A Study of Traits
Lesson 3: A Closer Look at Proteins

Grade: 9-10 General Biology

Length of lesson: 120 minutes

Placement of lesson: Lesson 3 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 3 Main Learning Goal

A protein's structure is the determined by its amino acid sequence. The structure of a protein influences its function.

Lesson 3 Focus Question

How can a protein determine the traits, and versions of a trait, of an individual organism?

Ideal student response

Proteins are made of amino acids bonded together in a chain. If there is a change in the number or order of amino acids due to deletion or substitution of amino acids, the overall shape of the protein will change. This change in shape may cause the protein to function (work) differently. In jaguars, a deletion and substitution of amino acids in the MC1R protein causes the protein to produce a different type of melanin that causes the jaguar's fur to be black instead of orange.

Science Content Storyline

The structure of a protein determines its function; if you change the structure, the protein may not function in the same way. Proteins are made up of amino acids. The specific sequence of amino acids determines the protein's structure and shape. If the amino acid sequence changes, the shape of the protein can change which can influences its function.

Materials

- Puzzle Set 1, one per table group
- Puzzle Set 2, one per table group
- Puzzle Set 3: Amino Acid Puzzle Set, one per table group
- Amino acid handout (printed in color), one per student
- Scissors, two per table group
- Transparent tape, one per group
- Colored pencils (one set per table)

Advance Preparation

- Print and cut out Puzzle Set 1. You will need one set of five puzzle pieces per group. Pieces can be laminated prior to cutting out and reused in multiple classes if desired.
- Print and cut out Puzzle Set 2. You will need one set of five puzzle pieces per group. Pieces can be laminated prior to cutting out and reused in multiple classes if desired.
- Determine if you will use Puzzle Set 3 (see Step 5, pages TE L3-12). If you use Puzzle Set 3: Amino Acid Puzzle Set, print and cut out the Amino Acid Puzzle Set. You will need one set of five puzzle pieces per group.
- Print one color copy of the Amino Acids handout per student. A class set can be printed and then put in page protectors for reuse.

Lesson 3 General Outline

Time (min)	Phase of lesson	How the science content storyline develops
10	**Link to Previous Lesson** The teacher reviews student ideas about proteins and how differences in proteins may connect to differences in individuals of the same species. The teacher also reviews the three possible explanations for variation and the current evidence that supports each explanation. **Lesson Focus Question**: **How can a protein determine the traits, or version of a trait, of an individual organism?** The teacher introduces the lesson focus question.	
90	**Amino Acids: Pieces of the Puzzle** <u>Activity Setup</u> Students work with puzzle pieces to consider ways in which smaller pieces can be put together to make a larger structure. They also consider how the order in which the smaller pieces are put together influences the shape of the larger structure. <u>Activity</u> Students use amino acids as puzzle pieces to consider how the order in which they put them together results in a protein with different structures. Students compare the sequence of amino acids of the MC1R protein in black and spotted jaguars. <u>Activity Follow-up</u> Students read about how the deleted amino acids in the MC1R protein leads to differences between black and spotted jaguars. Students draw a diagram to show their understanding of how amino acid sequence affects the fur color of jaguars.	The structure of a protein determines its function; if you change the structure, the protein may not function in the same way. Proteins are made up of amino acids. The specific sequence of amino acids determines the protein's structure and shape. If the amino acid sequence changes, the shape of the protein can change which can influences its function.
15	**Synthesize and Summarize** Students use a table to compare the similarities and differences between the characteristics of two proteins. They revisit the focus question and add to their ideas.	
5	**Summarize and Link to Next Lesson** The teacher and students summarize the lesson and link to the next lesson.	

Lesson 3: A Closer Look at Proteins

Phase of Lesson: *Link to Previous Lesson and Lesson Focus Question: How can a protein determine the traits, and versions of a trait, of an individual organism?*

Main Learning Goal: A protein's structure is determined by its amino acid sequence. The structure of a protein influences its function.

Focus Question:

How can a protein determine the traits, and versions of a trait, of an individual organism?

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 3: A Closer Look at Proteins

Introduction

You have learned that differences in the types or amounts of a protein may be connected to the differences among individuals of the same species and considered new evidence that supports the three possible explanations for variation. In this lesson, you will look more closely at the structure of proteins and how differences in structure can result in differences in protein function. These differences in protein function can result in two organisms of the same species with different versions of a trait.

Process and Procedure

Lesson Focus Question

1. Write the focus question for this lesson in the box below. After you have written the focus question and your best ideas, turn and talk with your table group about your ideas. As you discuss your ideas, consider which ideas are similar and which are different. Be prepared to share your discussion with the whole class.

How can a protein determine the traits, and versions of a trait, of an individual organism?

Focus on Student Thinking

- Use appropriate elicit (STeLLA Strategy 1) and probe questions (STeLLA Strategy 2) as students discuss their ideas with their teams.
    - Following are some question examples:
        - What is your idea about how a protein can determine what trait an individual has? **(Elicit)**
        - Clarify what you mean by …. **(Probe)**
        - Can you say more about why you think the amount of eumelanin affects fur color in jaguars? **(Probe)**
        - Does anyone have a different idea? **(Elicit)**
        - Tell us more about your idea. **(Probe)**

Implementation	Notes

Link to Previous Unit
● Ask a student to summarize what they learned in the previous lesson. Then ask others whether they agree and if there are other ideas they would add to the summary. Ideas to highlight from the discussion include:
  o There are many different types of proteins in the body of an organism.
  o Some of the differences between individuals of the same species are caused by different amounts of proteins while others are caused by a change in the structure of the protein.
  o Differences in proteins can be connected to differences in individuals of jaguars, mosquitos, and geese.
  o Students may also share how the ideas above support, or not, one or more of the three possible explanations for variation.
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. 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.
● Once students have written the focus question and their best ideas in their workbooks, provide time for teams to discuss their ideas. This is not a time to challenge their ideas, but rather make their current thinking about the focus question visible through the use of Strategy 1: Ask questions to elicit student ideas and predictions and Strategy 2: Ask questions to probe student ideas and predictions.
Use the information in "Focus on Student Thinking" in the SE key to see examples of ways to elicit and probe student ideas.	

Lesson 3: A Closer Look at Proteins

Phase of Lesson: *Looking for Variation: Differences in Proteins*

Main Learning Goal: A protein's structure is determined by its amino acid sequence. The structure of a protein influences its function.

Focus Question:

How can a protein determine the traits, and versions of a trait, of an individual organism?

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 6: Engage students in developing and using models
- Strategy F: Make explicit links between science ideas and activities

Science Ideas

- Proteins are made of amino acids bonded together in a chain.
- If there is a change in the number or order of amino acids due to deletion or substitution of amino acids, the overall shape of the protein will change.
- A change in protein structure may cause the protein to function differently.
- The deletion and substitution of amino acids in the MC1R protein causes the protein to produce a different type of melanin which results in different coloration.

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.

A Closer Look at Proteins

2. Proteins are large molecules that are made up of smaller molecules joined together. In this lesson, your will have a chance to learn more about the smaller molecules that make up proteins. To begin thinking about this, imagine the smaller molecules are like the pieces in Puzzle Set 1.

   With your team, see how many different ways you can put the puzzle pieces together. Record at least 4 different ways you can put them together in the table below.

Order or Sequence of Puzzle Pieces	Shape of Chain When Pieces Are Put Together
Red-green-blue-yellow-purple	_____
Yellow-blue-green-red-purple	_____
Green-yellow-red-blue-purple	_____
Purple-yellow-green-blue-red	_____

Implementation	Notes

Activity Setup: A Closer Look at Proteins
• The purpose of the activity set up is to consider how the shape of individual puzzle pieces influences the shape of the chain when the pieces are put together in different orders.
• Share that as students work through the lesson, they are going to learn more about what makes up proteins. To begin thinking about this, they will first consider how smaller pieces can be put together to make a larger object.
• **STEP 2:** Distribute Puzzle Set 1 to each team. Ask teams to come up with as many different ways as they can to put the puzzle pieces together.
  ○ Give a time limit, such as two minutes.
  ○ Have students record four ways they put their pieces together. Students can write the color of the dot on each piece in the first column of the table to indicate the order of the pieces. Students can draw a line to represent the shape of the chain.
  ○ Because the puzzle pieces are all the same, they should be able to put them together in many different combinations, but the overall shape should be a straight line.
• Have several teams share one of their sequences and the shape of the chain. As teams share, highlight that the shape of the chain does not change with different sequences.
• Ask students to think individually about how the combinations that could be made would be affected if the five puzzle pieces were not identical to each other.
  ○ Invite students to share their ideas with the whole class.
  ○ Students should realize that they may not be able to make as many different sequences if the shapes are different. They should also realize that the shapes of the overall structure may be different.	

3. In Puzzle Set 1, the pieces were all the same shape. You made a prediction about what would happen if the pieces were not all the same shape. Use Puzzle Set 2 to see some of the different combinations you can make when the puzzle pieces are different. Record at least 3 different ways you can put them together in the table below.

Order or Sequence of Puzzle Pieces	Shape of Chain When Pieces Are Put Together
Val-Ala-Leu-Thr-Glu	
Glu-Val-Ala-Thr-Leu	
Thr-Leu-Val-Ala-Glu	

How are the shapes of the chains you made with Puzzle Set 1 similar to or different than the shapes of the chains you made with Puzzle Set 2?

Implementation	Notes

• **STEP 3:** Distribute Puzzle Set 2 to each team. Note that each piece is identified by three letters. At this point, do not share that the letters are abbreviations for specific amino acids.
• Give teams several minutes to put the pieces together in different orders and draw at least three combinations in their workbooks.
• Lead a class discussion about the work students have been doing thus far. Use elicit and probe questions to make student thinking visible about how the combinations and overall structure changed when the puzzle pieces had different shapes and how their results matched, or not, their predictions.
  ○ Remind students that they are beginning to think about proteins, imagining that the puzzle pieces are like the building blocks of a protein.
  ○ Ask students the elicit question, "We have been thinking about proteins. Based on our work with Puzzle Sets 1 and 2, does anyone have any new ideas about how there can be so many different types of proteins?"
  ▪ The purpose of this discussion is to probe student thinking. The puzzle piece activities have not given students any specific information about proteins at this point. However, if students have previously learned that proteins need a specific shape to function, such as an enzyme, they may be developing some initial ideas about how using differently shaped building blocks might result in a protein with a specific shape.
  ▪ Students do not need to understand this idea at this point in the lesson but having a clear idea of where students are in their thinking will help you know where to focus discussions in the remainder of the lesson.	

Focus on Student Thinking

- Ask students an elicit question about the impact of puzzle pieces with the same and different shapes on the final shape of different sequences (STeLLA Strategy 1).
    - As students respond, ask probe questions (STeLLA Strategy 2) and challenge questions (STeLLA Strategy 3) to make student thinking about the different Puzzle Sets visible.
    - Sample probe and challenge questions:
        - What do you mean when you say the shapes are the same or different? **(probe)**
        - Say more about how the shapes of the final structures changed when you used the pieces from Puzzle Set 2. **(probe)**
        - Can you explain why the shapes of the final structures changed with different sequences of the pieces from Puzzle Set 2, but not from Puzzle Set 1? **(challenge)**
        - Our focus question is about proteins. What do you think this activity might have to do with proteins? **(challenge)**
- The following is an example dialogue between teacher and students:
        - **T:** We have been thinking about proteins. Based on our work with Puzzle Sets 1 and 2, does anyone have any ideas about how there can be so many different types of proteins? **(This elicit question engages students in thinking about how their work with the Puzzle Sets is a model for thinking about proteins—STeLLA Strategy 6.)**
        - **S1:** Well, if they have different kinds of pieces, like our puzzle pieces, then there can be lots of different sequences that would make them all different.
        - **T:** Can anyone add on to this idea? **(elicit)**
        - **S2:** Also, if the individual pieces have different shapes like in Puzzle Set 2, then the overall proteins can have different shapes as well as different sequences.
        - **T:** Can you say more about how their overall shapes would be different? **(probe)**
        - **S2:** Like in Puzzle Set 2, the pieces were a little different from each other, so they could link together differently—like sometimes make a turn instead of going straight. And depending on the order the pieces are in; the turns and straights come in different places and make different shapes.
        - **T:** That was a good explanation. S1 or S2, how are your models with the puzzle pieces related to proteins, and how does this explain why there can be so many types of proteins? **(This challenge question reminds students that their work with the Puzzle Sets is a content representation for proteins.)**

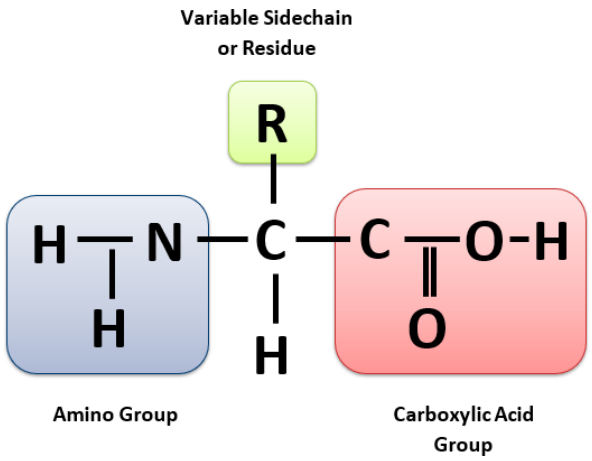
Implementation	Notes
Refer to “Focus on Student Thinking” in the SE key for possible questions to elicit, probe, and challenge student ideas. Refer to “Focus on Student Thinking” in the SE key for possible dialogue using STeLLA Strategy 6: Engage students in developing and using content representations and models.	

4. When you put a puzzle together, the pieces are the building blocks that form the full puzzle. In the same way, proteins are made of smaller pieces or building blocks. The building blocks of proteins are called amino acids. There are 20 different amino acids found in organisms.

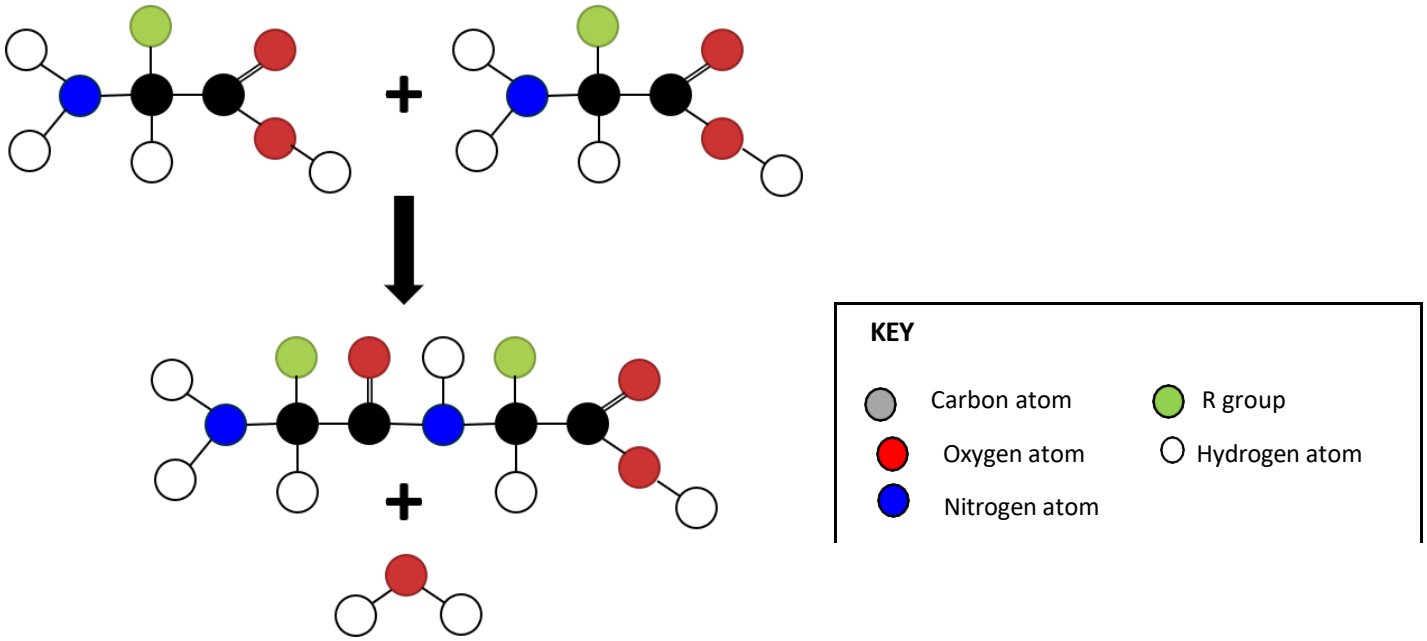
   Look at the handout that shows the 20 amino acids. In the table below, list the similarities and differences you see among all the amino acids.

Similarities among the 20 amino acids	Differences between the 20 amino acids
They all have a carbon atom bonded to 2 oxygen atoms on the right side (and a hydrogen atom bonded to one of the oxygens). They all have a nitrogen atom bonded to 2 hydrogen atoms on the left side. For all of them, the nitrogen atom is also bonded to a carbon atom in the middle, and the carbon atom with the 2 oxygens is also bonded to this other carbon, too. *(Note: This is a subtle feature that students may not notice at first.)*	The middle carbon is also bonded to other atoms that are all different from one amino acid to another.

Implementation	Notes

Activity: Differences in Jaguar Proteins
 	
• **STEP 4:** Distribute the amino acid handout to students. Note that the three letters on Puzzle Set 2 correspond with the three-letter abbreviations of some of the amino acids on the chart (i.e. Ala is the abbreviation for Alanine).
 	
• Allow time for students to quietly look for patterns among the amino acids. Students should begin working individually to complete the table. If students seem to be struggling with their ideas, you may invite them to discuss the task with their team.
 	
• Some of the similarities students should notice include:
  ○ One end of each amino acid (the bottom of the amino acids in the handout) is the same. At the center is a gray (carbon) atom with one white (hydrogen) atom attached.
  ○ Attached to the gray central (carbon) atom, there is a blue (nitrogen) and at least one white (hydrogen) atom.
  ○ There are also one gray (carbon), two red (oxygen), and one white (hydrogen) atoms attached to the gray central (carbon).
• The key difference between amino acids is the other atoms attached to the gray central (carbon) atom are different for each amino acid.
 	
• Once students have recognized these features, show the generalized structure of all amino acids. Show how this form of representing an amino acid aligns with the images they were studying on the handout.
  ○ The different atoms attached to the central carbon are called the sidechain or residue and may contain many atoms or just a few. The residue atoms may be bonded in chain or ring structures. On simplified diagrams of a generalized amino acid, the sidechain or residue is labeled as "R".
  ○ You may wish to share that the name "amino acid" is derived from the amino group and the carboxylic acid group.
 	
 
 	
• On their amino acid handout, have students draw arrows to the amino and carboxylic acid groups and circle the R groups on several amino acids to show that all amino acids have this generalized structure.	

5. Like puzzle pieces, amino acids fit together in a specific way in order to bond to one another to make a protein. Look at the example below.



Based on the example, write a rule about how amino acids bond together:

Add any new ideas from the class discussion in a different color.

Implementation	Notes

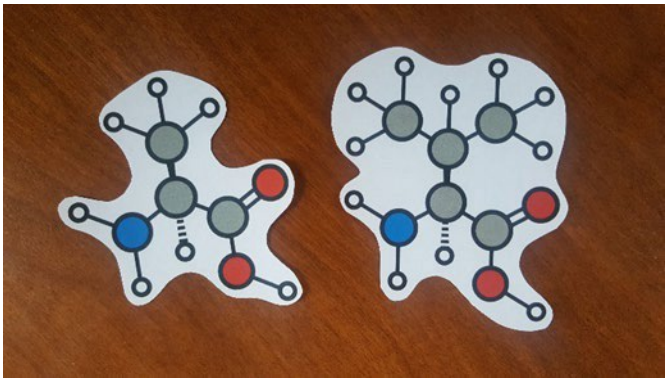
• **STEP 5:** Once students have had an opportunity to study the diagram, encourage students to discuss their ideas about how amino acids bond together with their team. If appropriate, teams can write their rule on a sentence strip and post the strips close to each other for the class to discuss.
• Ask several teams to share their rules. If the rules are very different from one another, help the class come to consensus on a class rule. For each part of the rule, students should be able to point to evidence on the diagram that led to it. The final rule should include:
  ○ The amino group of one amino acid always bonds to the carboxyl group of the next amino acid.
  ○ When the bond between amino acids is formed, a molecule of water is formed.
Students should recognize that when two amino acids are joined, a hydrogen atom is removed from the nitrogen atom of the amino group. The nitrogen atom is bound to the carbon of the carboxylic acid group and an oxygen and hydrogen was removed from that carbon to form a water molecule with the hydrogen removed from the nitrogen atom.
• During the class discussion, have students add new ideas to their original rule. Use STeLLA Strategy F: Make explicit links between science ideas and activities.
• Ask students if changing the order of amino acids would change the protein. For example, $A + B \rightarrow C + H_2O$, but $B + A \rightarrow D + H_20$.
• Decision Point:
  ○ If you are using Puzzle Set 3: Amino Acid Puzzle Set, continue with Step 6.
  ○ If you are not using Puzzle Set 3, note that the shapes produced by Puzzle Set 2 are caused by the differences in the R groups of the amino acids. Some R groups are attracted to each other, while others are repelled by each other. Then proceed to Step 8.	

6. With your team, use the Amino Acid handout to identify the amino acids in your Amino Acid Puzzle Set. Make sure you can identify the following parts of each amino acid:

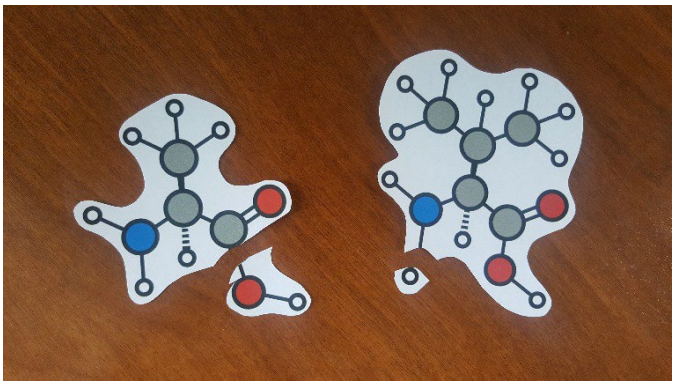
   - Amino group
   - Carboxylic acid group
   - R group

   Use the rule you developed to put together the five amino acids in the puzzle set. You can put the amino acids in any order as long as you follow the rule you developed.

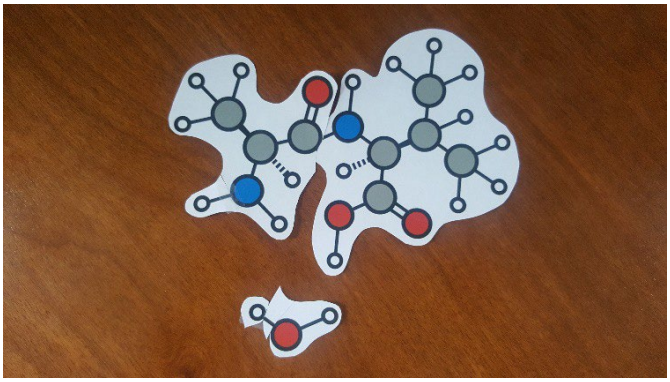
Two Amino Acids



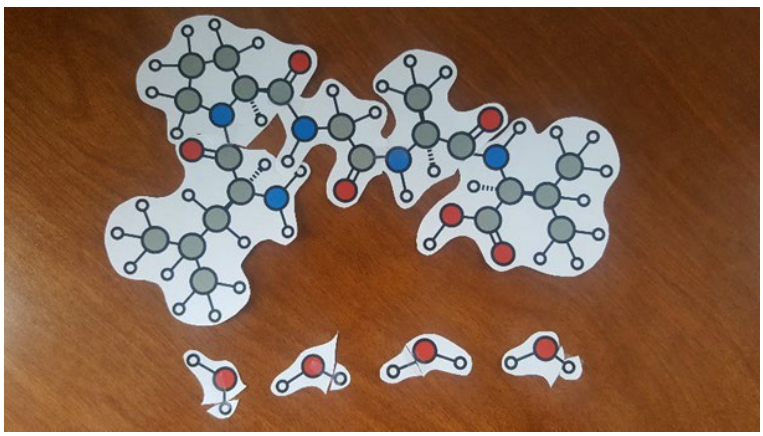
Two Amino Acids cut



Two Amino Acids bonded



Five Amino Acids bonded



Implementation	Notes

• **STEP 6:** Share that teams will apply our rule with a new puzzle set. Distribute the Amino Acid Puzzle Set to each team. Ask students to use the Amino Acid handout to identify the five amino acids in their set. Make sure that each team can identify the amino group, the carboxylic acid group and the R group on each amino acid.
• Have students follow the rule to bond their five amino acid molecules together.
  ○ They should use scissors to cut off:
  ▪ one hydrogen atom from the nitrogen atom of the amino group
  ▪ one oxygen and hydrogen atom from the carboxylic acid group
  ○ They should then tape the nitrogen atom from which the hydrogen atom was removed to the carbon atom from which the oxygen was removed. They should also tape the oxygen and hydrogen atoms together to make a water molecule. An example of the process is shown in the SE key.	

7. A short sequence of amino acids bonded together is called a peptide. Visit at least two other teams to compare your peptide to theirs. *Remember that all teams had the same amino acid puzzle pieces as your team did.* Record the differences between the peptides your team observed.

Focus on Student Thinking

- Use appropriate elicit (STeLLA Strategy 1) and probe questions (STeLLA Strategy 2) as you lead a class discussion about the similarities and differences between the peptides students observed.
    - Following are some example questions:
        - What similarities did you find among the teams' peptides? **(Elicit)**
        - What do you mean when you say the bonds between the amino acids are the same? **(Probe)**
        - What differences did you find among the peptides? **(Elicit)**
        - Can you say more about the shapes, or structures, of the peptides? **(Probe)**
        - Did you see any other similarities (differences) among the peptides? **(Probe)**
    - The following are ideas students may share:
        - All of the bonds between amino acids are from the amino group of one amino acid to the carboxylic acid group of the next amino acid.
        - Sometimes the side chains get in the way.
        - We put the amino acids in different orders.
        - They twisted and turned in different ways.
        - Every time we bonded two amino acids together, we made a molecule of water.
- The following dialogue illustrates using STeLLA Strategy F: Make explicit links between science ideas and activities:
    - **T:** What differences did you find among the peptides? **(Elicit)**
    - **S1:** We put the amino acids in different orders.
    - **T:** What else?
    - **S2:** They had different shapes.
    - **T:** Can you elaborate about what you mean by different shapes? **(Probe)**
    - **S2:** They twisted and turned in different ways.
    - **T:** So, their overall structures varied. What does this activity tell you about the effect of amino acid sequence on protein structure? **(A challenge question that helps students explicitly link their activity with a science idea about proteins.)**
    - **S3:** Well, it makes them different.
    - **T:** What do you mean by different? **(Probe)**
    - **S3:** Depending on which amino acids are next to each other, and the side groups they have, the protein chain will bend and turn differently, giving them different shapes for different orders of amino acids.

Implementation	Notes

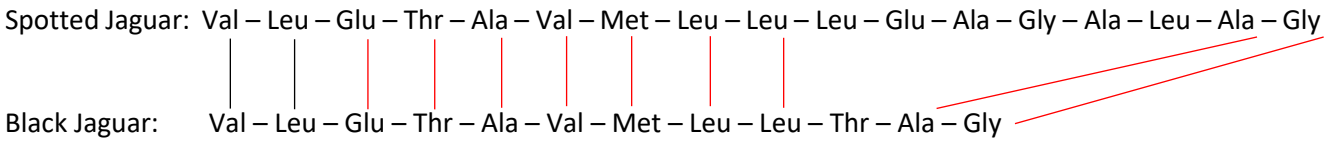
• **STEP 7:** Once teams have joined all their amino acids into a sequence, draw the class together and note that a short sequence of amino acids bonded together is called a peptide.
• Provide directions for a timed gallery walk where teams move as a group to another table to observe that group's work for a few minutes. When observing other groups' peptides, teams should look for and record the following patterns:
  ○ Accuracy of bonding (are all amino acids bonded together correctly?)
  ○ Differences between the peptide they constructed and the one they are observing.
• Once students have observed at least two other teams' peptides, have students return to their tables and record their observations in their workbooks.
• Lead a class discussion about the similarities and differences between the peptides they observed.
  ○ Elicit and probe student observations about the similarities between the peptides. Student should observe that when five amino acids are bonded together, four water molecules are formed.
  ○ Elicit and probe student observations about the differences between the peptides. As students share differences, highlight that some differences observed are differences in the sequence, or order of amino acids. Other differences observed are differences in the overall shape produced. Share that, when talking about proteins or other molecules, the shape is referred to as the structure of the molecule.
  ○ Use STeLLA Strategy F: help students make explicit links between science ideas and activities. This will help you to make sure that students understand that differences in amino acid sequence can lead to differences in protein structure.
 	
Refer to "Focus on Student Thinking" in the SE key for possible questions to elicit, probe, and challenge student ideas.
 	
See the example dialogue using STeLLA Strategy 6: Engage students in developing and using content representations and models.	

8. Many amino acids are bonded together make a protein. Three facts about proteins that will help you understand them better are:

   - Different proteins have different sequences of amino acids.
   - Different sequences of amino acids result in proteins that have different structures.
   - Within a species, a particular protein such as MC1R or hemoglobin will have the same or nearly the same sequence in each individual.

   With your team, discuss each statement to make sure you know what they mean. Point to the amino acids and peptides you put together to help you explain your ideas. Use the space below to record your ideas.

9. Study the amino acid sequences for a small portion of the MC1R protein in spotted jaguars and black jaguars. Draw lines between the two sequences to show the similarities between them. The first two are shown for you.



   Notice that the places where you did *not* draw lines between the two sequences show the places where they are different.

Implementation	Notes

• **STEP 8:** Invite students to read the three statements about proteins and discuss them with their team. Encourage students to use the amino acid puzzle pieces and the peptides they made to help them explain their ideas about the statements.
  o Circulate around the room and use STeLLA Strategy 2: Ask questions to probe student ideas and predictions and STeLLA Strategy 3: Ask questions to challenge student thinking to make student thinking visible.
  o Use STeLLA Strategy F: Make explicit links between science ideas and activities to ensure students are referring to the work done thus far as they explain each statement. Students should realize that the order of amino acids influences the overall shape of peptides and proteins.
• As students are discussing the statements, encourage them to record their ideas in their workbooks.
• **STEP 9:** Provide time for students to examine the amino acid sequences for a small portion of the MC1R protein in spotted and black jaguars.
  o Remind students that, in Lesson 2, they learned that MC1R is a regulatory protein that controls the type of pigment made in cells.
  o Refer students to the Amino Acids handout. Note that there are three ways to denote a particular amino acid: the full name, a three-letter abbreviation, and a one-letter abbreviation. In the sequences shown in their workbooks, the three-letter abbreviation was used.
• Have students draw lines between the two sequences to show similarities between them. The places where they do *not* draw lines shows where the two sequences are different. Then ask students to share things they noticed that were similar and different between the two sequences. As ideas are shared, encourage students to add new ideas to their workbooks. Key ideas to highlight include:
  o There are fewer amino acids in the black jaguar sequence.
  o The first nine amino acids are the same in both sequences.
  o The tenth amino acid in each sequence is different. In spotted jaguars, the tenth amino acid is Leu (leucine) and in black jaguars, the tenth amino acid is Thr (threonine).
  o The last two amino acids in each sequence are the same: Ala – Gly (alanine – glycine).
• Remind students that in Lesson 2, they learned that the MC1R protein found in both black and spotted jaguars was present in high amounts, even though part of the protein was deleted in black jaguars.	

Focus on Student Thinking

- Use appropriate elicit (STeLLA Strategy 1), probe (STeLLA Strategy 2), and challenge (STeLLA Strategy 3) questions as you lead a class discussion about the differences between the two amino acid sequences.
    - Following are some example questions:
        - What do you think is the importance of the differences in the two sequences? **(Elicit)**
        - So you've noticed that the amino acid sequences are different at the end. Why do you think that's important? **(Probe)**
        - How could you use what we've learned about the structure and function of proteins to help you think more about how the difference is important? **(Challenge)**
    - The following are ideas students may share:
        - The spotted jaguars have more amino acids, so they must have more protein.
        - The sequence of amino acids in black jaguar MC1R protein is different, so the protein will look different.
- The following dialogue illustrates using STeLLA Strategy F: Make explicit links between science ideas and activities:
    - **T:** What do you think is the importance of the differences in the two sequences? **(Elicit)**
    - **S1:** The sequence of amino acids in black jaguar MC1R protein is different, so the protein will be different.
    - **T:** What do others think? **(Elicit)**
    - **S2:** I don't get it. Are both sequences for MC1R? How is that possible?
    - **T:** Good question. What do others think? Are both sequences for MC1R? **(Elicit)**
    - **S2:** Ummm. It says they are.
    - **S1:** Since the amino acid sequence is different the protein will be different.
    - **S2:** Yeah.
    - **T:** You said and you agreed that since the amino acid sequence is different the protein will be different. What activity did we do that highlighted that idea?
    - **S2:** That was in the last lesson?

      [more talk]
    - **T:** So what do you think that means? **(Elicit)**
    - **S3:** Is that why they are different colors?
    - **T:** Well, what do you think?
    - **S3:** Yeah?
    - **T:** So let's be clear, S1 says…, S2 says…S3 says… Do you all agree with all those statements?

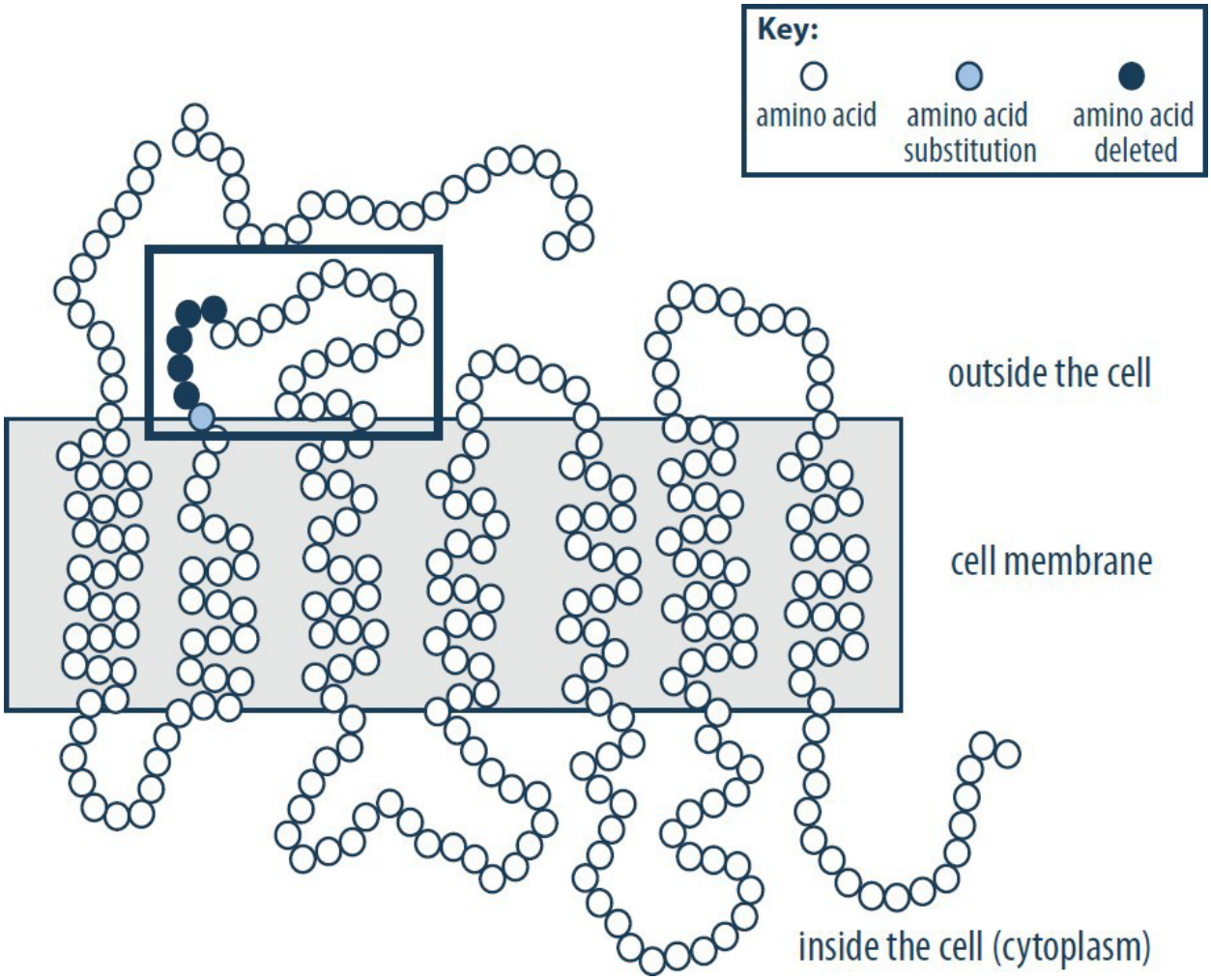
Implementation	Notes
Refer to “Focus on Student Thinking” in the SE key for possible questions to elicit, probe, and challenge student ideas. Refer to “Focus on Student Thinking” in the SE key for examples of dialogue using STeLLA Strategy 6: Engage students in developing and using content representations and models.	

10. As you read the following information, underline ideas that will help you draw a picture to show the mechanism that causes some jaguars to be black and some to be spotted.

The sequences of amino acids in Step 9 above show a small portion of the MC1R protein. The figure below shows the whole protein. In this figure, the circles represent individual amino acids. All of the circles together in the sequence represent the whole MC1R protein. The shaded rectangle represents the cell membrane of a type of cell that produces colored pigment. The portion of the protein above the shaded rectangle is located outside of the cell. The amino acids of the portion of the protein in the shaded rectangle are embedded in the cell membrane. The portion of the protein below the shaded rectangle is located inside the cell in the cytoplasm.

In spotted jaguars, a hormone protein binds to the part of the MC1R protein that has a box drawn around it. This causes the cell to make a type of melanin called pheomelanin. Pheomelanin is reddish-orange in color and causes the fur around the spots to be orange.

In black jaguars, the amino acids that are shaded black are deleted. The amino acid shaded blue is the amino acid Thr that was substituted for the Leu amino acid found in spotted jaguars. As a result of these changes, the structure of the protein is different. The hormone protein cannot bind to the MC1R protein because the portion of the protein outside of the cell is smaller. This causes the cell to make a type of melanin called eumelanin. This melanin is dark in color and causes the jaguar's fur to be dark. These black jaguars still have spots, but they are difficult to see because all of the jaguar's fur is dark.

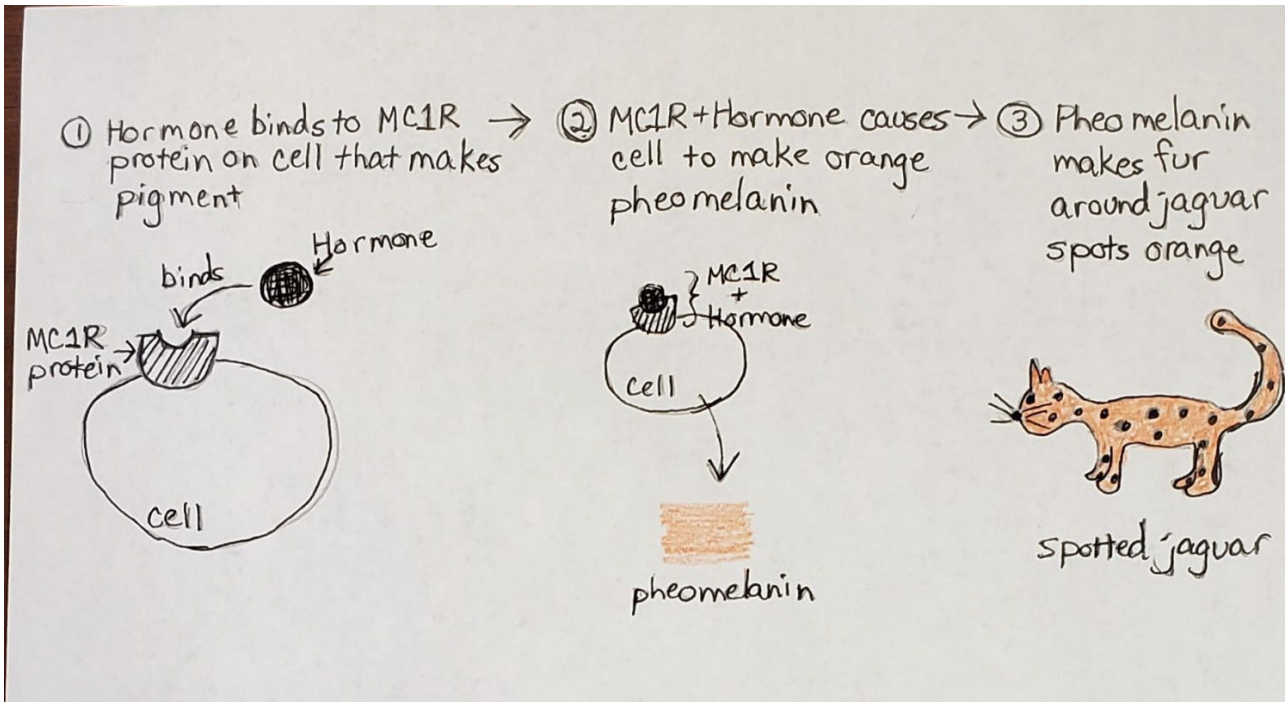


Implementation	Notes

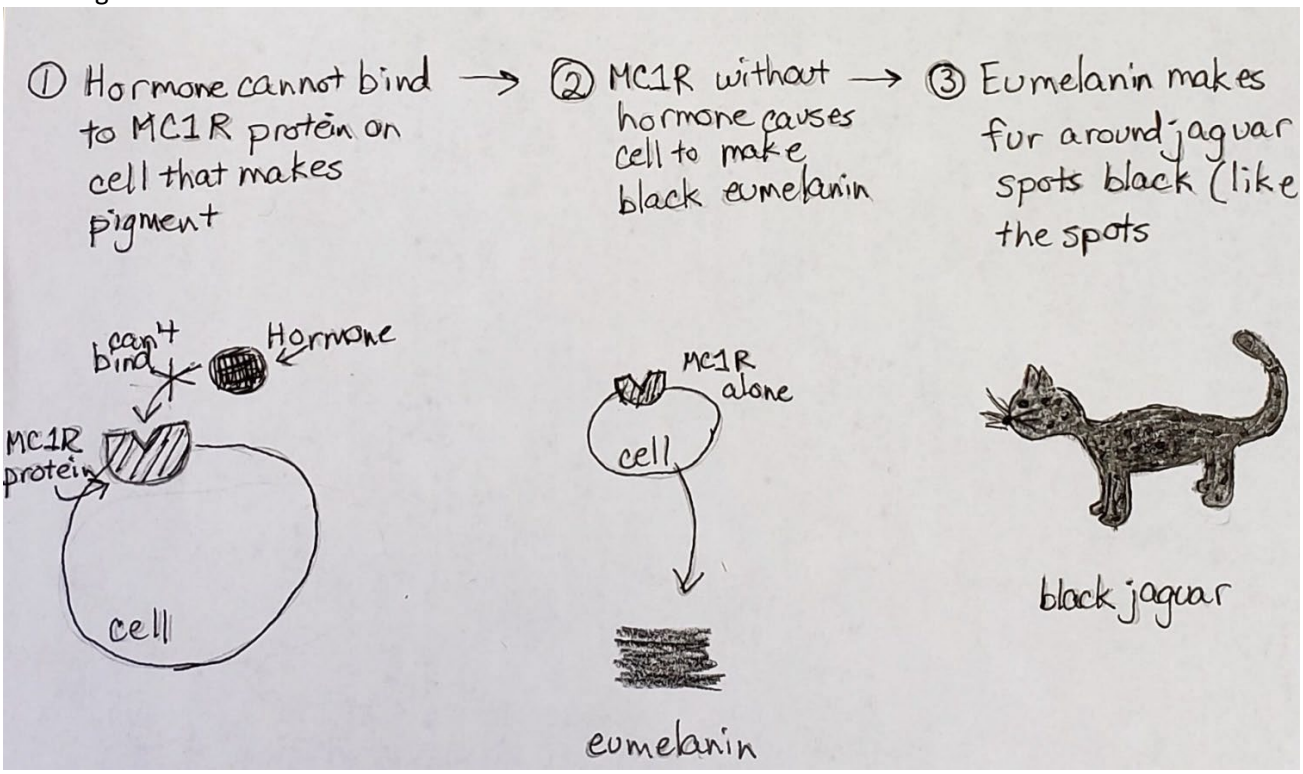
Activity Follow-up: MC1R Protein Differences in Black and Spotted Jaguars
• **STEP 10:** Have students read the information. Emphasize that students should underline information that will help them draw a picture to show the mechanism of how different proteins can cause jaguars to have different colored fur.
  ○ This is a good opportunity to use a connected Common Core ELA standard. For example, you might model the process by having a student read the first three sentences and then do a think-aloud to model what you would underline and why.
  ○ Alternatively, you could have students read the passage in pairs. One partner reads a paragraph and the other summarizes the paragraph.
• Have table groups discuss the reading to make connections between the diagram and the amino acid sequences shown in Step 9. Ensure that everyone knows how the differences in the MC1R protein of spotted and black jaguars results in differences in fur color. Ask probe and challenge questions as the groups are discussing.	

11. Draw a picture to show the mechanism that causes a jaguar to be spotted. Draw a second picture to show the mechanism that causes a jaguar to be black. Label your diagrams so it is clear what each part of your picture represents. In each diagram, show the **hormone protein**, the **MC1R protein**, and the **types of melanin (pheomelanin or eumelanin)**.

Spotted Jaguars



Black Jaguars



Implementation	Notes
• **STEP 11:** Have students use the information from the reading and figure to draw the mechanism that causes the differences in jaguar fur color. Encourage them to include all the information in the reading in their drawing (STeLLA Strategy 6: Engage students in developing and using content representations and models). You may wish to provide colored pencils for them to use in making their drawings. • To help students begin to synthesize and summarize key science ideas, once students have had an opportunity to draw on their own, have them discuss their ideas with their teams. Encourage students to add to or revise their drawings based on their discussions with their team. • Have several students share their drawings with the whole class and explain them. If available, use a document camera to share student drawings. Encourage students to use STeLLA Strategy 4: Engage students in communicating in scientific ways as they discuss their ideas. Use STeLLA Strategies 1 and 2 to make student thinking visible.	

Lesson 3: A Closer Look at Proteins

Phase of Lesson: *Summarize and Link*

Main Learning Goal: A protein's structure is determined by its amino acid sequence. The structure of a protein influences its function.

Focus Question:

How can a protein determine the traits, and versions of a trait, of an individual organism?

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 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.
- 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.

Synthesize and Summarize Key Science Ideas

12. In Lesson 2, you learned that there are many different types of proteins that have different functions in a cell. Three types of proteins responsible for differences in jaguar fur color are hormone proteins, regulatory proteins (MC1R), and pigment proteins (pheomelanin and eumelanin).

    Look at the characteristics of proteins listed in the left column of the table below. In the right column, write the word "same" or "different" to show if the characteristic would be the same or different between these three types of proteins. Be prepared to share the reasons for your answers.

Characteristic of a Protein	**Is the characteristic the same or different between MC1R, hormone, and pigment?**
The twenty amino acids that can be used as the building blocks to make a peptide or protein	same
The process by which the amino acids bond to each other	same
The sequence of amino acids	different
The structure of the proteins	different

13. The focus question for this lesson was: *How can a protein determine the traits, and versions of a trait, of an individual organism?* Return to your original answer and revise your ideas in a different color. Your goal is to include the most accurate answer that includes all the information you have learned.

Focus on Student Thinking

- Use appropriate elicit (STeLLA Strategy 1) and probe questions (STeLLA Strategy 2) as students share and explain their drawings.
    - Examples questions include:
        - Tell us about your drawing. **(Elicit)**
        - Can you clarify what is happening here where you show the MC1R and hormone proteins? **(Probe)**
        - Can you say more about how the MC1R, hormone, and pheomelanin or eumelanin proteins are different between the two types of jaguars? **(Probe)**
        - Does anyone have a drawing that shows this differently? **(Elicit)**

Implementation	Notes
Refer to "Focus on Student Thinking" in the SE Key for possible questions to elicit and probe student ideas. *Summarize* • **STEP 12:** The purpose of this step is to have students think about the characteristics of proteins that are consistent among all proteins and those that vary. The characteristics that vary may result in proteins with different structures and functions. These differences can lead to the variation of traits seen among individuals of the same species. • Have teams discuss the characteristics and complete the table. Once teams have completed the table, lead a class discussion of each characteristic. • **STEP 13:** Have students work individually to answer or revise their answer to the focus question for the lesson, writing in a different color. *Link to Next Lesson* • Remind students that in this lesson they learned about proteins. They found that amino acids are the building blocks of proteins and the structure and function of a protein depends on its specific sequence of amino acids. • Ask students how they think a cell assembles the amino acids in the correct sequence. Tell them they will learn more about how a cell does this in the next lesson.	