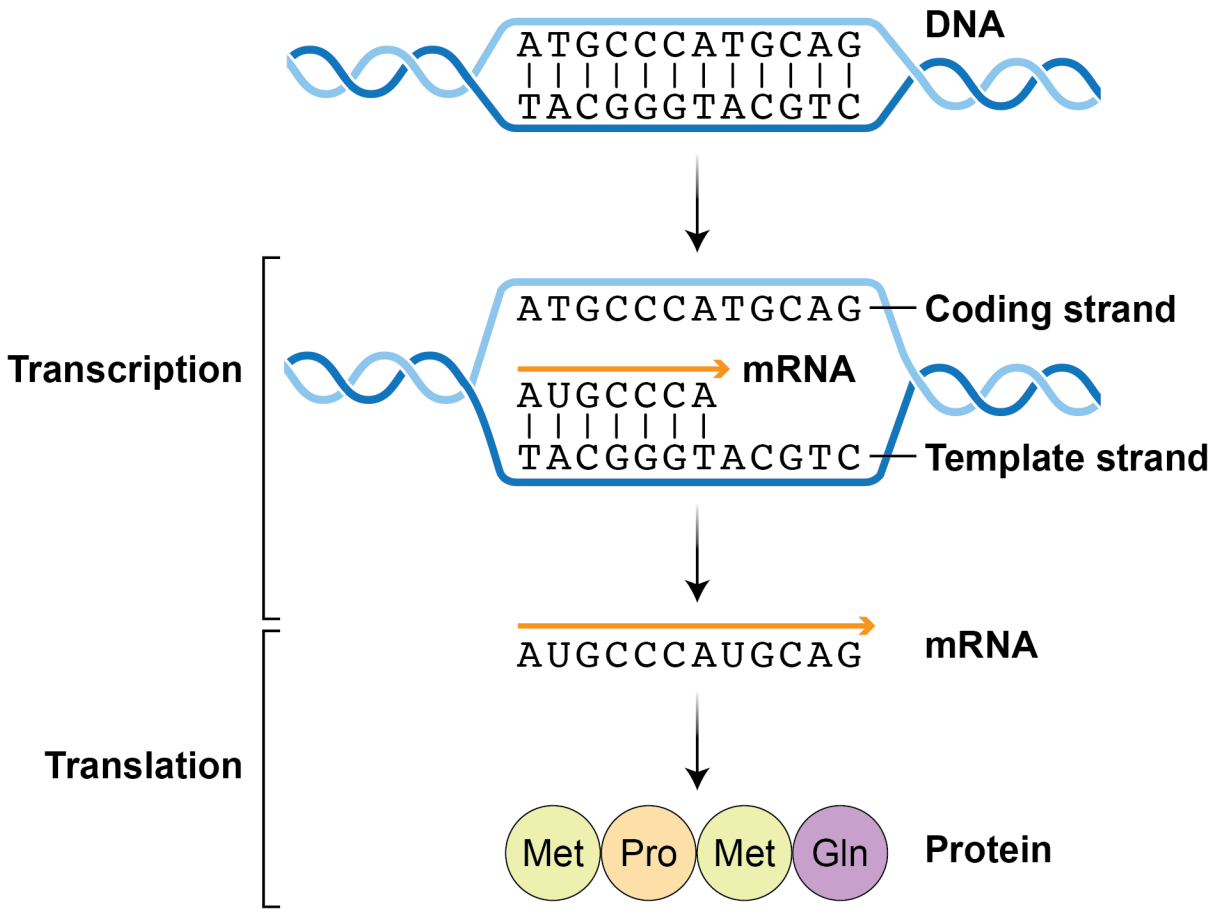

Figure 2. A summary of the processes by which genes (such as *Mc1r*) are used to make proteins (such as MC1R). First, during transcription, cells use the genetic information in DNA to create an RNA message (mRNA). Then, during translation, the mRNA is used to build a protein. The cell "reads" the mRNA sequence in groups of three nucleotides at a time, called codons. Each codon determines which amino acid is added to a growing protein.

The nucleotide sequences on the "DNA Evidence Sheet" are for the DNA **coding strand**, which is shown in the transcription step of Figure 2. Using these coding strand sequences, you will determine:

- the nucleotide sequence of the DNA **template strand**
- the nucleotide sequence of the **mRNA**
- the amino acid sequence of the **protein**

5. Preview Tables 1 and 2 at the end of this document. The first four columns of both tables have been filled out as examples.
   a. What patterns exist in the base pairings between the **coding strand** and the **template strand**? In other words, what "rules" could you use to get the template strand sequence from the coding strand sequence?

   b. What patterns exist in the base pairings between the **template strand** and the **mRNA**? In other words, what "rules" could you use to get the mRNA sequence from the template strand sequence?

6. Complete the rest of Tables 1 and 2, or whichever parts are indicated by your instructor, by following these steps:
   a. Fill in the first row (**"DNA coding strand"**) for both tables. These are the DNA sequences for the first 20 codons of the *Mc1r* gene, shown on the "DNA Evidence Sheet." You may want to cross them off the sheet as you go.
   b. Fill in the second row (**"DNA template strand"**) for both tables.
   c. Fill in the third row (**"mRNA"**) for both tables.
   d. Fill in the fourth row (**"Protein"**) for both tables. You will need to translate each codon into an amino acid. Your instructor will provide you with a **"Genetic Code Chart"** for this step.
   e. **Circle, highlight, or indicate in another way** any differences between the sequences in Tables 1 and 2.
7. Use Tables 1 and 2 to answer the following questions.
   a. Are there differences between the *Mc1r* gene sequences of these mice? If yes, which nucleotides in the DNA coding strands are different?

   b. Do any differences in the DNA sequences result in differences in the amino acid sequences? If yes, which amino acid(s) are different?

   c. How can changes in a DNA sequence lead to changes in an amino acid sequence?

PART 3: Why Do Mice Have Different Fur Colors?

8. Figure 3 shows the first 20 amino acids for the MC1R protein in mice with **dark**-colored fur.

   a. Circle, or indicate in another way, the amino acid that differs between mice with dark-colored fur and mice with light-colored fur. What is this amino acid in mice with **light**-colored fur?

   b. How could this amino acid difference result in mice with different fur colors?

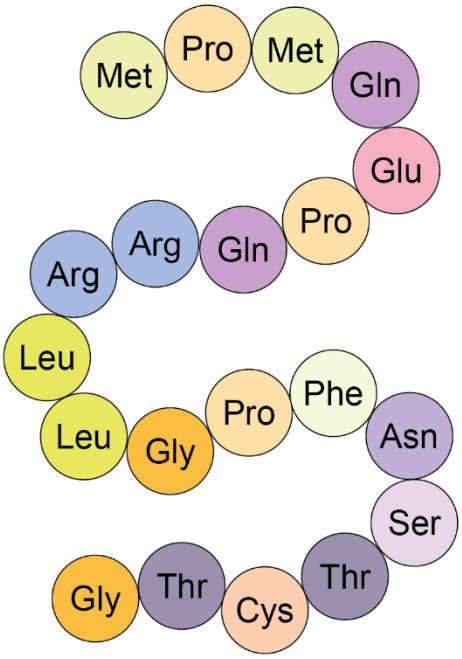

Figure 3. The first 20 amino acids of the MC1R protein in dark-colored mice.

Now watch the first part (**0:00–7:49**) of the short film *The Making of the Fittest: Natural Selection and Adaptation*. This film tells the story of rock pocket mice and will be useful for answering later questions in this activity.

PART 4: Do All Mice with a Certain Fur Color Have the Same Genetic Variations?

As mentioned in the *Natural Selection and Adaptation* film, the *Mc1r* gene (and the MC1R protein it encodes) plays an important role in the fur color of the rock pocket mouse. Different versions of the MC1R protein produce different amounts of a dark-colored pigment (eumelanin) and a light-colored pigment (pheomelanin) in the mouse's fur.

In mouse populations from the Pinacate region, four differences in the *Mc1r* gene account for the difference between light-colored and dark-colored fur. These differences are in Codon 18 (the codon you previously examined), 109, 160, and 233.

Table 3 shows data on these four codons for mice from Pinacate and three other locations (Kenzin, Armendaris, and Carrizozo). Some of the amino acids in this table have been left blank.

Table 3. Selected *Mc1r* mRNA sequences, and their amino acid sequences, for rock pocket mice in different locations.

Mouse fur color		**Light**	**Dark**	**Dark**	**Dark**	**Dark**
Location		**Pinacate** (desert)	**Pinacate** (lava flow)	**Kenzin** (lava flow)	**Armendaris** (lava flow)	**Carrizozo** (lava flow)
Codon 18	mRNA	CGC	UGC	CGC	CGC	CGC
	Amino acids	Arg	Cys			
Codon 109	mRNA	CGG	UGG	CGC	CGG	CGG
	Amino acids					
Codon 160	mRNA	CGG	UGG	CGG	CGG	CGG
	Amino acid					
Codon 233	mRNA	CAA	CAC	CAA	CAA	CAA
	Amino acids					

9. Complete Table 3 by filling in the missing amino acids. You can find the amino acid corresponding to each mRNA codon using the **"Genetic Code Chart"** from Part 2.
10. Answer the following questions using the data in Table 3.
    a. Based on these codons, how many versions of the MC1R protein are represented? At which codon(s) do their amino acids differ?

    b. Compare the amino acids of the mice with dark-colored fur to those of the mice with light-colored fur. What do you notice?

    c. Based on the information throughout this activity, why would variations in a trait like fur color be important to species survival?

Watch the rest (7:50–end) of the short film *The Making of the Fittest: Natural Selection and Adaptation* to find out how the story ends and gain more knowledge about this topic.

PART 5: How Can Changes in DNA Result in Changes in Populations?

11. In this activity, you identified specific changes in the *Mc1r* gene sequence that result in rock pocket mice with different fur colors. How might a particular version of the *Mc1r* gene become more or less common in a population over time?

12. Scientists have made these observations:
    - The mouse populations that live on **light**-colored desert rocks consist mainly of mice with **light**-colored fur (and a few mice with dark-colored fur).
    - The mouse populations that live on **dark**-colored volcanic rocks consist mainly of mice with **dark**-colored fur (and a few mice with light-colored fur).

    How do you explain these observations? Make sure to discuss why the populations have individuals with *both* fur colors in different numbers.

13. Describe another example where changes in DNA may have resulted in changes in appearance among different populations of the same species.

Table 1. *Mc1r* gene sequence in a mouse with light-colored fur.

Codon Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
DNA coding strand	ATG	CCC	ATG	CAG																
DNA template strand	TAC	GGG	TAC	GTC																
mRNA	AUG	CCC	AUG	CAG																
Protein	Met	Pro	Met	Gln																

Table 2. *Mc1r* gene sequence in a mouse with dark-colored fur.

Codon Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
DNA coding strand	ATG	CCC	ATG	CAG																
DNA template strand	TAC	GGG	TAC	GTC																
mRNA	AUG	CCC	AUG	CAG																
Protein	Met	Pro	Met	Gln																