A Study of Traits
Lesson 2: The Same and Different

Grade: 9-10 General Biology

Length of lesson: 85 minutes

Placement of lesson: Lesson 2 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 2 Main Learning Goal

Characteristics (different versions of a trait) that organisms exhibit are the result of proteins in their bodies. Proteins perform many jobs (functions) in cells. The function (job) of a protein depends on its specific structure. If the structure (sequence of amino acids) changes, the protein may not function in the same way.

Lesson 2 Focus Question

What differences would you expect to find in two organisms of the same species that have different versions of a trait?

Ideal student response

Individuals of the same species may have different characteristics or versions of a trait than other individuals of the same species. They have different characteristics because they have different proteins. Proteins do many different jobs and serve different functions in cells because they have different shapes or structures. If the structure or shape of a protein is changed, it may not function in the same way it did before it was changed.

Science Content Storyline

The characteristics (different versions of a trait) of an individual organism are the result of the proteins in that organism. The structure of a protein determines its function; if you change the structure, the protein may not function in the same way. In jaguars, a protein determines if an individual has spotted or black fur.

Materials

- No additional materials are required for this lesson.

Lesson 2 General Outline

Time (min)	Phase of lesson	How the science content storyline develops
10	**Link to Previous Lesson** The teacher reviews the variations of the three case studies (jaguars, mosquitos, and geese) and the possible explanations (parents, genes, mutation) generated in the first lesson. **Lesson Focus Question**: **What differences would you expect to find in two organisms of the same species that have different versions of a trait?** The teacher introduces the lesson focus question.	
60	**Looking for Variation: Differences in Proteins** <u>Activity Setup</u> Students talk with a partner about the possible differences inside a jaguar that a scientist might look for to determine why jaguar fur looks different in individuals. <u>Activity</u> Students compare data of proteins found in two jaguars, one spotted and one black, looking for specific patterns that could be the reason for the differences in fur color. Students make a link between the proteins identified as consistently different in the black and spotted jaguars and their role in fur coloration. <u>Activity Follow-up</u> Students revisit the protein data, consider the role of proteins in the variations among geese and mosquitos, and confirm that protein differences might explain each of these variations.	The characteristics (different versions of a trait) of an individual organism are the result of the proteins in that organism. In jaguars, a protein determines if an individual has spotted or black fur.
10	**Synthesize and Summarize** Students compare new ideas about proteins to the possible explanations from Lesson 1 and consider if their new ideas provide any evidence supporting or eliminating any of the possible explanations.	
5	**Summarize and Link to Next Lesson** The teacher and students summarize the lesson and link to the next lesson.	

Lesson 2: The Same and Different

Phase of Lesson: *Link to Previous Lesson and Lesson Focus Question: What differences would you expect to find in two organisms of the same species that have different versions of the same trait?*

Main Learning Goal: Characteristics (different versions of a trait) that organisms exhibit are the result of proteins in their bodies. Proteins perform many jobs (functions) in cells. The function (job) of a protein depends on its specific structure. If the structure (sequence of amino acids) changes, the protein may not function in the same way.

Focus Question:

What differences would you expect to find in two organisms of the same species that have different versions of a 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

- Characteristics of all organisms are determined by proteins in each cell.

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 2: The Same and Different

Introduction

You have been learning about jaguars, mosquitos, and geese to help you understand why individuals may have different versions of a trait than others of the same species. You considered three possible explanations for variation. In this lesson, you will look more closely at two organisms of the same species that have different versions of a trait.

Process and Procedure

Lesson Focus Question

1. Write the focus question for this lesson in the box below. Write your best ideas about the question under the box. Think about the example of the black and spotted jaguars and the differences you might expect to find between them. Leave space to revise your answer as you learn more.

What differences would you expect to find in two organisms of the same species that have different versions of a trait?

Focus on Student Thinking

- Ask students to share their ideas with the entire group. The purpose is for you and the students to get a sense of the class's thinking about the focus question. Use STeLLA Strategy 1: Ask questions to elicit student ideas and predictions. Make it clear to students that just like at the beginning of Lesson 1, we are gathering a lot of ideas and that you are not going to tell which predictions are right or wrong at this point.
- Sample student responses follow:
  - The cells from spotted and black jaguars would look different.
  - The DNA from spotted and black jaguars is different.
  - If you look at their skin cells, spotted jaguars would have both black and orange pigment in the cells, but black jaguars would have only black pigment in their cells.
  - You would see different genes in the two jaguar variations.
- Be sure to probe ideas to ensure that a depth of student thinking is surfaced. Use STeLLA Strategy 2: Ask questions to probe student ideas and predictions. Again, the purpose here is to get a quick, public snapshot of what students are thinking. The goal is not to interrogate one student for five minutes. If interesting misconceptions emerge, note them on the board and come back to them at the end of the lesson. Examples of probe questions include the following:
  - Tell us more about the differences you would see in the cells from the two jaguars.
  - What do you mean when you say the DNA from spotted and black jaguars is different?
  - Can you tell us what a gene looks like?

Implementation	Notes
Link to Previous Unit ● Remind students that in the last lesson we looked at three examples of variation in different species, spotted and black jaguars, mosquitos who are resistant to insecticide and those who are not, and geese who are able to fly at extremely high altitudes and those that cannot. ● Review the three possible explanations for variation: parents, genes, and mutation. Remind students that they considered which explanation best aligned with their original ideas. ● Share that in this lesson we will continue to explore why organisms of the same species have differences by looking more closely at the example of the spotted and black jaguars. We will examine some of the differences we find in the cells of jaguars that might help us understand what is causing the differences in their fur color. *Lesson Focus Question* ● **STEP 1:** Introduce the lesson focus question, "What differences would you expect to find in two organisms of the same species that have different versions of a trait?" Ask students to write their best ideas about the lesson focus question in the space under the box, considering the example of the black and spotted jaguars. ● Ask students to share some of their initial ideas about what scientists might have looked for to answer the question of why organisms of the same species might have different versions of the same trait. If students have learned about the organization of the body, you might ask them to consider which level they think might be the best place for scientists to look for the cause of the variation. Use the information in "Focus on Student Thinking" in the SE key to see examples of ways to elicit and probe student ideas.	

Lesson 2: The Same and Different

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

Main Learning Goal: Characteristics (different versions of a trait) that organisms exhibit are the result of proteins in their bodies. Proteins perform many jobs (functions) in cells. The function (job) of a protein depends on its specific structure. If the structure (sequence of amino acids) changes, the protein may not function in the same way.

Focus Question:

What differences would you expect to find in two organisms of the same species that have different versions of a 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: 60 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

Science Ideas

- Different jaguars have different colored fur because they have different amounts of melanin in their fur. Orange jaguars have moderate amounts of melanin while black jaguars have much more melanin.
- Some mosquitos that were exposed to insecticides such as DDT were resistant to insecticides and survived when exposed to insecticides.
- Some geese can fly at extremely high altitudes because they have a different type of hemoglobin. Other geese do not have this hemoglobin and cannot fly at extreme altitudes.
- The characteristics (different versions of a trait) of an individual organism are the result of the proteins in that organism.

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.

Looking for Variation: Differences in Proteins

2. Consider the possible explanations for variation among jaguar coat color: parents, genes, or mutations. If scientists wanted to determine which of these might cause differences in fur color, they might consider different kinds of evidence. In the table below, write the name of the explanation (parents, genes, or mutations) next to the type of evidence scientists would examine to find differences between spotted and black jaguars.

Evidence scientists might examine to look for differences to explain the variation in jaguar fur color	Explanation(s) that this evidence could support
Pedigrees (jaguar family trees)	Parents
Cells	Genes*
Chemicals or substances in cells	Genes**
Chemicals or substances in the nucleus of cells	Genes, mutations

* Students may or may not associate genes with the way that *cells* appear.

** Students may or may not have learned (or remember from) middle school that genes determine the proteins that are made in cells.

Add notes from the class discussion in the space below:

Implementation	Notes

Activity Setup: Looking for Variation
• **STEP 2:** Have students read the text above the table. The purpose of this step is to have students think about what scientists might look for as they consider the origins of variation within organisms of the same species.
  ○ Have students write the name of each explanation (parents, genes, or mutations) in at least one cell in the right column of the table to represent where scientists might look for differences. Students may put an explanation name in more than one cell.
• Have students discuss their ideas about where they put each possible explanation. Tell them to add notes from the discussion in the space below the table, noting ideas that might be new to them.
  ○ Do not spend too much time on the discussion. The purpose of the discussion is to help students think about where they might find evidence of variation rather than arriving at a correct answer. Accept all answers at this point and do not correct student ideas.	

3. One scientist decided to focus on chemicals found in cells. She chose to look at the different proteins found in jaguars with different fur colors. With your partner, examine the scientist's data about different proteins found in 20 jaguars.

   a. For each protein description, circle the type of protein.

   b. Use the What I See/What It Means tool to identify similarities and differences in the patterns of proteins between black and spotted jaguars:
      i. In the space to the right of the table, draw arrows to any places where you see patterns of differences between black and spotted jaguars.
      ii. Next to each arrow, write "What I See" and a brief description of what you observe.
      iii. For each "What I See" statement, write a "What it Means" statement to show why you think the observation is important to explain the difference in fur color.

Protein Name and Description	Black Jaguars	Spotted Jaguars
Hemoglobin: a transport protein in the cytoplasm of red blood cells that carries oxygen to other cells of the body.	High levels in redblood cells	High levels in red blood cells
Keratin: a structural protein in the cytoplasm of cells that supports and protects cells. Keratin is found in skin, fingernails, and claws.	High levels in skinand claws	High levels in skin and claws
Sodium Channel: a structural protein found in cell membranes that allows sodium to move into and out of cells.	High levels in nervecells	High levels in nerve cells
Actin and Myosin: two structural proteins that work together to cause muscle contraction and movement	High levels in muscle cells	High levels in muscle cells
Eumelanin: a pigment protein found in hair, skin, and eyes.	High levels in fur	Low levels in fur
Antibodies: Immune proteins that circulate in the immune system to fight infections	High levels, particularly duringinfections	High levels, particularly during infections
Acetylcholinesterase: an enzyme protein that supports normal functioning of the nervous system. Insecticides prevent this enzyme from functioning properly.	High levels in nervecells	High levels in nerve cells
Insulin: a hormone protein that helps to regulate blood sugar levels.	Low levels, exceptafter meals	Low levels, except after meals
DNA Polymerase: an enzyme protein that makes copies of genetic information of DNA molecules in the nucleus of cells	High levels	High levels
MC1R: a regulatory protein that controls the type of pigment made in cells	High levels; part ofprotein deleted	High levels; protein complete
Ferritin: a storage protein found in the blood that stores and releases iron	High levels in blood	High levels in blood
Pepsin: an enzyme protein that breaks down food during digestion	High levels in stomach after eating	High levels in stomach after eating

What I see: Black jaguars have higher levels of eumelanin in their fur than spotted jaguars.

What it means: The difference between black and spotted jaguars is the amount of eumelanin in their cells.

What I see: Black jaguars have incomplete MC1R proteins; spotted jaguars have complete MC1R proteins.

What it means: The difference between black and spotted jaguars is whether they have complete or incomplete MC1R proteins in their cells

Implementation	Notes

Activity: Differences in Jaguar Proteins
• **STEP 3:** Have students read the text above the table. Review the directions for the activity.
  • Do a think aloud to model circling the type of protein using hemoglobin as an example. Read the description of hemoglobin and circle the phrase "transport protein".
  • Review the directions for using the What I See/What It Means tool to analyze the data in the table.
  • As students work, use elicit and probe questions to support them in focusing on the differences in the amount of eumelanin and the amount and structure of MC1R.
• Ask students to share their findings with the whole class. Use STeLLA Strategy 1: Ask questions to elicit student ideas and predictions to gather a variety of ideas and STeLLA Strategy 2: ask questions to probe student ideas and predictions to make student thinking visible. Use STeLLA Strategy 3: Ask questions to challenge student thinking as necessary to make sure the important differences between eumelanin and MC1R are highlighted in the discussion.	

Focus on Student Thinking

- Ask students to share their findings with the entire group. Use STeLLA Strategy 1: Ask questions to elicit student ideas and predictions, such as "What differences did you see between the proteins in black and spotted jaguars?"
- Use STeLLA Strategy 2: Ask questions to probe student ideas and predictions to ensure that the depth of student thinking is revealed. Examples of probe questions include the following:
    - Tell us more about the differences you saw in eumelanin from the two variations of jaguars.
    - Can you say more about the difference you saw between the MC1R protein in black and spotted jaguars?
- Push students' thinking about the differences in proteins between black and spotted jaguars and the three explanations for variations using STeLLA Strategy 3: Ask questions to challenge student thinking. Examples of challenge questions are:
    - How do you think the two protein differences (eumelanin and MC1R) in black and spotted jaguars relate to each other?
    - In what way(s) does the evidence of the difference between proteins in black and spotted jaguars support one or more of the three explanations for variations?
- The What I See/What It Means tool is a sensemaking strategy that helps students analyze and interpret data and observations. The following is an example of a dialogue that emphasizes this strategy:
    - T: Show me one of your "What I see" statements. (**Elicit**)
    - S1: We only have one: "Black jaguars have high levels of eumelanin and spotted jaguars have low levels of eumelanin."
    - T: What can you say about any other differences in proteins between the two variations of jaguars? (**Probe; Encourage students to look for patterns**)
    - S2: We didn't see any other differences; they have the same amounts of all the other proteins.
    - T: Look at the table again. Where do you see any differences in the last two columns besides differences in levels of the protein? (**Probe; Encourage students to look for patterns)**
    - S1: Oh! For the MC1R protein, it says it's complete for spotted jaguars, but part of it is deleted for black jaguars.
    - T: What can you say about the type of protein for eumelanin and MC1R? (**Probe**)
    - S1: Um, let's see. It says eumelanin is a pigment protein—that makes sense!
    - S2: And MC1R is a regulatory protein.
    - T: What do you think that means? (**Challenge**)
    - S2: I don't know . . .
    - T: Both of the proteins are different in some way between black and spotted jaguars. Think about how they might work together to cause the variation we see. (**Challenge; Encourage students to interpret their observations of differences in proteins between the two types of jaguars)**

Implementation	Notes
Refer to “Focus on Student Thinking” in the SE key for possible questions to elicit, probe, and challenge student ideas, as well as a dialogue using STeLLA Strategy 5: Engage students in analyzing and interpreting data and observations.	

4. Refer to the protein data on the previous page and the Variations in Organisms case studies about mosquitos and geese from Lesson 1.

   a. What protein might show differences between mosquitos that are resistant to insecticides and those that are not? What do you predict are the differences in the protein between mosquitos?

Protein Name	Mosquitos that are resistant to insecticide	Mosquitos that are not resistant to insecticide
Acetylcholinesterase (AChE)	Different form of AChE	Usual form of AChE

   b. What protein might show differences between geese that can fly at extremely high altitudes and those that cannot? What do you predict are the differences in the protein between geese?

Protein Name	Geese that can fly at extremely high altitudes	Geese that cannot fly at extremely high altitudes
Hemoglobin	Hemoglobin that binds oxygen quickly	Usual type of hemoglobin

Focus on Student Thinking

- Ask students to share their ideas with the whole class. Use STeLLA Strategy 1: Ask questions to elicit student ideas and predictions. Examples elicit questions are:
  - What protein or proteins did you think might be different between resistant and non-resistant mosquitos?
  - Does anyone have a different idea?
- Make student thinking visible by using STeLLA Strategy 2: Ask questions to probe student ideas and predictions. Examples of probe questions include the following:
  - Tell us more about how the hemoglobin in geese that can fly at high altitudes is different than the hemoglobin in geese that cannot.
  - Can you say more about why you think ferritin might be different in geese that can fly at high altitude and those that cannot?

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Implementation	Notes
Activity Follow-up: Protein Differences in Mosquitos and Geese • Ask an elicit question to see if students think that changes in other proteins might be responsible for the differences in individuals of these two species. Probe student ideas to make their thinking visible. • **STEP 4:** Have students look back at the Variations in Organisms case studies for mosquitos and geese. Review the variations that exist between individuals of each species: some mosquitos are resistant to insecticide while others are not, some geese can fly at extreme altitudes while others cannot. • Have student pairs discuss if they think there might be differences in proteins between individuals of the two species. Ask for a show of hands to indicate those that think differences in proteins are present in individuals of each species. • Have students refer to the protein data table and predict which protein might show differences between individuals and what the differences in the protein might be for each of the two organism types. Invite students to share their ideas with the whole class. Use STeLLA Strategy 1: Ask questions to elicit student ideas and predictions to gather a variety of ideas and STeLLA Strategy 2: ask questions to probe student ideas and predictions to make student thinking visible. Refer to “Focus on Student Thinking” in the SE key for possible questions to elicit and probe student ideas.	

Lesson 2: The Same and Different

Phase of Lesson: *Synthesize and Summarize*

Main Learning Goal: Characteristics (different versions of a trait) that organisms exhibit are the result of proteins in their bodies. Proteins perform many jobs (functions) in cells. The function (job) of a protein depends on its specific structure. If the structure (sequence of amino acids) changes, the protein may not function in the same way.

Focus Question:

What differences would you expect to find in two organisms of the same species that have different versions of a 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.
- 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

5. Reread your initial response to the lesson focus question. Revise your ideas using a different color. If you prefer to rewrite your answer, draw a line, then write your answer below the line in a different color. Be prepared to share why you made the changes you did.
6. In Lesson 1, you considered three possible explanations for variation: parents, genes, and mutations. Based on what you learned in this lesson, do you have any new evidence to support one or more of the possible explanations? If so, write the name of the explanation and the evidence below.

   I have new evidence to support the explanation of

   A. Parents B. Genes * C. Mutations *

   The new evidence that supports this explanation is:

   A. The black and spotted jaguars have differences in two of their proteins. That could be evidence that they inherited different proteins from their parents.

   B. Individuals in a species that show variations, like jaguar fur color, have different forms or amounts of proteins. Because genes tell the cell what proteins to make, this evidence supports the gene explanation.

   C. Mutations make things different, like the protein differences in black and spotted jaguars, so what we learned here supports the mutation explanation.

   *If students have learned and remember that genes code for proteins, they may recognize that what they learned about protein differences between individuals that have different variations of a trait is evidence that supports the genes explanation. They may also remember that mutations occur in genes, and thus realize that the evidence of differences in the proteins would support that explanation as well.

Focus on Student Thinking

- Ask students to discuss their ideas in their small groups. Use STeLLA Strategy 1: Ask questions to elicit student ideas and predictions, such as “Which explanation(s) do you think is(are) supported by any new evidence from this lesson?”
- Use STeLLA Strategy 2: Ask questions to probe student ideas and predictions to make students’ thinking visible. Examples of probe questions include the following:
  - Say more about how the differences you observed in proteins between black and spotted jaguars supports the parents explanation.
  - So, are you saying that genes determine what proteins are made? Is that what you mean? Or can you tell us what you do mean?

Implementation	Notes
Summarize • **STEP 5:** Invite students to reread their initial response to the lesson focus question and consider the ideas from their work in this lesson. Have students revise or add to their ideas about the lesson focus question in a different color. • Have students share any changes that they made and the reasons why they made those changes. • **STEP 6:** Ask students to look back at the three explanations from Lesson 1. Provide time for students to decide if they have any new evidence that supports one or more of the three possible explanations. Encourage small groups of students to discuss their ideas. Use STeLLA Strategy 1: Ask questions to elicit student ideas and predictions to gather a variety of ideas and STeLLA Strategy 2: ask questions to probe student ideas and predictions to make student thinking visible. Refer to "Focus on Student Thinking" in the SE key for possible questions to elicit and probe student ideas.	

Lesson 2: The Same and Different

Phase of Lesson: *Summarize and Link*

Main Learning Goal: Characteristics (different versions of a trait) that organisms exhibit are the result of proteins in their bodies. Proteins perform many jobs (functions) in cells. The function (job) of a protein depends on its specific structure. If the structure (sequence of amino acids) changes, the protein may not function in the same way.

Focus Question:

What differences would you expect to find in two organisms of the same species that have different versions of a 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: 5 Minutes

STeLLA Strategies

- ❖ Strategy I: Summarize key science ideas

Science Ideas

- Individual organisms have characteristics that differ from other individuals of the same species.
- 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.

Implementation	Notes

Summarize
• Remind students that we are trying to answer the 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?*
  ○ On the first day of the unit, students made some initial predictions about what might cause the variations in individuals of the same species.
  ○ In this lesson, we found that differences in the proteins in the cells of jaguars seem to have a connection to the differences in fur color. We also found differences in the proteins of mosquitos and geese that might have a connection to differences in individuals of those species.
Link to Next Lesson
● Link to the next lesson by sharing that in the next lesson they will have a chance to learn more about proteins and how they work in the body of organisms.	