A Study of Traits
Lesson 9: Tools to Predict Traits

Grade: 9-10 General Biology

Length of lesson: 115 minutes

Placement of lesson: Lesson 9 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 9 Main Learning Goal

Using information about parental alleles, inheritance, and proteins in cells it is possible to make predictions about the traits of family members.

Lesson 9 Focus Question

Is it possible for a family who all show the same version of a trait to have an individual with a different version of the trait? If so, how did that happen? If not, why not?

Ideal student response

The traits of an individual are determined by the combination of alleles it receives from its parents. One allele from each parent is passed to the offspring through the process of meiosis and sexual reproduction. Because alleles on chromosomes are separated randomly in meiosis, it is possible for siblings of the same parents to receive different combinations of alleles. The combination of alleles may make the offspring heterozygous or homozygous for a trait. The DNA nucleotide sequence of the allele codes for the amino acid sequence of a protein. Different alleles have different DNA sequences and code for different amino acid sequences. Different amino acid sequences result in different protein structures and functions that result in a particular phenotype. Mutations can also change the DNA sequence of an allele, resulting in a different phenotype for a trait.

Science Content Storyline

Pedigrees are a tool that can help analyze the traits of a family. Information from both classical and molecular genetics as well as tools such as pedigrees, provide evidence to explain how variation in a population's traits arise.

Materials

- Chart paper
- Markers

Advance Preparation

- Determine the number of small groups that will evaluate each claim (parents, genes, mutation). Each small group will need one piece of chart paper and markers.
- Determine if students will complete the scientific argument and rebuttal in class or as homework. Lesson times are for completion in class.

Lesson 9 General Outline

Time (min)	Phase of lesson	How the science content storyline develops
10	**Link to Previous Lesson** The teacher reviews student explanations for gene expression from Lesson 8 **Lesson Focus Question**: **Is it possible for a family who all show the same version of a trait to have an individual with a different version of the trait? If so, how did that happen? If not, why not?** The teacher introduces the lesson focus question.	
60	**Jaguar Pedigrees** <u>Activity Setup</u> Students read about research on jaguars and learn how to read a pedigree. <u>Activity</u> Students use pedigrees of jaguars to determine whether black jaguars can have a spotted offspring. <u>Activity Follow-up</u> Students consider how the three possible explanations for variation are supported by the evidence in the lessons.	Pedigrees are a tool that can help analyze the traits of a family. Information from both classical and molecular genetics as well as tools such as pedigrees, provides evidence to explain how variation in a population's traits arise.
45	**Synthesize and Summarize** Students use the argument tool to use science ideas from the lesson series to explain variation among a population of jaguars.	

Lesson 9: Tools to Predict Traits

Phase of Lesson: *Link to Previous Lesson and Lesson Focus Question: How can multiple offspring of the same parents have different versions of the same trait?*

Main Learning Goal: Using information about parental alleles, inheritance, and proteins in cells it is possible to make predictions about the traits of family members.

Focus Question: Is it possible for a family who all show the same version of a trait to have an individual with a different version of the trait? If so, how did that happen? If not, why not?

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.
- There are different explanations, including parents, genes, and mutations, for why these variations occur.
- Evidence helps scientists evaluate the strengths and limitations of explanations.

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 9: Tools to Predict Traits

Introduction

In the last lesson, you considered how individuals from the same parent can look different from one another. But what about other family members? In this lesson you will consider the different explanations for variation in a population. You will apply these ideas to a real population of jaguars to explain the variation within a family.

Process and Procedure

Lesson Focus Question

1. Write the focus question for this lesson in the box below. Underneath the box, write bullet points to show your current ideas about whether it is possible for a family of black jaguars to have a spotted jaguar.

Is it possible for a family who all show the same version of a trait to have an individual with a different version of the trait? If so, how did that happen? If not, why not?

Focus on Student Thinking

Use appropriate elicit (STeLLA Strategy 1) and probe questions (STeLLA Strategy 2) to reveal student thinking about the inheritance of different traits within a family.

- Following are some question you might ask:
  - What are your ideas about how one individual in a family could show a different version of a trait than everyone else? **(Elicit)**
  - Say more about how a mutation could cause that to happen. **(Probe)**
  - What do you mean when you say they have a recessive trait? **(Probe)**

Implementation	Notes
Link to Previous Unit ● Remind students of their work in the previous lesson by having several students read the explanation they developed in Lesson 8. Ideas to highlight from the explanations include: ○ An organism receives its DNA from its parents; half from its mother and half from its father. ○ Mutations in DNA can result in a different sequence of amino acids. This change in sequence may result in a different structure and function of the protein. ○ Proteins are responsible for the traits an organism displays. *Lesson Focus Question* ● **STEP 1:** Ask a student to read the focus question aloud. Then ask another student to paraphrase what the focus question is asking. ● Allow time for students to write the focus question in the box in their workbooks. Students should write bullet points to show their current ideas about whether it is possible for a family of black jaguars to have a spotted jaguar. Share that they will have a chance to revise their ideas as they work through the lesson. ● Once students have written the focus question and their bulleted ideas in their workbooks, use Strategy 1: Ask questions to elicit student ideas and predictions and Strategy 2: Ask questions to probe student ideas and predictions in a whole class discussion. As students share ideas, encourage them to consider which shared ideas are similar to and different than their own. Use the information in "Focus on Student Thinking" in the SE key to see examples of ways to elicit and probe student ideas.	

Lesson 9: Tools to Predict Traits

Phase of Lesson: *Jaguar Pedigrees*

Main Learning Goal: Using information about parental alleles, inheritance, and proteins in cells it is possible to make predictions about the traits of family members.

Focus Question: Is it possible for a family who all show the same version of a trait to have an individual with a different version of the trait? If so, how did that happen? If not, why not?

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: 80 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 5: Engage students in analyzing and interpreting data and observations
- Strategy 7: Engage students in constructing explanations and arguments

Science Ideas

- An individual's traits are determined by the combination of alleles it receives from its parents. An individual may be homozygous or heterozygous for a trait.
- An individual's traits are the result of proteins coded for by the combination of genes they receive from their parents.
- Mutations in the DNA may result in a protein with a different structure and function.
- Alleles are passed from parents to offspring on chromosomes. In meiosis, chromosome pairs are separated in the production of eggs and sperm. Chromosomes are recombined through sexual reproduction.

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.

Jaguar Pedigrees

2. Read the following information about scientists studying a jaguar family. As you read, annotate the text.

Jaguar Research

In 2003, a group of scientists published a paper that provided information about several generations of jaguars. They included information on 116 jaguars to learn more about the fur color trait in families. For each jaguar, the data included not only the fur color but also the fur color of the mother and father if they were known.

Later, another scientist who was studying the data noticed something interesting. She saw that jaguar number 9267 was spotted, but that most of the jaguar's family members were black. The scientist began creating a pedigree with some of the closest relatives to 9267. Her pedigree looked like the following. There is an arrow pointing to 9267. The scientist knew that the jaguar was spotted, a female, and that her parents were 8669 and 2498.

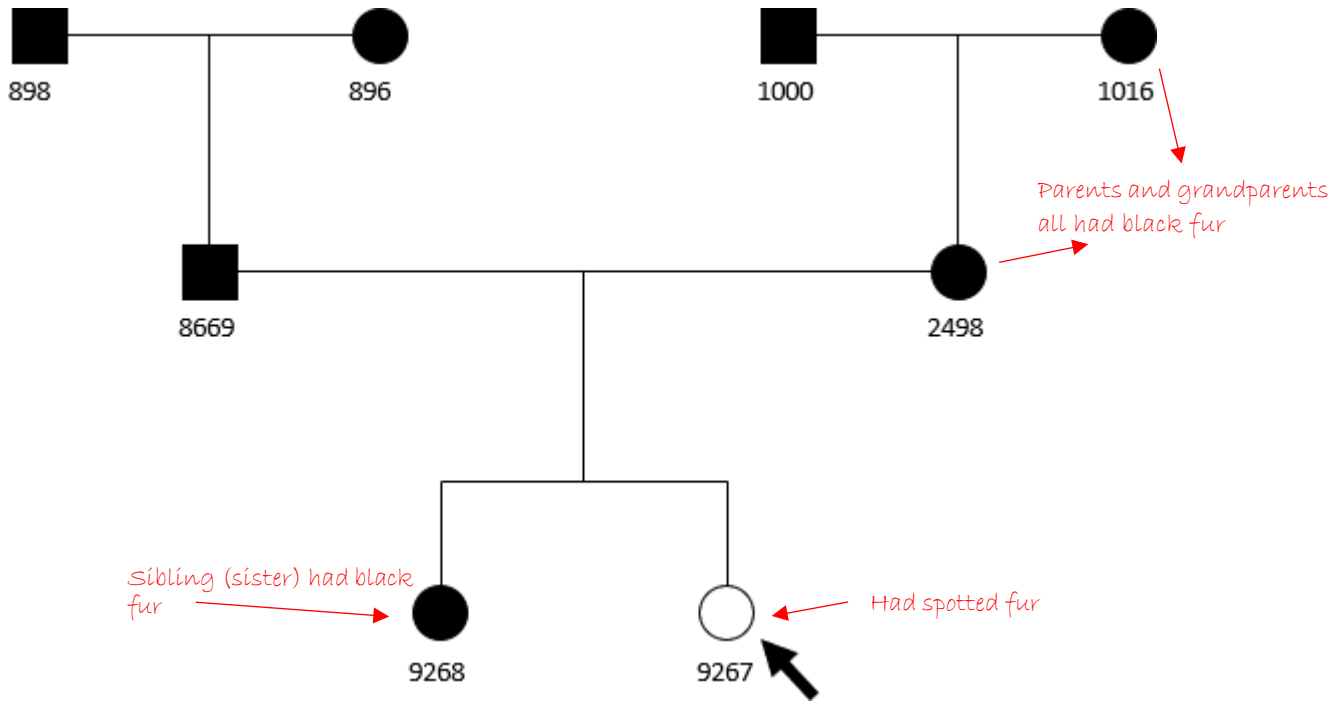
open means spotted, circle means female

A pedigree is a tool that scientists use to chart an individual's ancestors. It is similar to a family tree, but focuseson a particular trait. A pedigree usually shows only the phenotype of an individual. However, a pedigree can beused to predict the genotype of an individual.

what an individual looks like

what genes an individual has

Using this information, study the pedigree. What else can you learn about how pedigrees represent different animals and relationships? Draw arrows and write short statements to show what you see or infer in the pedigree. If you have questions, write them down as well.



Implementation	Notes
Activity Setup: Jaguar Pedigrees • **STEP 2:** Provide time for students to read and annotate the short article, *Jaguar Research*. After students have read the article, invite several students to summarize the key points in the article. • On the pedigree chart, have students draw arrows to what they notice and write short "what I see" statements. Then hold a class discussion about their observations. Create a class chart that will serve as a key. Important ideas to include in the chart include: o Female jaguars are represented by circles and male jaguars are represented by squares. o Black jaguars are represented by black symbols and spotted jaguars are represented by white symbols. o Individuals that have mated have a horizontal line drawn between them. o A vertical line and a bracket connect the parents to their offspring. • Make sure that everyone can interpret the symbols of a pedigree by asking students the sex and fur color of a particular jaguar on the chart. You might also ask students to identify the offspring of a particular jaguar, and the two sisters represented on the chart. • If your students are struggling with this step, consider providing them with statements about the pedigree. Students can determine if the statements are true or false to help them think about the points above.	

3. Using the pedigree as a tool to help you analyze the jaguar family, answer the following.

   Example responses are shown.

   a. How many family members are shown?

      8

   b. How many of the family members have black fur?
      7
   c. How many of the family members are female?
      5
   d. What are the numbers of jaguar 2498's mother and father?
      1000 and 1016
   e. How are jaguars 9267 and 9268 related to each other?

      They are siblings (sisters)

Focus on Student Thinking

Use appropriate elicit (STeLLA Strategy 1), probe (STeLLA Strategy 2), and challenge (STeLLA Strategy 3) questions to make student thinking about the pedigree visible.

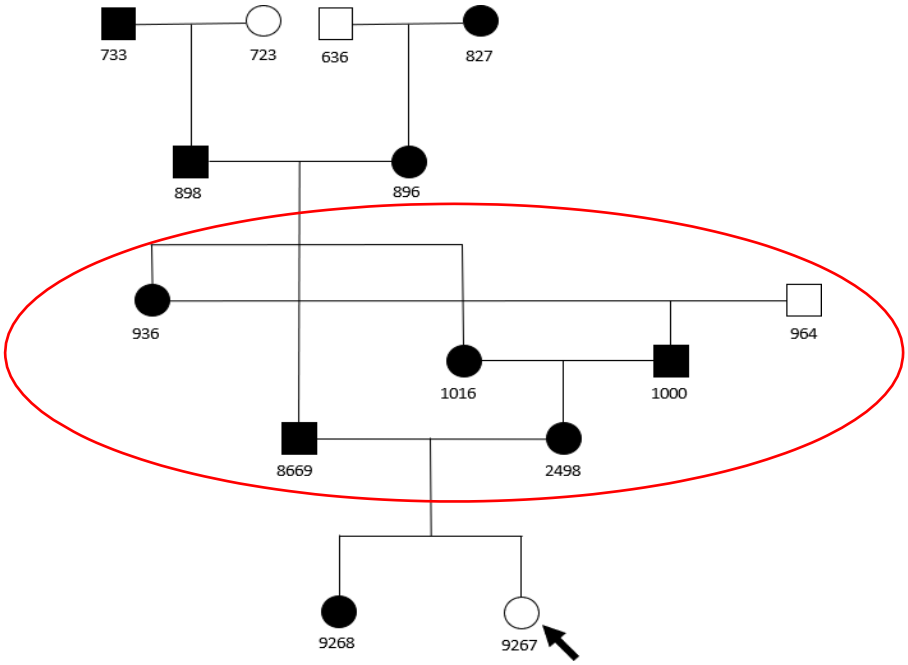
- Following are some question you might ask:
  - What is one of your "what I see" statements? **(Elicit)**
  - Tell us more about why you think spotted fur is recessive. **(Probe)**
  - Can you put that idea in a complete sentence? **(Probe)**
  - Knowing that jaguar 9267 is spotted, what does that tell you about jaguars 1000 and 1016? **(Challenge)**
- The following is an example of a dialogue that engages students in analyzing and interpreting the data in the pedigree (STeLLA Strategy 5). Notice how the teacher's questions consistently direct students' attention to the individuals in the pedigree.
  - T: What is one of your "what I see" statements? **(Elicit)**
  - S1: I said "Both of 9267's parents are black but she is spotted." That means spotted fur is recessive.
  - T: Tell us more about why you think spotted fur is recessive. **(Probe)**
  - S1: Well, 9267 is the only spotted leopard in the whole family, so I think that means it's recessive.
  - T: What does that mean about her fur color alleles? **(Challenge)**
  - S1: Umm, I guess it's two little fs.
  - T: So then, what do you know about her parents' genotypes? **(Challenge)**
  - S2: They must each have a little f allele.
  - S3: But they also much each have a big F allele, so they're heterozygous.
  - T: Tell us more about why they must be heterozygous. **(Probe)**
  - S3: They each have to have a little f to give to 9267, but they also have to have a big F because their fur is black.
  - T: What can you say about her sister's genotype? **(Challenge)**
  - S2: She must be big F, big F.
  - S3: Not necessarily. She could be either.
  - T: Say more about how she could be either. **(Probe)**

Implementation	Notes
• **STEP 3:** This step allows students to confirm that they understand how to interpret information in a pedigree. Discuss each statement and the evidence from the pedigree that supports their answer. Ask probe and challenge questions as needed to make student thinking visible. 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 dialogue using STeLLA Strategy 5: Engage students in analyzing and interpreting data and observations.	

4. Jaguar 9267 is a spotted jaguar, but all her family members are black. Consider the three possible explanations: genes, parents, and mutations. Which of the explanations best fit the data about jaguar 9267 and her family? You may choose as few or as many explanations as reasonably fit. Explain your ideas about the explanations you think best fit the data. **Question 4 found on page SE L9-3 in student edition*

See the next page for reasons students might select each of the three explanations.

5. The scientist who created the pedigree decided it would be valuable to look at some additional family members. She examined additional family members and developed the following pedigree.



With your team, describe the additional family members that are part of the new pedigree.

How does this information help you understand how jaguar 9267 can have spotted fur when her parents and grandparents all have black fur? Use the following words in your description:

- Heterozygous
- Homozygous
- Dominant
- Recessive
- Gene
- Allele

Focus on Student Thinking

Use appropriate elicit (STeLLA Strategy 1), probe (STeLLA Strategy 2), and challenge (STeLLA Strategy 3) questions to reveal student thinking now about the explanation for 9267's spotted fur.

- Following are some question you might ask:
  - Do you have any new ideas about how 9267 got spotted fur? **(Elicit)**
  - Say more about why you don't think she has spotted fur because of a mutation. **(Probe)**
  - Explain what you mean when you say 2498 got a little f allele from his grandfather. **(Probe)**
  - Based on the pedigree, what can you say about the jaguar 1000's genotype? **(Challenge)**

Implementation	Notes
Activity: Jaguar Pedigrees • **STEP 4:** Invite students to discuss their ideas with their teams. After teams have had time to discuss their ideas, lead a class discussion about the ideas. Be sure to discuss each of the three explanations. At this point, students should realize that any of the three explanations fit the data: o Parents: Jaguar 9267 could have inherited the spotted trait from her parents, even though they are both black. If both parents were heterozygous for fur color, they would have black fur because it is the dominant trait. Jaguar 9267 is spotted because she received a recessive allele from each parent. o Genes: Some traits are the results of genes. Although this is not a complete story, students should realize jaguars have a gene for fur color that has two alleles. o Mutation: Mutation is also a possible explanation at this point. If there was a mutation in the DNA of jaguar 9267 that caused part of the MC1R protein to be deleted (in both alleles), she may have spotted fur. • **STEP 5:** Provide time for students to examine the new pedigree. Ask them to work with their teams to describe how the new information helps to explain why jaguar 9267 has spotted fur. Students should realize that it is unlikely that jaguar 9267's spotted fur is the result of a new mutation because her great grandparents had spotted fur. Refer to "Focus on Student Thinking" in the SE key for possible questions to elicit, probe, and challenge student ideas.	

6. Read and annotate the article, *Scientific Argumentation*.

   Example annotations are shown.

Scientific Argumentation

Scientific argumentation is a process for reaching agreements and justifying the best explanation for a natural phenomenon. Scientists use argumentation to listen to, compare, and evaluate competing explanations. They and their peers attempt to identify strengths, weaknesses, and limitations in claims, evidence, and reasoning, with the ultimate goal of refining and improving the explanation. An important component of a scientific argument is a rebuttal. A rebuttal refutes alternative claims, evidence and/or explanations.

I never thought of it this way—I thought it was to win.

Scientific argumentation is used to compare and evaluate competing explanations in light of currently accepted explanations and new evidence. Scientists may determine that one explanation has stronger evidence and reasoning to support it, while another explanation has weaker evidence and may be refuted. Alternatively, scientists may find that the evidence for several explanations may be combined to create an even stronger argument.

Like what we wanted to do for the three explanations for variation!

7. Throughout this lesson series, we have considered three explanations for the variation that exists between individuals of the same population. Your teacher will assign you one of the three explanations.

   With your group, consider the evidence from today's lesson and the other activities in this unit. Use the first part of the Argument Tool on the next page to record the evidence that best supports your claim.

   Then critique the quality and strength of the evidence that supports the claim.

Implementation	Notes
Activity Follow-up: Jaguar Pedigrees • The purpose of this Activity Follow-up is to help students consider the three explanations – genes, parents, and mutations – and whether the evidence from the jaguar pedigree activity and other unit activities provides evidence to support one or more of the explanations. • **STEP 6:** Have students read and annotate the short article, Scientific Argumentation. After students have finished, have a brief class discussion about the role of argumentation in science, how scientific argumentation differs from other arguments they may have observed in other settings, and how scientific argumentation is similar to and different from scientific explanations. Key points (based on the *Framework* and the NGSS) to highlight include: o The purpose of scientific argumentation is to refine and improve explanations of natural phenomena. o In the process of scientific argumentation, scientists present the case for their ideas and defend their explanations. They and their peers then attempt to identify weaknesses and limitations in the argument. They examine their own understanding in light of the evidence and comments offered by others and collaborate with peers in searching for the best explanation for the phenomenon being investigated. o When scientists engage in argumentation, they ask probing questions that seek to identify the premise of the argument, request further elaboration, or challenge the interpretation of a data set. They use the sentence stems found on the *Communicating in Scientific Ways* chart. By this process of respectful discourse, science maintains its objectivity and progress. o Like scientific explanations, the components of a scientific argument include a claim, evidence, science ideas, and reasoning. While the claim of a scientific explanation answers the question about the phenomenon under investigation, the claim of a scientific argument answers the question about which explanation is best supported by evidence, science ideas, and reasoning. • **STEP 7:** Assign small groups of students to each of the claims (parents, genes, mutation). Groups can use the Argument Tool in their workbook to record their thinking. After discussing their ideas, each group should chart their ideas using the first page of the Argument Tool as a template. o Groups should record evidence from the pedigree and other unit activities that supports their claim. o They should the record science ideas and reasoning that evaluates and critiques the quality and strength of the evidence that supports the claim.	

Name _____

Argument Tool

Example responses are shown.

Question

What is the question that you are investigating?

What's 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?

Claim A	Claim B	Claim C
What is a claim you could argue? **Parents is the best explanation for the similarities and differences we see in individuals within a species.**	What is a claim you could argue? **Genes is the best explanation for the similarities and differences we see in individuals within a species.**	What is a claim you could argue? **Mutation is the best explanation for the similarities and differences we see in individuals within a species.**
The evidence that supports this claim is… Two black jaguars often have black offspring, but sometimes they have spotted offspring. Two spotted jaguars always have spotted offspring. A black jaguar and spotted jaguar may have all black, or black and spotted offspring.	**The evidence that supports this claim is…** The nucleotide sequence of the MC1R gene is different in black and spotted jaguars. The nucleotide sequence of the AChE gene is different in mosquitos that are resistant and non-resistant to insecticide. The nucleotide sequence of the hemoglobin A gene is different in geese that can and cannot fly at high altitudes.	**The evidence that supports this claim is…** There is a deletion mutation in the MC1R gene for black fur in jaguars compared to the MC1R gene for spotted fur. There is a substitution mutation in the AChE gene for resistance to insecticide compared to non-resistance. There is a substitution mutation in the hemoglobin A gene for geese that fly at high altitude compared to those that do not.

Scientific Reasoning: Evaluating the Evidence and Claim

Use science ideas to critique the quality and strength of the evidence that supports the claim. Genes determine many traits of Individuals and individuals have two alleles for every gene. Dominant alleles show their trait as long as at least one is present. Recessive alleles show their trait only when both are present. Offspring inherit one of each parent's two alleles for a trait. The combination of alleles they inherit determines their trait.	Use science ideas to critique the quality and strength of the evidence that supports the claim. Traits are based on the function of proteins. Different versions of a trait are caused by differences in the proteins associated with the trait. The amino acid sequence of a protein determines its structure and function. The nucleotide sequence in a gene codes for the amino acid sequence in a protein. Genes are sequences of nucleotides in DNA.	Use science ideas to critique the quality and strength of the evidence that supports the claim. When DNA is copied, sometimes mistakes are made. Sometimes the copying enzymes skip over some nucleotides, causing a deletion mutation. Sometimes the copying enzymes pair the nucleotide bases incorrectly, resulting in substitution mutation. Sometimes the copying enzymes slip back and copy a portion of the nucleotides twice, resulting in an insertion mutation.

Implementation	Notes

• If multiple small groups have charted the same claim, combine the small groups into a larger group. Have each small group share their evidence, science ideas, and reasoning with each other. They should revise one of their charts to incorporate the best thinking of the larger group. Mark that this is one example of engaging in scientific argumentation.
• Post the three charts, one for each claim, around the room so that the class can gather around each chart for discussion. Have each large group share their evidence, science ideas, and reasoning with the whole class.
  ○ As groups present, students should record the key evidence, science ideas, and reasoning in the appropriate column of the Argument Tool in their workbook.
  ○ Ask probe and challenge questions to clarify student thinking and invite students to ask questions of the presenting group. You may choose to have them use sentence stems from the Communicating in Scientific Ways chart.
  ○ Students may say that the mutation claim is not supported because the extended pedigree suggests that the spotted fur of jaguar 9627 was not a spontaneous mutation. Lead a class discussion about their ideas. If most students seem to agree with the idea that the mutation claim is not supported, ask the elicit question, "How do you think the spotted fur allele first appeared in the family?" Ask probe questions to make student thinking visible. As the discussion continues, highlight the idea that there was a mutation in the MC1R allele at some point which caused the different colors of jaguars. However, the mutation did not occur in jaguar 9627.
  ○ This discussion serves as an opportunity to link back to natural selection and evolution. If you choose to make this link, share with students that there are more spotted jaguars in the world, and spotted fur color is considered the "wild type" and black fur color arose as a result of mutation. Ask an elicit question to start a conversation about why the black phenotype has persisted after the mutation happened. As part of the discussion, be sure to bring up the ideas of how the population of jaguars changed over time after this mutation occurred.
• As students discuss the evidence, science ideas, and reasoning for the three claims, they should realize that there is evidence for all three claims and that combining the three claims would create a stronger argument to explain the variation seen in fur color of jaguars as well as the variation seen in the traits of all species of plants and animals. It is important that students arrive at this conclusion prior to beginning the next portion of the lesson.	

Focus on Student Thinking

- Use appropriate elicit (STeLLA Strategy 1), probe (STeLLA Strategy 2), and challenge (STeLLA Strategy 3) questions to reveal student thinking about the evidence and reasoning for the three explanations of variation among individuals.
    - Following are some questions you might ask:
        - Share the evidence, science ideas, and reasoning for your explanation. **(Elicit)**
        - Can you clarify your reasoning for why that evidence supports the explanation? **(Probe)**
        - Say more about what nucleotide sequence has to do with protein structure. **(Probe)**
        - Based on the evidence and reasoning you have all shared, what claim can you make about the best explanation for variation in individuals? **(Challenge)**
        - Can you see any way to combine the evidence and reasoning into a single best explanation for variation in individuals? **(Challenge)**
    - The following is an example of a dialogue that engages students in constructing explanations and arguments (STeLLA Strategy 7). Notice how the teacher uses a challenge question to push students to thinking about putting all their ideas together to create the strongest argument.
        - T: What is your thinking about the *best* explanation for variation in individuals? **(Elicit)**
        - S1: I think genes is the best explanation because genes code for proteins and proteins determine traits.
        - T: Say more about that. **(Probe)**
        - S1: The nucleotide sequence in a gene is copied into mRNA, and then every three nucleotides stands for an amino acid, so it puts the amino acids in the right order to make the protein that makes the trait.
        - T: How does that explain variation in traits? **(Challenge)**
        - S2: See, that's why the mutation explanation is better, because that makes the gene different, so then the protein is different too.
        - S3: But the parent explanation tells how offspring get the different genes, so you need that too.
        - T: Can you see a way to combine all of your ideas into a single best explanation for variation in individuals? **(Challenge)**

Implementation	Notes
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 7: Engage students in constructing explanations and arguments.	

Lesson 9: Tools to Predict Traits

Phase of Lesson: *Synthesize and Summarize*

Main Learning Goal: Using information about parental alleles, inheritance, and proteins in cells it is possible to make predictions about the traits of family members.

Focus Question: Is it possible for a family who all show the same version of a trait to have an individual with a different version of the trait? If so, how did that happen? If not, why not?

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: 15 Minutes

STeLLA Strategies

- Strategy 7: Engage students in constructing explanations and arguments
- Strategy 9: Engage students in making connections by synthesizing and summarizing key science ideas

Science Ideas

- An individual's traits are determined by the combination of alleles it receives from its parents. An individual may be homozygous or heterozygous for a trait.
- An individual's traits are the result of proteins coded for by the combination of genes they receive from their parents.
- Mutations in the DNA may result in a protein with a different structure and function.
- Alleles are passed from parents to offspring on chromosomes. In meiosis, chromosome pairs are separated in the production of eggs and sperm. Chromosomes are recombined through sexual reproduction.

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

8. **The unit central question is:** What's 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?

   Use the three explanations and evidence from all the lessons to write a scientific argument that answers the focus question. Use the Argument Tool on the next page to help organize your ideas.

Implementation	Notes
Summarize • **STEP 8:** Remind students of the unit central question: What's 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? Share that, from their critique of the three claims in Step 7, the best explanation for the variation we observe is a combination of the three claims. • Review the directions on page two of the Argument Tool with students. Depending on student comfort with scientific argumentation, you may choose to ask elicit and probe questions that highlight: o The scientific question is the unit central question o The most accurate claim includes all three explanations (parents, genes, mutation) o The evidence, science ideas, and reasons will be drawn from their notes of the previous class discussion. • Provide time for students to write their scientific argument. Once they have completed the argument, they should then write a rebuttal that explains why each of the three claims alone is insufficient to answer the question. Alternatively, you may choose to assign this as homework. • Share how you will collect the argument and/or student workbooks at the end of the lesson.	

Name _____

Argument Tool continued

Constructing a Scientific Argument

Write a scientific argument that includes:

- The scientific question
- Your claim (use ideas from all three claims that are best supported by evidence, science ideas, and reasoning)
- Relevant evidence that supports your claim
- Relevant science ideas
- Scientific reasoning that critiques the evidence and evaluates your claim

Scientific Argument

The similarities and differences we see in individuals within a species are due to interactions among the mutations, the genes of the individual organism, and the genes of the parents that can be passed on to the offspring. Mutations (e.g., substitution, insertion, and deletion mutations) promote variation in traits. These variations can be seen in differences in the DNA sequences of individuals displaying the variations in traits. For example, jaguars with spotted fur have a longer DNA sequence (and therefore protein sequence) for the MC1R gene than jaguars with black fur. Black fur in jaguars is caused by a deletion mutation in the MC1R gene. Insecticide resistance in mosquitoes is caused by a substitution mutation in the AChE gene for resistance. Geese that fly at high altitude display a substitution mutation in the hemoglobin A gene as compared to the DNA sequence for hemoglobin A of those that do not. The nucleotide sequence of the hemoglobin A gene is different in geese that can and cannot fly at high altitudes.

The genes of individuals determine the traits of the individual based on the function of proteins coded for by the DNA/genes. Different versions of a trait are caused by differences in the proteins associated with the trait. The amino acid sequence of a protein determines its structure and function. Therefore, a change in the DNA sequence, such as a change caused by a mutation, can change the protein structure and therefore its function. Mutations can happen when DNA is copied and mistakes are made. Sometimes the copying enzymes skip over some nucleotides, causing a deletion mutation. Sometimes the copying enzymes pair the nucleotide bases incorrectly, resulting in a substitution mutation. Sometimes the copying enzymes slip back and copy a portion of the nucleotides twice, resulting in an insertion mutation.

The genes that are passed from parent to offspring also make a difference in the similarities and differences of individuals. For example, two black jaguars often have black offspring, but sometimes they have spotted offspring. Two spotted jaguars always have spotted offspring. A black jaguar and spotted jaguar may have all black, or black and spotted offspring.

Rebuttal

Write a rebuttal that explains why each of the three claims alone is insufficient to answer the question.

No one claim, A, B, or C, is sufficient because mutations can change the DNA/genes that offspring inherit and changes in the DNA can result in a change in the protein structure and function. This change in the protein can result in a variation in the trait.

Adapted from the Regents of the University of California

Implementation	Notes