

## Lesson 6: Sibling Differences

### Introduction

You have learned that the DNA sequence in an organism codes for the amino acid sequence that makes a protein. The amino acid sequence determines the shape of the protein and its function. The function of the protein determines the traits of an organism, such as whether a jaguar is black or spotted. In this lesson we will consider how the offspring of two jaguars get the DNA that determines their traits.

### Process and Procedure

#### Lesson Focus Question

1. Write the focus question for this lesson in the box below. Leave space to modify your ideas. Be prepared to share your ideas with the whole class.

## Studying Jaguar Families

- In the early 2000s, scientists were interested in learning more about the fur color of different jaguars. In this lesson, you will analyze jaguar data in the same way scientists did. To begin, you will be assigned a jaguar to study. Follow your teacher's directions to find the number of the animal you will study, then write the number below.
- Use the data table below to determine if the jaguar you are studying is male or female. Circle the row of the jaguar you are studying.

Jaguar Number	Male or Female
1	male
2	male
3	female
4	female
5	male
6	female
7	male
8	male
9	female
10	female

- Choose a partner who is studying a jaguar of the opposite sex. Write down the number of the jaguar your partner is studying.
- Your teacher will provide you with a small part of the DNA sequence for your jaguar's MC1R gene. Use the DNA sequence of the jaguar you are studying to determine its fur color. Once you have determined the fur color of your jaguar, check your work with your partner.

Record the fur color of the jaguars you and your partner are studying:

The fur color of the jaguar I am studying is: \_\_\_\_\_.

The fur color of the jaguar my partner is studying is: \_\_\_\_\_.

6. Use the following table to determine the fur color of the first offspring from the pair of jaguars you and your partner are studying. Then fill in the blanks in the Pair 1 table below. Your teacher will tell you when to repeat steps 4 to 6 with new partners. You will fill in the blanks in the Pair 2 and Pair 3 tables then.

		Females				
Males	Jaguar #	3	4	6	9	10
	1	black	black	black	black	black
	2	spotted	black	black	spotted	black
	5	spotted	black	black	black	spotted
	7	spotted	black	black	spotted	black
	8	black	black	black	spotted	black

Pair 1:

	Jaguar #	Fur Color	Fur color of first offspring
My jaguar			
My partner's jaguar			

Pair 2:

	Jaguar #	Fur Color	Fur color of first offspring
My jaguar			
My partner's jaguar			

Pair 3:

	Jaguar #	Fur Color	Fur color of first offspring
My jaguar			
My partner's jaguar			

7. Observe the data chart of jaguar parents and first offspring. Write any patterns you observe below.

8. Read the following information to learn more about how a jaguar's fur color relates to its DNA.

### DNA and Traits

Each jaguar offspring received one copy of the MC1R gene from its mother and one copy from its father. Each copy of the gene is called an **allele**. If a jaguar with spotted fur and a jaguar with black fur have an offspring that has black fur, the offspring has one allele for spotted fur and one allele for black fur.

No matter what color fur a jaguar has, it will always have two alleles for fur color. The two alleles may be the same or different from one another depending on the alleles of the parents.

Draw a diagram to represent the information you just read.

9. Look back at the class data chart for the fur color of jaguar offspring. Fill in the total number of each offspring's fur color in the table below.

	Fur Color of Parent		
	Black and Black	Black and Spotted	Spotted and Spotted
Fur Color of Offspring	# spotted: _____	# spotted: _____	# spotted: _____
	# black: _____	# black: _____	# black: _____

On the previous page, you read that each offspring must have two alleles. Consider the fur color of the offspring and the fur color of the parents. Underneath the total number of the offspring, write the alleles (black or spotted) that you think the offspring have. If there were no offspring of a particular fur color, do not write any alleles.

10. To learn more about how alleles determine an organism's traits, read the essay, *Phenotype and Genotype*.

### Phenotype and Genotype

Often, there is more than one combination of alleles that can produce a trait. With dogs, there are two different combinations of alleles that cause their fur to be black. Only one combination causes tan fur. It is valuable to be able to distinguish whether we are talking about the *combination of alleles* for a trait or the *physical appearance* of the trait.

Blood type, fur color, and petal shape—these are some physical traits that we observe when an organism's genetic (or DNA) information is expressed. The traits of an organism are its **phenotype**. There are both observable and hard-to-observe traits. The term phenotype can refer to either a specific trait or to the collection of traits that characterizes an entire organism. For instance, we can say that a collie has a long-hair phenotype rather than a short-hair phenotype. We also can say that a collie has a very different overall phenotype from a Great Dane. A collie is smaller, has longer hair, and has shorter legs than a Great Dane. The genetic plan passed from parents to offspring provides the blueprint for the offspring's phenotype. Because of this, offspring usually have a phenotype similar to their parents' phenotypes.

But how does the genetic information determine an organism's physical traits? To understand this, let's look at a simple example. In snapdragon plants, one gene determines the color of the flower. In some snapdragons, one of their two alleles codes for red flowers. That gene is transcribed into mRNA. The mRNA is then translated into a protein for red pigment. The red pigment protein may cause the flowers to appear red. When the allele for red flowers is not present, no red pigment protein is made, and the flower is white. Although many phenotypes depend on more than one gene, all are based on whether or not particular proteins are made.

All of the genetic information in an organism is called its **genotype**. The genotype is the combination of alleles an organism has. For any gene, an organism has two alleles. One allele was inherited from the father. The other allele came from the mother. Scientists often use a shorthand way of writing alleles by using a letter for each allele. In the case of dog fur, the letter *f* might be used for each allele because the trait is fur color. An uppercase *F* would represent the allele for black fur, and a lowercase *f* would represent the allele for tan fur. The specific letter that is used does not matter, but it is usually wise to choose letters in which the uppercase letter looks different from the lowercase letter.

Let's think about a female dog who has black fur. Her genotype might be *Ff*. She may have inherited the *F* allele from her mother and the *f* allele from her father. Or the *F* allele may be from her father and the *f* allele from her mother. Either way, this combination results in a genotype that is **heterozygous** ("hetero-" = "different") for the fur color alleles. Alternatively, a dog who inherits two identical alleles (*FF* or *ff*) has a genotype that is **homozygous** ("homo-" = "the same") for fur color. Here, a dog with the *FF* genotype would have the black fur phenotype. A dog with the *ff* genotype would have the tan fur phenotype. From this we can see that two different genotypes—*FF* and *Ff*—both lead to one phenotype of black fur. How can this be?

Inheritance is complex, and we know that there can be genetic factors and environmental factors that affect traits. However, to simplify the example, imagine that fur color is controlled by only one gene. One allele is involved in having black fur. A second allele is involved in having tan fur. These alleles interact to determine which fur color a dog has. A dog who inherits even one allele for black fur (from either parent) will show that phenotype, regardless of the other allele he or she inherits for that gene. Black fur is a dominant trait. A **dominant trait** presents itself whether the individual is homozygous or heterozygous for that gene. The genotype of a dog with two alleles for black fur ( $FF$ ) is “homozygous dominant.” A dog with two different alleles ( $Ff$ ) has a heterozygous genotype. Both alleles are present and are part of determining the phenotype. Because the dominant  $F$  allele is present, the dog would have black fur. Dominant alleles, shown by uppercase letters, are usually written first in a genotype.

A **recessive trait** is observable only in individuals who are homozygous for the gene associated with the trait. This trait is only seen when a dominant allele is *not* present. Dogs who have tan fur did not inherit an allele for black fur from either parent. Instead, they inherited two alleles carrying information for tan fur. These dogs have a genotype ( $ff$ ) that is called “homozygous recessive.”

After reading *Phenotype and Genotype*, look back at the alleles you predicted for each jaguar offspring’s fur color in Step 9. Revise your answers if needed in another color.

## Synthesize and Summarize Key Science Ideas

11. Based on the reading, write a paragraph that explains how two black jaguars could have an offspring with spotted fur. Include the following ideas in your paragraph:

- allele
- phenotype
- genotype
- dominant
- recessive
- heterozygous
- homozygous