# A Study of Traits
# Lesson 6: Sibling Differences

**Grade:** 9-10 General Biology

**Length of lesson:** 140 minutes

**Placement of lesson:** Lesson 6 of 9

**Unit Overarching Goal**

In plants and animals, similarities and differences among individuals within a species result from proteins coded for by the DNA inherited from their parents. Variations among individuals are the result of mutation, meiosis, and recombination through sexual reproduction.

**Unit Central Question**

What is the best explanation for the similarities and differences we see in individuals within a species—not only for one species, but for every species of plant and animal?

**Lesson 6 Main Learning Goal**

The combination of genes that an individual organism has comes from its parents. These genes determine the version of a trait an organism displays.

**Lesson 6 Focus Question**

Why do two parents sometimes have children that have the same version of a trait as they do and sometimes have children with a different version of that trait?

**Ideal student response**

The version of a trait an individual displays is determined by the combination of alleles it receives from its parents. A baby receives one allele from each parent. If the baby receives the same alleles for a trait, the baby is homozygous for that trait. If the baby receives different alleles for a trait, the baby is heterozygous for that trait. Some alleles seem to have a stronger influence (are dominant) over a trait. In jaguars, the allele for black fur is dominant over the allele for orange fur.

**Science Content Storyline**

The fur color of a jaguar is determined by the combination of alleles (different forms of a gene) it receives from its parents. An offspring can be heterozygous or homozygous for a trait. Some alleles seem to be more influential for a trait because they are dominant.

**Materials**

- Red, yellow, and green craft sticks, 1 set per student
- Jaguar MC1R DNA strips, 1 strip per student, plus one extra male and female strip
- Chart paper
- Markers

**Advance Preparation**

- Print and cut the Jaguar MC1R DNA strips.
- Make a chart for the collection of class data from jaguar matings
- As you read through the Teacher Edition, determine if you will have students write and revise the paragraph for the Synthesize and Summarize or if you will assign the paragraph as homework.

**Lesson 6 General Outline**

| Time (min) | Phase of lesson | How the science content storyline develops |
|---|---|---|
| 10 | **Link to Previous Lesson and Lesson Focus Question**<br>The teacher reviews how the DNA sequence in an organism codes for the amino acid sequence that makes a protein. In this lesson, students will consider how offspring get the DNA that codes for their traits.<br>**Lesson Focus Question**: **Why do two parents sometimes have children that have the same version of a trait as they do and sometimes have children with a different version of a trait?**<br>The teacher introduces the lesson focus question. | |
| 90 | **Amino Acids: Studying Jaguar Families**<br><u>Activity Setup</u><br>Students learn that they will learn about jaguars in the same way scientists did. They are assigned a particular jaguar that they will study.<br><u>Activity</u><br>Students work with a partner to learn about the colors of offspring that different pairs of jaguars might have. They compare the DNA sequences of their assigned jaguar to learn its fur color. They then discover the color of the offspring that results when their jaguar mates with another. The class creates a chart to examine patterns in parents and offspring. They complete a brief reading to learn about alleles.<br><u>Activity Follow-up</u><br>Students read about phenotypes and genotypes to apply these ideas to other ideas they have learned in the lesson. | The fur color of a jaguar is determined by the combination of alleles (different forms of a gene) it receives from its parents. An offspring can be heterozygous or homozygous for a trait. Some alleles seem to be more influential for a trait because they are dominant. |
| 30 | **Synthesize and Summarize**<br>Students write a paragraph to summarize what they have learned and show the relationships between key terms that are important for understanding the science ideas. | |
| 10 | **Summarize and Link to Next Lesson**<br>The teacher and students summarize the lesson and link to the next lesson. | |

# Lesson 6: Sibling Differences

**Phase of Lesson:** *Link to Previous Lesson and Lesson Focus Question: Why do two parents sometimes have children that have the same version of a trait as they do and sometimes have children with a different version of a trait?*

**Main Learning Goal:** The combination of genes that an organism has comes from its parents. These genes determine the version of the trait an organism displays.

## Focus Question:

Why do two parents sometimes have children that have the same version of a trait as they do and sometimes have children with a different version of the trait?

## Unit Overarching Goal:

In plants and animals, similarities and differences among individuals within a species result from proteins coded for by the DNA inherited from their parents. Variations among individuals are the result of mutation, meiosis, and recombination through sexual reproduction.

## Notes:

## Time: 10 Minutes

## STeLLA Strategies

- Strategy 1: Ask questions to elicit student ideas and predictions
- Strategy 2: Ask questions to probe student ideas and predictions

## Science Ideas

- Individual organisms have characteristics that differ from other individuals of the same species.
- The characteristics (different versions of a trait) of an individual organism are the result of the proteins in that organism.
- Protein structure and function are determined by the sequence of amino acids. The sequence of amino acids is determined by the DNA sequence of a gene.

## Common Student Ideas

- Genes are traits
- Each parent contributes genetic information for certain traits and not others (i.e. he has his mother's eyes and father's nose).
- Different cell types (skin, muscle, bone) found in an individual's body contain different DNA.
- Some characteristics of offspring are determined by the parents' environmentally acquired characteristics.
- DNA is made of proteins and/or amino acids.
- Organisms eat protein; they do not make proteins.

# 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 organisms, 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.

| |
|---|
| Why do two parents sometimes have children that have the same version of a trait as they do and sometimes have children with a different version of the trait? |

**Focus on Student Thinking**

- Use appropriate elicit (STeLLA Strategy 1) and probe questions (STeLLA Strategy 2) to make student thinking about the focus question visible.
    - Possible questions include:
        - What are your ideas about why children do not always have the same version of a trait as their parents? **(Elicit)**
        - Tell us more about that idea. **(Probe)**
        - What do you mean when you say one version of a trait is stronger than the other? **(Probe)**
        - Can you say more about your thinking that children are a mixture of their parents? **(Probe)**

| Implementation | Notes |
| --- | --- |
| *Link to Previous Unit*<br>● Remind students that they have seen how the DNA sequence in an organism codes for the amino acid sequence that makes a protein. The protein determines the physical characteristics of an organism, such as whether a jaguar is black or spotted.<br>● Ask students to consider how the offspring of two jaguars get the DNA that determines their traits.<br>*Lesson Focus Question*<br>● **STEP 1:** Ask a student to read the focus question aloud. Then ask another student to paraphrase what the focus question is asking.<br>● Allow time for students to write the focus question in the box in their workbooks. Reassure them that they are just beginning the lesson, so they may not know the answer, but they should think about their best ideas about the question. Share that they will have a chance to revise their ideas as they work through the lesson.<br>● Ask several students to share their initial thinking with the whole class.<br>Use the information in "Focus on Student Thinking" in the SE key to see examples of ways to elicit and probe student ideas. | |

# Lesson 6: Sibling Differences

**Phase of Lesson:** *Studying Jaguar Families*

**Main Learning Goal:** The combination of genes that an organism has comes from its parents. These genes determine the version of the trait an organism displays.

## Focus Question:

Why do two parents sometimes have children that have the same version of a trait as they do and sometimes have children with a different version of the trait?

## Unit Overarching Goal:

In plants and animals, similarities and differences among individuals within a species result from proteins coded for by the DNA inherited from their parents. Variations among individuals are the result of mutation, meiosis, and recombination through sexual reproduction.

## Notes:

## Time: 90 Minutes

## STeLLA Strategies

- Strategy 1: Ask questions to elicit student ideas and predictions
- Strategy 2: Ask questions to probe student ideas and predictions
- Strategy 3: Ask questions to challenge student thinking
- Strategy 4: Engage students in communicating in scientific ways
- Strategy 5: Engage students in analyzing and interpreting data and observations

## Science Ideas

- Individual organisms have characteristics that differ from other individuals of the same species.
- The characteristics (different versions of a trait) of an individual organism are the result of the proteins in that organism.
- Protein structure and function are determined by the sequence of amino acids. The sequence of amino acids is determined by the DNA sequence of a gene.
- Different forms of a gene are called alleles. An individual's traits are determined by the combination of alleles it receives from its parents.
- An organism's combination of alleles is its genotype, while the trait the individual displays is its phenotype.

## Common Student Ideas

- Genes are traits
- Each parent contributes genetic information for certain traits and not others (i.e. he has his mother's eyes and father's nose).
- Different cell types (skin, muscle, bone) found in an individual's body contain different DNA.
- Some characteristics of offspring are determined by the parents' environmentally acquired characteristics.
- DNA is made of proteins and/or amino acids.
- Organisms eat protein; they do not make proteins.

## Studying Jaguar Families

2. 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 to a jaguar to study. Follow your teacher's directions to find the number of the animal you will study, then write the number below.

   An example is given for steps 2 to 6.

   Jaguar number 5

3. 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 |

4. Choose a partner who is studying a jaguar of the opposite sex. Write down the number of the jaguar your partner is studying.

   Jaguar number 4

5. 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: __black_____.

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

| Implementation | Notes |
|---|---|
| *Activity Setup: Studying Jaguar Families*<br>• Share with students that in this lesson they will learn more about jaguars in the same way that scientists did. Scientists studied jaguars and their offspring to learn more about how coat color is inherited.<br>• **STEP 2:** Assign each student a number, 1-10. Assign numbers in any way you choose, such as numbering off, choosing from a hat, or picking numbers. Have students record their assigned number in their workbook.<br>• **STEP 3:** Have students use the data chart to determine if the jaguar they are studying is male or female by circling the appropriate row on the chart.<br>  ○ Although this data table is simple, it will provide a sense of how comfortable students are with data tables as they will use a more complicated data table later in the activity.<br>*Activity: Studying Jaguar Families*<br>• **STEP 4:** Have students pair up so each team is studying both a male and female jaguar.<br>  ○ If you have an odd number of students in the class, you should be prepared to act as a partner and share information about a jaguar of the opposite sex.<br>  ○ It is possible to have a group of three students. The two individuals of the same sex will both have to determine information about the offspring produced from mating with the individual of the opposite sex. This may be an uncomfortable idea for students, so we recommend you act as a partner for a brief period.<br>• **STEP 5:** Distribute the appropriate jaguar DNA strip to each student. It is important that the strips be distributed so there is as even a distribution of jaguar numbers as possible. Keep one male and one female sequence. If there is an odd number of students, the person without a partner will pair with you using the appropriate gender sequence.<br>  ○ Content Note: Each student will have one DNA sequence that represents the fur color of their jaguar. In the real world, each jaguar would have two DNA sequences, one from each parent. Because the concept of two alleles will be introduced following this activity, only one sequence is provided to students in this lesson.<br>• Ask students how they could determine the fur color of their jaguar. Have students turn and talk with an elbow partner, then have pairs share at their table. Invite several groups to share their ideas with the whole class. Possible responses include:<br>  ○ Compare the sets of three nucleotides with the number of sets of amino acids from the jaguar MC1R protein in Lesson 3.<br>  ○ Compare the DNA sequences with those in Lesson 5.<br>  ○ Transcribe and translate the DNA code on their strip and compare the resulting amino acid sequence to those in Lesson 3. | |

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** | 5 | Black | Black |
| **My partner's jaguar** | 4 | Black | |

Pair 2:

| | **Jaguar #** | **Fur Color** | **Fur color of first offspring** |
|---|---|---|---|
| **My jaguar** | 5 | Black | Spotted |
| **My partner's jaguar** | 10 | Black | |

Pair 3:

| | **Jaguar #** | **Fur Color** | **Fur color of first offspring** |
|---|---|---|---|
| **My jaguar** | 5 | Black | Spotted |
| **My partner's jaguar** | 3 | Spotted | |

## Implementation

## Notes

- Have students work individually to determine their jaguar's fur color. Once they have determined their jaguar's fur color, they should check their answer with their partner.
    - Circulate through the room as pairs are working, asking probe and challenge questions. This is an opportunity to formatively assess student understanding of science ideas from earlier lessons in the unit.
    - Do a quick share around the room to check that each jaguar's color is identified correctly.
- Have students record the fur color of both their jaguar and that of their partner. The key is as follows:

| | | |
|---|---|---|
| 1 | M | black |
| 2 | M | spotted |
| 3 | F | spotted |
| 4 | F | black |
| 5 | M | black |
| 6 | F | black |
| 7 | M | spotted |
| 8 | M | black |
| 9 | F | spotted |
| 10 | F | black |

- **STEP 6:** Determine if your students need help reading the data table in this step. If needed, model the process of determining the fur color of the offspring of a pair of jaguars. Use STeLLA Strategy 5: Engage students in analyzing and interpreting data to make sure students are interpreting the data table correctly.
- Share that students will work with their partner who is studying a jaguar of the opposite sex and determine what color their first offspring will be. Highlight that students should use sentence stems from STeLLA Strategy 4: Engage students in communicating in scientific ways as they discuss their ideas with their partner. Students will record the color of their first offspring in their workbook, in the table labeled Pair 1.
- Have students stand in an open area of the room with their partner, pen and workbook. With their partner, they should use the table to determine the fur color of their first offspring and record it in their workbook.
- Create a class data chart as shown below. Students should add a tally mark representing the fur color of the offspring in the appropriate column. Ask one pair to share the color of the parents' fur and that of their offspring to model the process.

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

**Focus on Student Thinking**

- Use probe (STeLLA Strategy 2) and challenge (STeLLA Strategy 3) questions to make student thinking about the data chart visible.
    - Possible questions include:
        - Say more about your idea that we should have done more pairs. **(Probe)**
        - What do you mean when you say black is dominant? **(Probe)**
        - How could two black jaguars have a spotted offspring? **(Challenge)**
        - What are your ideas for why there are so many more offspring with black fur than spotted fur? **(Challenge)**

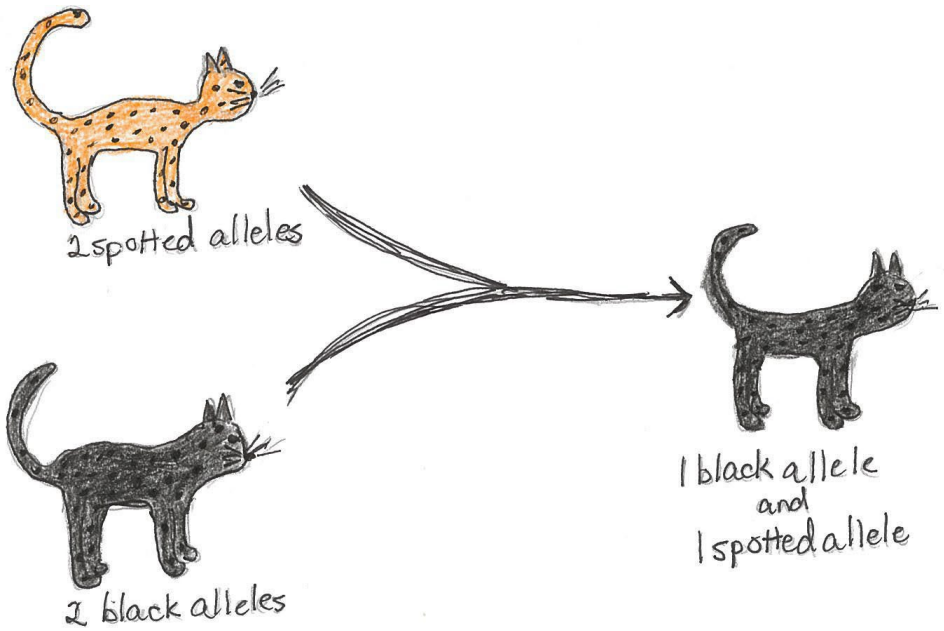
8. Read the following information to learn more about how a jaguar's fur color relates to its DNA.

**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.



| Implementation | Notes |
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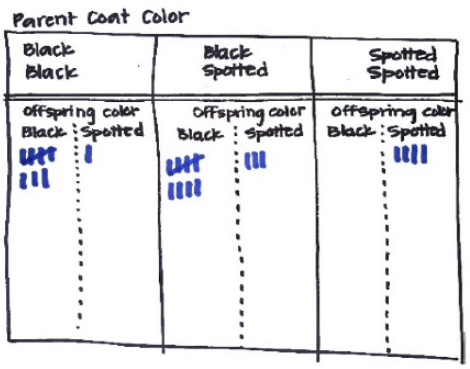


- The example chart above shows the offspring pattern for every mating combination. Repeat rounds of pairing and recording until the class chart shows roughly the same pattern as above. It is important that at least one offspring of two black parents is spotted, and the majority of offspring between black and spotted parents are black. All the offspring of two spotted jaguars should be spotted.
- **STEP 7:** Have students gather around the data chart and silently think about how this pattern may have been produced and what questions have arisen for them about the relationship between coat color and DNA. Have students record any patterns in their workbook. Ask several students to share their ideas and questions. Use probe and challenge questions to make students' thinking visible. The patterns students should notice are:
    - Parents who both have spotted fur always have spotted offspring.
    - Parents who both have black fur usually have black offspring but occasionally have a spotted offspring.
    - One spotted parent and one black parent have come offspring with black fur and some with spotted fur.

Use the information in "Focus on Student Thinking" in the SE key to see examples of probe and challenge questions.

- **STEP 8:** Have students read the passage DNA and Traits. While they are reading, distribute a set of green, red, and yellow craft sticks to each student.
- Ask students to draw a diagram to represent what they have read. Creating a different representation will help students make sense of the information. As students work, circulate through the room asking probe questions to clarify any aspects of their drawings that are not clear.
- Ask students to share their drawings with their teammates. They should discuss similarities and differences among the drawings. Based on their discussion, students may revise their drawings.
- If a document camera is available, have several students share their drawings with the whole class. Alternatively, have several students report their ideas about how the pattern shown on the data chart could have resulted. Ask probe and challenge questions to help the class come to

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.

Responses are based on the data chart in step 6 of the TE. Some of the alleles listed are incorrect, but they represent what students might write based on what they know at this point.

| | **Fur Color of Parent** | | |
|---|---|---|---|
| | **Black and Black** | **Black and Spotted** | **Spotted and Spotted** |
| **Fur Color of Offspring** | # spotted: 1<br>Spotted allele??<br>Black allele | # spotted: 3<br>Spotted allele<br>Black allele | # spotted: 4<br>Spotted allele<br>Spotted allele |
| | # black: 8<br>Black allele<br>Black allele | # black: 9<br>Black allele<br>Spotted allele | # black: 0 |

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.

**Focus on Student Thinking**

- Use elicit (STeLLA Strategy 1), probe (STeLLA Strategy 2), and challenge (STeLLA Strategy 3) questions to reveal student thinking about the alleles carried by black and spotted jaguars.
  - Possible questions include:
    - What two alleles do you think the spotted jaguars have? **(Elicit)**
    - Can you clarify your reasoning? **(Probe)**
    - How can the black jaguar offspring have either two black alleles or one black and one spotted allele? **(Challenge)**
  - A dialogue that engages students in analyzing and interpreting data (STeLLA Strategy 5) about the inheritance of fur color in jaguars might sound like the following:
    - T: What two alleles do you think the spotted jaguars have? **(Elicit)**
    - S1: I think they have two spotted alleles.
    - T: Say more about why you think this. **(Probe)**
    - S1: Well, both of their parents are spotted, so they would get one spotted allele from each parent.
    - T: How do you explain the spotted offspring that had two parents with black fur? **(Challenge)**
    - S2: Maybe the black parents each had a spotted allele hiding in it.
    - T: What do you mean by a spotted allele that is hiding? **(Probe)**
    - S2: Well, I think the black allele is stronger than the spotted allele and it takes over to give the parents black fur.
    - T: Do you see any other evidence in the chart that supports that idea? **(Challenge)**

| Implementation | Notes |
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| consensus on their understanding. As students discuss their ideas, ask the group to hold up craft sticks to show their agreement with the explanation:<br>o Green = agree<br>o Red = disagree<br>o Yellow = not sure<br>• **STEP 9:** Have students look back at the class data chart and record the total number of spotted and black offspring for each mating type.<br>• Remind students that they read that each offspring must have two alleles. In teams, have students write the alleles (spotted or black) that they think each offspring has.<br>o You may choose to do one example as a think-aloud to model the type of thinking needed. Begin with the offspring of two spotted parents. You might say, "I know that both parents are spotted, so they must each have at least one spotted allele. The offspring are all spotted, so maybe they received a spotted allele from each parent. That means, the spotted offspring of two spotted parents will have two spotted alleles for fur color." Allow students to discuss their ideas with their teams.<br>• After student teams have had time to discuss the possible alleles of the offspring, hold a class discussion asking students to share their ideas. Ask probe questions to clarify and make student thinking visible.<br>o Students may have difficulty explaining how two black jaguars can have a spotted offspring. Students may realize that the black allele seems more influential in determining fur color because there were more black offspring from one black and one spotted parent. If students do not mention this idea at this point in the lesson, do not lead students to the idea as the next reading will introduce it. However, it is important that students justify their thinking with evidence from patterns in the class data.<br>o Share with students that the next reading will give them additional information for their ideas.<br><br>Refer to "Focus on Student Thinking" in the SE key for possible questions to elicit, probe, and challenge student ideas and for an example of a dialogue using STeLLA Strategy 5: Engage students in analyzing and interpreting data. | |

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?

| Implementation | Notes |
| --- | --- |
| *Activity Follow-up: Studying Jaguar Families*<br>• **STEP 10:** Have students read the essay, Phenotype and Genotype. Because this is a longer reading, select an appropriate reading strategy for your students. For example, in pairs, have one student read a paragraph aloud and the other student summarize the paragraph.<br>• After reading the essay, have students revisit their ideas about the jaguar offspring alleles and revise them as needed. Then lead a class discussion about the alleles that lead to the phenotypes observed. As the discussion progresses, write the alleles on the board. We recommend using "F" for the black fur allele and "f" for the spotted fur allele. Ideas that should emerge from the discussion include:<br>  ○ The offspring of two spotted jaguars are always spotted. This means the parents and offspring are homozygous for the spotted allele (ff).<br>  ○ The offspring of two black parents were mostly black with a some spotted offspring. Because these parents had spotted offspring, they must have both been heterozygous (Ff) for fur color. You may wish to have students consider the combinations that could come from the Ff x Ff cross. Because more offspring would have black fur, the results help show that the black fur trait is dominant. Avoid using a Punnett square at this point, but rather allow students to reason through the combinations.<br>  ○ The offspring of a black jaguar and a spotted jaguar is the most complex to consider. Here, students must remember that there are several sets of parents that could contribute to the results. Some of the black jaguar parents must have the FF genotype while others have the Ff genotype. Because of this, there were more black jaguar offspring. This is important as students considered whether one allele seemed more influential than the other. At this point, challenge students to think about the offspring that would result from both an FF x ff cross and an Ff x ff cross to ensure they can predict the phenotype of offspring correctly. | |

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.

**Focus on Student Thinking**

- Use elicit (STeLLA Strategy 1) and probe (STeLLA Strategy 2) questions to make student thinking about the data chart visible.
    - Possible questions include:
        - What can you say about the genotype of two black jaguars that have a spotted offspring? **(Elicit)**
        - Tell us more about how your determined that the black allele is dominant. **(Probe)**
        - [in a discussion of black jaguars and spotted jaguars that have spotted offspring] Can you clarify why you say the black jaguars in this case must be heterozygous? **(Probe)**
        - What do you mean when you say it's impossible to tell the genotypes of the black jaguars? **(Probe)**

| Implementation | Notes |
| --- | --- |
| Refer to “Focus on Student Thinking” in the SE key for possible questions to elicit and probe student ideas. | |

**Phase of Lesson:** *Synthesize and Summarize*

**Main Learning Goal:** The combination of genes that an organism has comes from its parents. These genes determine the version of the trait an organism displays.

## Focus Question:

Why do two parents sometimes have children that have the same version of a trait as they do and sometimes have children with a different version of the trait?

## Unit Overarching Goal:

In plants and animals, similarities and differences among individuals within a species result from proteins coded for by the DNA inherited from their parents. Variations among individuals are the result of mutation, meiosis, and recombination through sexual reproduction.

## Notes:

## Time: 30 Minutes

## STeLLA Strategies

- Strategy 9: Engage students in making connections by synthesizing and summarizing key science ideas

## Science Ideas

- Individual organisms have characteristics that differ from other individuals of the same species.
- The characteristics (different versions of a trait) of an individual organism are the result of the proteins in that organism.
- Protein structure and function are determined by the sequence of amino acids. The sequence of amino acids is determined by the DNA sequence of a gene.
- Different forms of a gene are called alleles. An individual's traits are determined by the combination of alleles it receives from its parents.
- An organism's combination of alleles is its genotype, while the trait the individual displays is its phenotype.

## Common Student Ideas

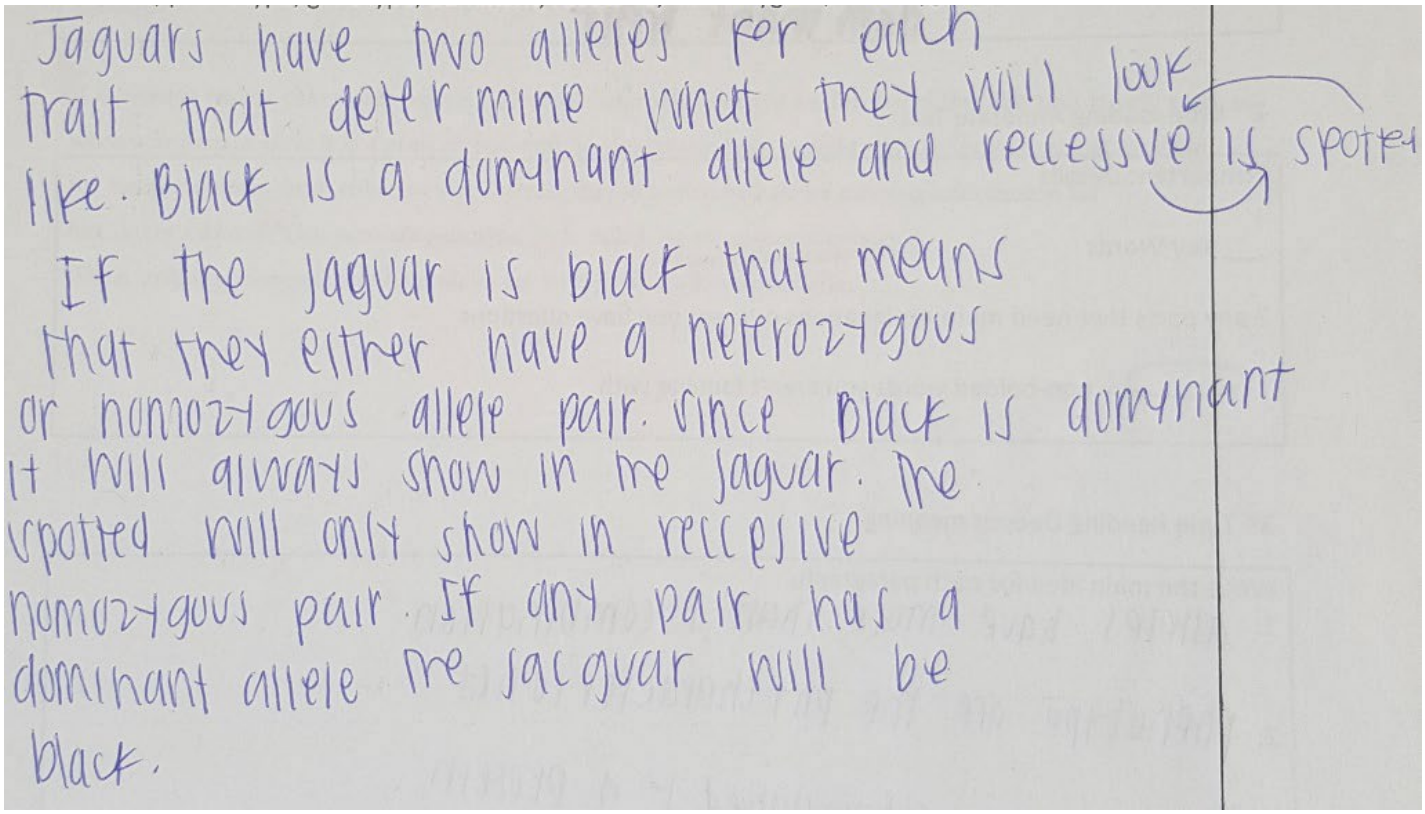
- Genes are traits
- Each parent contributes genetic information for certain traits and not others (i.e. he has his mother's eyes and father's nose).
- Different cell types (skin, muscle, bone) found in an individual's body contain different DNA.
- Some characteristics of offspring are determined by the parents' environmentally acquired characteristics.
- DNA is made of proteins and/or amino acids.
- Organisms eat protein; they do not make proteins.

## 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

Sample student response:



| Implementation | Notes |
| --- | --- |
| • **STEP 11:** The purpose of this step is to provide an opportunity for students to synthesize and summarize the information they have learned about jaguar fur color and inheritance. Note that the prompt is the lesson focus question.<br>• Review the directions for writing the paragraph with students. Allow plenty of time for students to write a thoughtful paragraph. Alternatively, you may assign this step as homework.<br>  ○ Use the Think, Share, Advise, Revise (TSAR) sense-making tool for students to get feedback and revise their paragraph. | |

# Lesson 6: Sibling Differences

**Phase of Lesson:** *Summarize and Link*

**Main Learning Goal:** The combination of genes that an organism has comes from its parents. These genes determine the version of the trait an organism displays.

## Focus Question:

Why do two parents sometimes have children that have the same version of a trait as they do and sometimes have children with a different version of the trait?

## Unit Overarching Goal:

In plants and animals, similarities and differences among individuals within a species result from proteins coded for by the DNA inherited from their parents. Variations among individuals are the result of mutation, meiosis, and recombination through sexual reproduction.

## Notes:

**Time: 10 Minutes**

## STeLLA Strategies

- Strategy 9: Engage students in making connections by synthesizing and summarizing key science ideas

## Science Ideas

- Individual organisms have characteristics that differ from other individuals of the same species.
- The characteristics (different versions of a trait) of an individual organism are the result of the proteins in that organism.
- Protein structure and function are determined by the sequence of amino acids. The sequence of amino acids is determined by the DNA sequence of a gene.
- Different forms of a gene are called alleles. An individual's traits are determined by the combination of alleles it receives from its parents.
- An organism's combination of alleles is its genotype, while the trait the individual displays is its phenotype.

## Common Student Ideas

- Genes are traits
- Each parent contributes genetic information for certain traits and not others (i.e. he has his mother's eyes and father's nose).
- Different cell types (skin, muscle, bone) found in an individual's body contain different DNA.
- Some characteristics of offspring are determined by the parents' environmentally acquired characteristics.
- DNA is made of proteins and/or amino acids.
- Organisms eat protein; they do not make proteins.

| Implementation | Notes |
| --- | --- |
| *Summarize*<br>• Have several students summarize what they have learned in this lesson in one or two sentences. The summaries should include the ideas that offspring get a combination of alleles for a trait from their parents and these alleles may be dominant or recessive for a trait.<br>• Invite students to respond individually to the prompt, "How did the model we used to study the fur color of jaguar offspring help you understand how an organism's traits are inherited?" Ask several students share their ideas.<br><br>*Link to Next Lesson*<br>• Share that in the next lesson we will think about several traits of jaguar offspring and how multiple traits are inherited. | |