Lesson 5: Explaining How Animals Grow

Overview

Students learn and use a scientific model to explain digestion and biosynthesis using the Three Questions.

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Guiding Question

How do animals use food to grow?

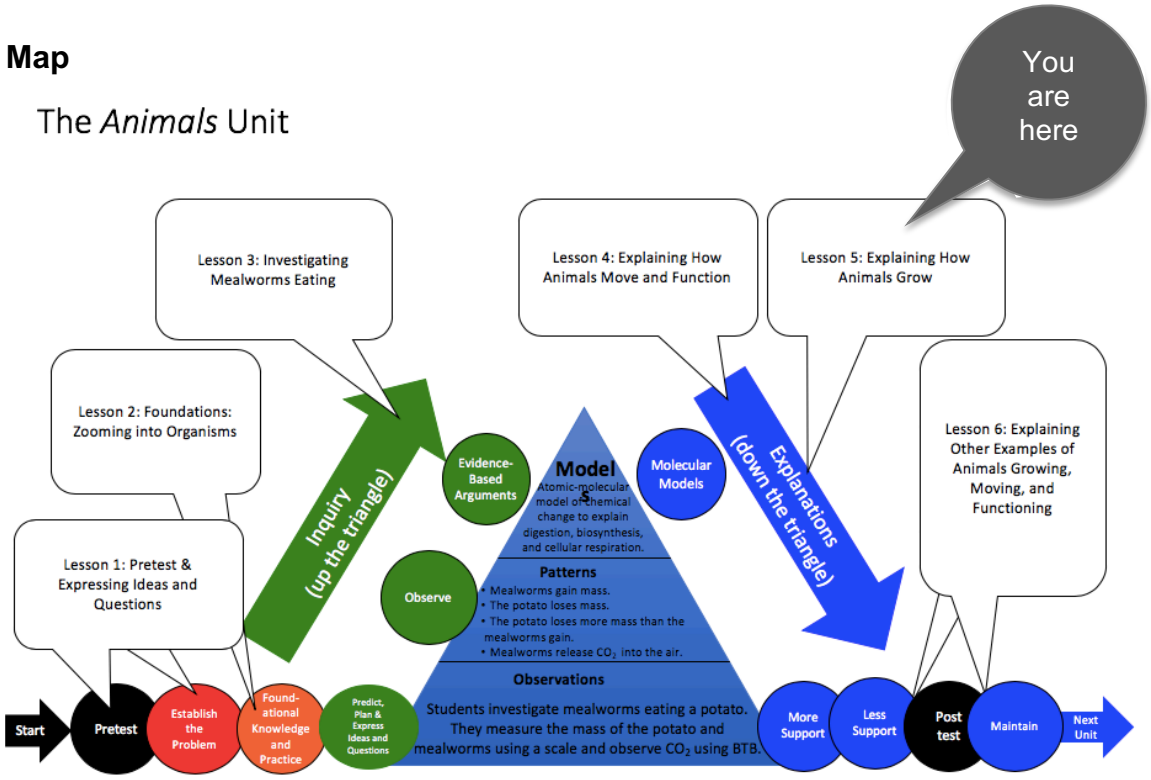
Activities in this Lesson

- Activity 5.1: Tracing the Processes of Cows Growing: Digestion and Biosynthesis (40 min)
- Activity 5.2: Molecular Models for Cows Growing: Digestion and Biosynthesis (40 min)

Note: The molecular modeling part of Activity 5.2 is exactly the same as the molecular modeling for biosynthesis in the Plants and Decomposers units. Additionally, it is a 2-turtle activity which means it involves a higher level of complexity. Consider skipping the activity if you have already taught it in another unit or if it is too advanced for your class.

- Activity 5.3: Explaining How Cows Grow: Digestion (40 min)
- Activity 5.4: Explaining How Cows Grow: Biosynthesis (40 min)

Unit Map



Learning Goals

Target Performances

Lesson 5 – Explaining How Animals Grow (students as explainers)	
Activity 5.1: Tracing the Processes of Cows Growing: Digestion and Biosynthesis	Students "zoom in" to the structure and function of a cow's organ systems and cells, tracing atoms and energy.
Optional Activity 5.2: Molecular Models for Cows Growing: Digestion and Biosynthesis	Students use molecular models to explain how polymers are broken into monomers during the process of digestion and monomers are linked into polymers during biosynthesis.
Activity 5.3: Explaining How Cows Grow: Digestion	Students explain how matter moves and changes and how energy changes during digestion in a cow (connecting macroscopic observations with atomic-molecular models and using the principles of conservation of matter and energy).
Activity 5.4: Explaining How Cows Grow: Biosynthesis	Students explain how matter moves and changes and how energy changes during biosynthesis in a cow's cells (connecting macroscopic observations with atomic-molecular models and using the principles of conservation of matter and energy).

NGSS Performance Expectations

Middle School

- MS. Matter and its Interactions. MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.

High School

- HS. From Molecules to Organisms: Structures and Processes. HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
- HS. From Molecules to Organisms: Structures and Processes. HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.

Background Information

Three-dimensional Learning Progression

The three activities in this lesson complete the **Explanations Phase** of the *Animals* unit. This involves modeling and coaching with the goal of helping students develop atomic-molecular scale accounts of the digestion, and biosynthesis that were drivers of the macroscopic changes they observed in their Mealworms Eating investigation in Lesson 3.

Key Ideas and Practices for Each Activity

Activity 5.1 is the first part of the **Explanations Phase** of the instructional model (going down the triangle) for digestion and biosynthesis. Students trace the chemical changes of digestion and biosynthesis in the body of a cow using a poster of a cow.

Activity 5.2 is a 2-turtle activity appropriate for advanced middle school or high school students and classes. If you decide not to teach 5.2, you can move directly from 5.1 to 5.3. In 5.2, students model the chemical changes of digestion and biosynthesis using paper molecules. This activity introduces and uses the vocabulary of polymer and monomer, as well as the names of specific monomers.

Activity 5.3 is the second part of the **Explanations Phase** of the instructional model (going down the triangle) for digestion. Students use the **Explanations Tool** to construct final explanations of what happens when animals break large organic molecules from their food into small organic molecules. This activity is appropriate for students who did only 5.1 and students who did both 5.1 and 5.2, but the vocabulary used to describe the molecules will be different depending on what activities were taught. Ideally, at this phase their explanations will combine evidence from macroscopic-scale observations during the investigation with their new knowledge of chemical change at the atomic-molecular scale.

Activity 5.4 continues the second part of the **Explanations Phase** of the instructional model (going down the triangle) for biosynthesis. Students use the **Explanations Tool** to construct final explanations of what happens when animals use small organic molecules to gain mass. This activity is appropriate for students who did only 5.1 and students who did both 5.1 and 5.2, but the vocabulary used to describe the molecules will be different depending on what activities were taught. Ideally, at this phase their explanations will combine evidence from macroscopic-scale observations during the investigation with their new knowledge of chemical change at the atomic-molecular scale.

Key Carbon-Transforming Processes: Digestion and Biosynthesis

Content Boundaries and Extensions

Talk and Writing

This lesson of the unit represents the fading portion of the **Explanations Phase**. This means that students are expected to develop explanations for carbon-transforming processes they studied in this unit in *new* and *novel* contexts. The table below shows specific talk and writing goals for the Explanations phase of the unit.

Talk and Writing Goals for the Explanations Phase	Teacher Talk Strategies That Support This Goal	Curriculum Components That Support This Goal
Examine student ideas and correct them when there are problems. It's ok to give the answers away during this phase! Help students practice using **precise language** to describe **matter and energy**.	*Let's think about what you just said: air molecules. What are air molecules?* *Are you talking about matter or energy?* *Remember: atoms can't be created. So that matter must have come from somewhere. Where did it come from?* *Let's look at the molecule poster again… is carbon an atom or a molecule?*	Molecule Poster Three Questions Poster
Focus on making sure that explanations include multiple **scales**.	*The investigation gave us evidence for what was happening to matter and energy at a macroscopic sale. But what is happening at an atomic-molecular scale?* *What is happening to molecules and atoms?* *How does energy interact with atoms and molecules during chemical change?* *Why doesn't the macroscopic investigation tell us the whole story?* *Let's revisit our scale poster… what is happening to matter at the molecular scale?*	Molecular Models Molecular Modeling Worksheets **Explanations Tool** PPT Animation of chemical change Powers of Ten Poster
Encourage students to recall the investigation.	*When did this chemical change happen during our investigation?* *How do we know that? What is our evidence?* *What were the macroscopic indicators that this chemical change took place?*	**Evidence-Based Arguments Tool** Investigation Video
Elicit a range of student explanations. Press for details. Encourage students to examine, compare, and contrast their explanations with others'.	*Who can add to that explanation?* *What do you mean by _____? Say more.* *So, I think you said _____. Is that right?* *Who has a different explanation?* *How are those explanations similar/different?* *Who can rephrase _____'s explanation?*	**Explanations Tool**

Activity 5.1: Tracing the Processes of Cows Growing: Digestion and Biosynthesis (40 min)

Overview and Preparation

Target Student Performance

Students "zoom in" to the structure and function of a cow's organ systems and cells, tracing atoms and energy.

Resources You Provide

- pennies (5 per pair of students)
- nickels (2 per pair of students)
- video of a cow growing, such as here: https://www.youtube.com/watch?v=LWJN7li120c

Resources Provided

- 5.1 Tracing the Processes of Cows Growing: Digestion and Biosynthesis PPT
- 5.1 Tracing the Process for Cow Growing: Digestion and Biosynthesis Directions (1 per student or pair of students)
- 5.1 Tracing Atoms and Energy in Animals Worksheet (1 per student)
- 5.1 Grading the Tracing Atoms and Energy in Animals Worksheet

Recurring Resources

- Digestion and Biosynthesis of Carbohydrates 11 x 17 Poster (1 per class)
- Digestion and Biosynthesis of Fat 11 x 17 Poster (1 per class)
- Digestion and Biosynthesis of Protein 11 x 17 Poster (1 per class)
- Metabolic Pathways 11 x 17 Poster (http://www.sigmaaldrich.com/content/dam/sigma-aldrich/docs/Sigma/General_Information/metabolic_pathways_poster.pdf) (1 per class)
- Cow 11 x 17 Poster (1 per pair of students)

Setup

Print a Cow 11 x 17 Poster for each pair of students. Gather enough pennies and nickels to have 5 pennies for each pair of students and 2 nickels for each pair of students. Print one copy of 5.1 Tracing the Processes of Cows Growing: Digestion and Biosynthesis Directions for each student or pair of students. Print one copy of 5.1 Tracing Atoms and Energy in Animals Worksheet for each student. Prepare a computer and a projector to display the PPT. Print and hang the Digestion and Biosynthesis 11 x 17 Posters and the Metabolic Pathways 11 x 17 Poster.

Directions

1. Have students start to think about how cows grow.

Tell students that in today's activity they will learn about how cows grow through digestion and biosynthesis.

- Open 5.1 Tracing the Processes of Cows Growing: Digestion and Biosynthesis PPT.

2. Use the instructional model to show students where they are in the course of the unit.

Show slide 2 of the 5.1 Tracing the Processes of Cows Growing: Digestion and Biosynthesis PPT.

3. Discuss Connecting Questions about Processes at Different Scales for Digestion

Display slide 3 in the PPT. Show students the short clip of a cow growing. Follow the link in the PPT, in the materials list, or here (https://www.youtube.com/watch?v=LWJN7li120c). You can opt to only play thirty seconds.

- Introduce students to the macroscopic driving question: *How do cows get food to all of their cells?*
- Connect this question at the macroscopic scale to an unanswered question at the microscopic scale: *How do food molecules get into a cow's blood?*
- Connect this question at the microscopic scale to an unanswered question at the atomic-molecular scale: *How are molecules in food changed chemically so that a cow's cells can use them?*
- Assure students that we will be able to answer several of their unanswered questions by the end of today's activity.

4. Have students think about what happens to the food cows eat (digestion).

Display Slide 4 to show students that animals use digested food in two ways. Tell students they have learned about one of those uses (cellular respiration). Today they'll be focusing on what happens to the food cows eat before the food molecules are used for cellular respiration, digestion, and later in the lesson the second way that animals' use digested food.

- Display Slide 5 to introduce the parts of a cow, focusing on the stomach, intestines, and leg muscle.
- Give each pair of students a Cow 11 x 17 Poster, a copy of 5.1 Tracing the Process for Cow Growing: Digestion and Biosynthesis Directions (you may want to give each student a copy of these directions), 2 nickels, and 5 pennies.
- Explain that they will follow the directions to use their nickels and pennies to trace the path of food in the cow.
- Tell students to pause at the end of the first page.

5. Show the animation of digestion.

Display slides 6 and 7 when all pairs have finished the first page of directions.

- Show students the animation of digestion so they can see what happens to carbon atoms and energy during the process.
- When watching the slides, ask students what is happening to energy. Listen to see if they notice that chemical potential energy is conserved in the C-C- and C-H bonds through digestion.
- Show students the Digestion and Biosynthesis 11 X 17 Posters to help students visualize the process.

6. Have students trace steps 4-6 on the cow poster.

Tell students to continue following the directions on 5.1 Tracing the Process for Cow Growing: Digestion and Biosynthesis Directions and pause when they finish step 6.

7. Transition students to talk about biosynthesis.

Use slides 9 and 10 in the PPT to transition to biosynthesis.

- Tell students that cells use digested food for cellular respiration (that they explained in Activity 4.2) and also for growth, which is done through a process called biosynthesis.
- Have students finish the directions on 5.1 Tracing the Process for Cow Growing: Digestion and Biosynthesis Directions to trace biosynthesis.

- Note: biosynthesis occurs in all cells, but here muscle cells are an example.

8. Show an animation of the process of biosynthesis.

Display slide 11-12 to show an animation of what happens to the molecules and chemical energy during biosynthesis.

- When watching the slides, ask students what is happening to energy. Listen to see if they notice that chemical potential energy is conserved in the C-C- and C-H bonds through biosynthesis.
- Show students the Digestion and Biosynthesis 11 X 17 Posters to help students visualize the process.

9. Discuss how animal cells use sugar molecules.

Use slides 13 and 14 to discuss how animal cells use sugar molecules.

- Use slide 13 to point out the problem: Lots of sugar molecules reach animal cells, but they are not made into starch or fiber polymers in animal cells.
- Use slide 14 to explain the two main ways that animals use sugar molecules: (a) they are used to make glycerol and fatty acids and eventually fat (this explains why eating lots of starch and sugar can make someone gain weight), and (b) they are used for cellular respiration, which uses sugar and oxygen to release energy.

10. Transition to have students consider the atoms that make up animals.

Show slide 15 of the PPT. Pass out 5.1 Tracing the Atoms and Energy in Animals Worksheet to each student.

- Tell students that now they have considered how molecules move through and are used by a cow, they will now consider the atoms that make up animals.
- Read the top portions of the worksheet with students.
- Have students work with a partner to complete the first chart on the worksheet about atoms.

11. Have students identify where the atoms that make up animals come from.

Show slide 16 of the PPT.

- Remind students that in Lesson 2 they learned about the molecules that make up cells and the atoms that make up the molecules.
- Discuss the answers to the first chart on the worksheet. The atoms in the large organic molecules of animals all primarily come from food. Water and air are used during cellular respiration.

12. Have students identify where the energy in animals come from.

Show slide 17 of the PPT.

- Have students complete the second chart on 5.1 Tracing the Atoms and Energy in Animals Worksheet on energy with a partner.
- Show slide 18. Remind students that chemical energy is in C-C and C-H bonds.
- Discuss students' answers together. Chemical energy is only found in the food that animals take in. There is no chemical energy in the water or air animals take in.

13. Show students that there are many additional metabolic pathways.

Use slide 19 and the Metabolic Pathways 11 x 17 Poster to show students that there are many more metabolic pathways besides what they learned about in this lesson.

- This poster only shows pathways in which small organic molecules are changed into other small organic molecules. There are other pathways that change small organic molecules into large organic molecules.
- Explain that these processes allow cows who eat mostly carbohydrates in grass to be made up of protein and fat.
- Organisms are complex; this poster also offers students a glimpse of their complexity.

Assessment

- Matter tracing: note if students are able to recognize that the same atoms that were in food are still the atoms in the large organic molecules at the end of biosynthesis.
- Energy tracing: note the ways that students explain how chemical energy is conserved through both digestion and biosynthesis.
- Use 5.1 Grading the Tracing Atoms and Energy in Animals Worksheet to grade students' answers on 5.1 Tracing Atoms and Energy in Animals Worksheet.

Differentiation & Extending the Learning

Differentiation

- Introduce the terms Large Organic Molecules and Small Organic Molecules with examples. Students will need this information to explain digestion and biosynthesis.
- Strategic grouping with strong speakers
- Hand out individual Cow Posters for students to trace molecules that can be written on and kept in the accompaniment of the Penny/Nickel exercise
- Work on Tracing Atoms and Energy worksheet together and create a pie chart to show what makes up animals from the information students gather

Modifications

- At the end of the activity, have students explain the difference between biosynthesis and digestion to a partner.
- Have the students "act out" digestion and biosynthesis by assigning them molecules using signs. Have them move around the room to represent the two processes by linking and unlinking hands.

Extending the Learning

- Try using this animation of digestion as a follow up activity. Notice the animation of digestion in the "zoom in" sections: http://kitses.com/animation/swfs/digestion.swf

Activity 5.2: Molecular Models for Cows Growing: Digestion and Biosynthesis (40 min)

Overview and Preparation

Target Student Performance

Students use molecular models to explain how polymers are broken into monomers during the process of digestion and monomers are linked into polymers during biosynthesis.

Note: This is a 2-turtle lesson, which is appropriate for advanced middle school or high school students and classes. If you decide not to teach this lesson, you can move directly from 5.1 to 5.3.

Resources You Provide

- scissors (1 per pair of students)
- removable or re-stick tape (1 dispenser per pair of students)

Resources Provided

- 5.2 Molecular Models for Cows Growing: Digestion and Biosynthesis PPT
- 5.2 Polymers for Cutting Handout (1 copy for every four students)

Recurring Resources

- Molecular Models 11 x 17 Placemat (1 per pair of students)
- Forms of Energy Cards (1 per pair of students)
- Digestion and Biosynthesis of Carbohydrates 11 x 17 Poster (1 per class)
- Digestion and Biosynthesis of Fat 11 x 17 Poster (1 per class)
- Digestion and Biosynthesis of Protein 11 x 17 Poster (1 per class)
- Cow 11 x 17 Poster (1 per pair of students)

Setup

Prepare one Molecular Models 11 x 17 Placemat, one pair of scissors, one set of Forms of Energy Cards, and one removable tape dispenser for each pair of students. Print one copy of 5.1 Polymers for Cutting Handout for every four students. Cut each handout in half so you can give each pair one of each polymer (protein, carbohydrate, and fat) and the attached water molecules. Prepare a computer and a projector to display the PPT. Print and hang the Digestion and Biosynthesis 11 X 17 Posters, the Cow 11 x 17 Poster, and the Metabolic Pathways 11 x 17 Poster.

Directions

1. Have students start to think about how cows grow.

Tell students that in today's activity we will use molecular modeling to think more about how cows grow through digestion and biosynthesis.

- Open 5.2 Molecular Models for Cows Growing: Digestion and Biosynthesis PPT.

2. Use the instructional model to show students where they are in the course of the unit.

Show slide 2 of the 5.2 Molecular Models for Cows Growing: Digestion and Biosynthesis PPT.

3. Discuss processes at different scales for digestion.

Display slide 3 in the PPT.

- Revisit the driving questions first seen in Activity 5.1. Tell students that today's activity is focused at the atomic-molecular scale.

4. Have students think about what happens to the food cows eat (digestion).

Display Slide 4 to review that animals use digested food in two ways.

5. Tell students that these large organic molecules in food are broken down into small organic molecules during digestion.

Display slide 5 to show students large organic molecules are broken down into small organic molecules during digestion. Tell students large organic molecules are called polymers and small organic molecules are called monomers. It may help students to remember these words by explaining the meaning of the words' prefixes (poly means many and mono means one).

- Tell students that they'll be using molecular models to model the process of digestion, which will help them answer several of their unanswered questions.

6. Review the "rules" of molecular bonding in digestion.

Use slide 6 to remind students how atoms bond to make molecules.

- Oxygen atoms bond to carbon or hydrogen (not other oxygen atoms) whenever possible. This will help students decide which monomer will bond to an –OH and which will bond to an –H.
- Nitrogen forms three bonds.
- Point out that digestion will not make or break "high energy" C-C or C-H bonds. Students can use this information to determine where to attach the –H vs. –OH in the activity.

7. Have students set up their reactants and model digestion.

Give each pair of students a Molecular Models 11 x 17 Placemat, one set of Forms of Energy Cards, one pair of scissors, a removable tape dispenser, and one protein molecule, one carbohydrate molecule, one fat molecule, and eight water molecules (from the 5.2 Polymers for Cutting Handout).

- Have students place a "chemical energy card" on the reactants side of their placemat, along with their water, protein, carbohydrate, and fat molecules.
- Coach students to simulate the process of hydrolysis by cutting a water molecule *each time* they make a cut in the polymer. This helps show that each time a bond between two monomers is broken, the chemical reaction requires water and new bonds form.
- **Protein**: Show slide 7. Have students cut one protein polymer into amino acid monomers. Then, cut the water molecules and attach an –H and an –OH to each amino acid. Watch the animation on slides 8-9.
- **Carbohydrate**: Show slide 10. Have students cut one starch polymer (a type of carbohydrate) into glucose monomers. Then cut the water molecules and attach an –H and an –OH to each glucose. Watch the animation on slides 11-12.
- **Fat**: Show slide 13. Have students cut one fat polymer into glycerol and fatty acid monomers. Then, cut the water molecules and attach an –H and an –OH to each monomer. Watch the animation on slides 14-15.
- Have students move the new molecules with the energy card to the products side of their placemat. When watching the slides, ask students what is happening to energy. Listen to see if they notice that chemical potential energy is conserved through digestion.

- Show the students the Digestion and Biosynthesis 11 x 17 Posters as a visual of the process.

8. Show students where digested monomers go in the body.

Use slide 16 to remind students that blood carries digested monomers to all parts of animals' bodies.

- Because the molecules are small, they can pass through the intestinal walls and into the blood.

9. Transition students to model biosynthesis.

Use slides 17 and 18 in the PPT to transition to biosynthesis.

- Ask students what they remember about biosynthesis from Activity 5.1

10. Remind students what is in cow muscle.

Show slide 19 to remind students of the information they learned from beef nutritional labels: cow muscles are made primarily of protein (18g) and fat (21g). This means that the cells in the animal's leg muscle are going to make fat and protein molecules so the muscle cells can grow bigger and divide.

- Tell students that they will use the placemat and molecules to model the process of biosynthesis, which is what happens when animals build polymers from monomers
- Point out that when they are modeling, they should remember that during biosynthesis, no "high energy" C-C or C-H bonds will be made or broken. The chemical energy is conserved!
- Refer to the Digestion and Biosynthesis 11 x 17 Posters in your classroom to help students visualize the biosynthesis of monomers to polymers.

11. Have students set up their reactants and model biosynthesis.

Have students place a "chemical energy card" on the reactants side of their placemat, along with their amino acids, fatty acids, glycerol and glucose molecules. Coach students to simulate the actual process of dehydration synthesis by making a water molecule *each time* they tape two monomers together. This helps show that each time a bond is broken a chemical reaction takes place and new bonds form.

- **Protein**: Show slide 20. Have students tape together four amino acid monomers to form one protein polymer and three water molecules. Then, watch the animation on slides 21-22.
- **Fat**: Show slide 23. Have students tape together one glycerol and three fatty acid monomers to form one fat polymer and three water molecules. Then, watch the animation on slides 24-25.
- **Carbohydrate**: Tell students that animals don't make starch (though they make other carbohydrates)!
- Have students move the new molecules with the energy card to the products side of their placemat. Ask students what is happening to energy during biosynthesis. Listen to see if they notice that chemical potential energy is conserved through the chemical change.
- Make the connection to cell division: cells have to both get bigger and also divide in order for animals to grow. This is why we perform biosynthesis: to make our cells get bigger (growth) so they can divide.

12. Conclude by having students think about the composition of materials that enter, stay in, and leave the cow.

Use slide 26 to have students consider the composition of materials that enter, stay in, and leave a cow.

- Students may point out that there is fat in the cow, but not in the grass. Ask them "Where did the fat in the cow come from?" After the lesson, they should be able to answer that question as they "built" fat molecules in their model biosynthesis.

Assessment

- Matter tracing: note if students are able to recognize that the same atoms that were in the reactants are also in the products.
- Energy tracing: note the ways that students explain how chemical energy is conserved through both digestion and biosynthesis.

Tips

- This activity may not be appropriate for middle school students due to its emphasis on molecular details of digestion and biosynthesis
- Laminate the Molecular Models 11 x 17 Placemats. These will be used multiple times in each unit.
- During the molecular modeling activity and animation, focus on how matter and energy are conserved through the chemical change. This is the main goal of the activity!

Differentiation & Extending the Learning

Differentiation

- Strategic grouping with strong speakers
- Introduce the terms Large Organic Molecules and Small Organic Molecules with examples. Students will need this information to explain digestion and biosynthesis.

Modifications

Extending the Learning

Activity 5.3: Explaining How Cows Grow: Digestion (40 min)

Overview and Preparation

Target Student Performance

Students explain how matter moves and changes and how energy changes during digestion in a cow (connecting macroscopic observations with atomic-molecular models and using the principles of conservation of matter and energy).

Resources You Provide

- (From previous lesson) 3.3 Evidence-Based Arguments for Mealworms Eating

Resources Provided

- 5.3 Explaining How Cows Grow: Digestion PPT
- 5.3 Explanations Tool for Cow Digestion (1 per student)
- 5.3 Grading the Explanations Tools for Cow Digestion
- (Optional) 5.3 How do Digest Food? Reading (1 per student)

Recurring Resources

- Animals Matter Tracing Tool (1 per student)
- Assessing the Animals Matter Tracing Tool
- Cow 11 x 17 Poster (1 per pair of students)
- (Optional) Example Animal Explanations Handout (1 per student or per group)
- Digestion and Biosynthesis of Carbohydrates 11 x 17 Poster (1 per class)
- Digestion and Biosynthesis of Fat 11 x 17 Poster (1 per class)
- Digestion and Biosynthesis of Protein 11 x 17 Poster (1 per class)
- Three Questions 11 x 17 Poster (1 per class)
- Three Questions Handout (1 per student)

Setup

Print one copy of the 5.3 Explanations Tool for Cow Digestion and 5.3 How do Animals Get the Matter and Energy They Need to Grow, Move, and Function? Reading (if you choose to use it) for each student. Prepare a computer and a projector to display the PPT. Print and hang the Digestion and Biosynthesis 11 x 17 Posters. In this activity, your students will need to use the Three Questions Explanation Checklist on the back of the Three Questions Handout. Be sure to have this available to students and see the notes in the Modifications at the end of the Activity for ideas about how to use it.

Directions

1. Use the instructional model to show students where they are in the course of the unit. Show slide 2 of the 5.3 Explaining How Cows Grow: Digestion PPT.
2. Remind students of their unanswered questions. Using slide 3 of the PPT have students revisit their arguments and unanswered questions from the Mealworm Investigation by looking at 3.3 Evidence-Based Arguments for Mealworms Eating.

- Remind students that after explaining cellular respiration in Lesson 4.2 there were still unanswered questions about how animals grow and where the glucose needed for cellular respiration comes from.
- In today's lesson, students will use what they learned in Lesson 5.1 (and 5.2) to explain how cows get food to their bodies' cells.

3. Have students review the process of digestion.

Use slides 4-5 of the 5.3 Explaining How Cows Grow: Digestion PPT to guide students through a review of digestion.

- Use Slide 4 to review how animals use food to grow. Ask students for their ideas about what they remember from the previous activity.
- Use slides 5 to remind students what happens to the food that IS digested: Large organic molecules (polymers) are divided into small organic molecules (monomers) that go into the blood.
- Display the following posters in your classroom to help students visualize the digestion of polymers to monomers.
  - **Carbohydrates:** Use the Digestion and Biosynthesis of Carbohydrates 11 x 17 Poster to offer students a visualization of how polymers like starch (which is a type of carbohydrate) are broken apart into monomers like glucose.
  - **Fat:** Use the Digestion and Biosynthesis of Fat 11 x 17 Poster to offer students a visualization of how polymers like fat are broken apart into monomers like fatty acids and glycerol.
  - **Proteins:** Use the Digestion and Biosynthesis of Protein 11 x 17 Poster to offer students a visualization of how polymers like proteins are broken down into amino acids.
  - Note: If you only taught 5.1, you can use the posters to help students visualize the process, but do not need to focus on the names of the small organic molecules.

4. Have students complete their Explanations Process Tool for Digestion.

Show slide 6 of the 5.3 Explaining How Cows Grow: Digestion PPT. Give each student one copy of 5.3 Explanations Tool for Cow Digestion.

- Tell students that in this part of the investigation, they will combine everything they learned about how cows get food to their body's cells into an explanation.
- Remind them to consider both their evidence from the investigation as well as what they learned in the molecular modeling (or tracing) activity to construct their explanations.
- Give students about 10 minutes to complete the Explanations process tool.

5. Have students share explanations with each other.

Show slide 7 of the 5.3 Explaining How Cows Grow: Digestion PPT. Divide students into pairs and have them compare explanations for the Three Questions and the final explanation on the process tool.

- Have students use the Three Questions 11 x 17 Poster (or Handout) as a reference. Have students check their explanations with the middle and right-hand columns of the poster or handout to make sure they are following the "rules."

6. Have students think about how digestion answers the Matter Movement question.

Use slides 8-13 in the PPT to have the students discuss what is happening to matter during digestion and to have them check their answers to the Matter Movement Question on their 5.3 Explanations Tool for Cow Digestion.

- Show students slides 8-10 to have them think about where atoms are moving from and moving to during digestion.
- Display slides 11-13 to have students compare their answers to the Matter Movement Question with the answers on the slides. Have students use a different colored writing utensil to make any needed changes to their answers. Allow students to ask questions if they do not understand why their ideas are incorrect.
- If students have model explanations to share, display student work and discuss. If students have common areas of weakness in their explanations, ask for a volunteer to share, display student work, and discuss ways of strengthening the response.

7. Have students think about how digestion also answers the Matter Change Question.

Show slide 14 to begin discussion the Matter Change Question.

- Display slides 15-16 to have students compare their answers to the Matter Change Question on the 5.3 Explanations Tool for Cow Digestion with the answers on the slide. Have students use a different colored writing utensil to make any needed changes to their answers. Allow students to ask questions if they do not understand why their ideas are incorrect.
- If students have model explanations to share, display student work and discuss. If students have common areas of weakness in their explanations, ask for a volunteer to share, display student work, and discuss ways of strengthening the response.

8. Discuss how digestion helps to answer Energy Change questions.

Display slide 17 to begin discussion the Energy Change Question.

- Display slide 18 to have students compares their answers to the Energy Change Question on the 5.3 Explanations Tool for Cow Digestion with the answers on the slide. Have students use a different colored writing utensil to make any needed changes to their answers. Allow students to ask questions if they do not understand why their ideas are incorrect.
- If students have model explanations to share, display student work and discuss. If students have common areas of weakness in their explanations, ask for a volunteer to share, display student work, and discuss ways of strengthening the response.

9. (Optional) Have students critique example explanations.

Display slide 19 of the PPT for the full story of digestion. Have students look at two handouts: (a) The Three Questions Handout, and (b) the Animals Example Explanations Handout.

- Ask students to evaluate the two example explanations of cow digestion on the Animals Example Explanations Handout: Which explanation is better? Why?
- Have students use the Three Questions Explanation Checklist on the back of the Three Questions Handout to justify their critiques of the explanations.

10. Have students critique and improve their full explanations.

Display slide 19 of the PPT for the full explanation. Have students use the Three Questions Explanation Checklist on the back of the Three Questions Handout to check that their story includes each of the parts (matter movement, matter change, energy change, and matter movement).

- If students don't have all four parts in their explanation, instruct them to add to their explanation using a different colored writing utensil.
- If students have model explanations to share, display student work and discuss. If students have common areas of weakness in their explanations, ask for a volunteer to share, display student work, and discuss ways of strengthening the response.

11. (Optional) Have students read about digestion and complete part of the matter tracing tool.

Pass out 5.3 How do Animals Digest Food? Reading. The reading provides a summary explanation of digestion and additional information about the digestion of fiber. Higher level students may not need the review of content provided in this reading, but you may want them to add to the matter tracing tool started in Activity 4.2.

- Students can complete the reading individually or in pairs.
- After reading, students can complete the digestion section of the Animals Matter Tracing Tool that they started completing in Activity 4.2.

12. Have students connect their atomic molecular explanations to the macroscopic scale by using the Animals Matter Tracing Tool.

Show slide 20. Have students get out their Animals Matter Tracing Tool. Have students individually:

- Draw arrows showing matter movement for digestion.
- Use the steps in the Three Questions to explain how matter moves and change during digestion.

Show slides 21 and 22. Have students compare their answers to the answers on the slides, discuss, and revise their answers if necessary.

13. Have students complete an exit ticket.

Show slide 23 of the 5.3 Explaining How Cows Grow: Digestion PPT.

- Conclusions: What happens to the food that a cow eats in the digestive system?
- Predictions and planning: How do you think a cow uses digested food to grow?
- On a sheet of paper or a sticky note, have students individually answer the exit ticket questions. Depending on time, you may have students answer both questions, assign students to answer a particular question, or let students choose one question to answer. Collect and review the answers.
- The conclusions question will provide you with information about what your students are taking away from the activity. Student answers to the conclusions question can be used on the Driving Question Board (if you are using one). The predictions and planning question allows students to begin thinking about the next activity and allows you to assess their current ideas as you prepare for the next activity. Student answers to the predictions and planning question can be used as a lead into the next activity.

Assessment

Use 5.3 Grading the Explanations Tools for Cow Digestion to grade student responses. This worksheet has "grading" in the title (instead of "assessing") because at this point, students can be held accountable for correct answers. If students are still struggling with these concepts, you may want to revisit parts of the activity they are finding difficult. Use Assessing the Animals Matter Tracing Tool to grade the tracing tool.

Differentiation & Extending the Learning

Differentiation

- You may want students to first complete the front side of the Explanations Tool with the Animals Matter Tracing Tool and check it together as a class to confirm that the arrows and responses to the prompts are correct. Then, students can use the corrected graphic organizer as a tool to construct their written explanation.
- As the Animals Matter Tracing Tool is completed, post in the classroom so students can refer to it.
- Encourage students to explain verbally as well as writing on the Animals Matter Tracing Tool
- Have students highlight challenging vocabulary in the 5.3 How do Animals Digest Food? Reading to support the word wall
- Refer to the word wall for questions on digestion related vocabulary.

Modifications

Extending the Learning

Activity 5.4: Explaining How Cows Grow: Biosynthesis (40 min)

Overview and Preparation

Target Student Performance

Students explain how matter moves and changes and how energy changes during biosynthesis in a cow's cells (connecting macroscopic observations with atomic-molecular models and using the principles of conservation of matter and energy).

Note: This lesson should be taught, regardless of it you taught only Activity 5.1 or both Activity 5.1 and 5.2. However, the language you use and the responses you should expect from your students will be different. Students who did 5.2, molecular modeling, should use the terms "polymers" and "monomers" in their explanations of digestion and biosynthesis, including the names of specific polymers (e.g., proteins, fats and carbohydrates) and monomers (e.g., amino acids, fatty acids, glycerol). Students only did 5.1 should use the terms "large organic molecules" and "small organic molecules" rather than polymers and monomers and use the names of specific large organic molecules (e.g., proteins, fats and carbohydrates) only. Throughout the PPT, you will find both sets of vocabulary.

Resources You Provide

- (From previous lesson) 3.3 Evidence-Based Arguments for Mealworms Eating

Resources Provided

- 5.4 Explaining How Cows Grow: Biosynthesis PPT
- 5.4 Explanations Tool for Cow Biosynthesis (1 per student)
- 5.4 Grading the Explanations Tools for Cow Biosynthesis
- (Optional) 5.4 How do Animals Grow? Reading (1 per student)

Recurring Resources

- (Optional) Big Idea Probe: What Happens to the Fat? (1 per student)
- (Optional) Assessing the Big Idea Probe: What Happens to the Fat?
- (Optional) Example Animal Explanations Handout (1 per student or per group)
- Animals Matter Tracing Tool (1 per student)
- Assessing the Animals Matter Tracing Tool
- Learning Tracking Tool for Animals
- Assessing the Learning Tracking Tool for Animals
- Three Questions 11 x 17 Poster (1 per class)
- Three Questions Handout (1 per student)
- Digestion and Biosynthesis of Carbohydrates 11 x 17 Poster (1 per class)
- Digestion and Biosynthesis of Fat 11 x 17 Poster (1 per class)
- Digestion and Biosynthesis of Protein 11 x 17 Poster (1 per class)
- Metabolic Pathways 11 x 17 Poster (http://www.sigmaaldrich.com/content/dam/sigma-aldrich/docs/Sigma/General_Information/metabolic_pathways_poster.pdf) (1 per class)

Setup

Print one copy of the 5.4 Explanations Tool for Cow Biosynthesis, and the 5.4 How do Animals Grow? Reading (if you choose to use it) for each student. If you are using it, print one copy of the Big Idea Probe: What Happens to the Fat? for each student. Prepare a computer and a

projector to display the PPT. Print and hang the Digestion and Biosynthesis 11 x 17 Posters and Metabolic Pathways 11 x 17 Poster. In this activity, your students will need to use the Three Questions Explanation Checklist on the back of the Three Questions Handout. Be sure to have this available to students and see the notes in the Modifications at the end of the Activity for ideas about how to use it.

Directions

1. Use the instructional model to show students where they are in the course of the unit.

Show slide 2 of the 5.4 Explaining How Cows Grow: Biosynthesis PPT.

2. Remind students of their unanswered questions.

Using slide 3 of the PPT have students revisit their arguments and unanswered questions from the Mealworm Investigation by looking at 3.3 Evidence-Based Arguments for Mealworms Eating.

- Remind students that after explaining cellular respiration in Lesson 4.2 and digestion in Lesson 5.3, there were still unanswered questions about how animals grow.
- In today's lesson, students will use what they learned in Lesson 5.1 (and 5.2) to explain how cows use food for growth.

3. Discuss what happens to the small organic molecules after digestion.

Show slide 4-5 of the PPT. Remind students that the products of digestion (small organic molecules or monomers) can be used by cells for either growth or energy.

- Allow students to explain the processes of digestion and cellular respiration as a review.

4. Have students complete their Explanations Process Tool for Biosynthesis.

Show slide 6 of the 5.4 Explaining How Cows Grow: Biosynthesis PPT. Give each student one copy of 5.4 Explanations Tool for Cow Biosynthesis.

- Tell students that in this part of the investigation, they will combine everything they learned about how cows use food to grow into an explanation.
- Remind them to consider both their evidence from the investigation as well as what they learned in the molecular modeling (or tracing) activity to construct their explanations.
- Give students about 10 minutes to complete the Explanations process tool.

5. Have students share explanations with each other.

Show slide 7 of the 5.4 Explaining How Cows Grow: Digestion and Biosynthesis PPT. Divide students into pairs and have them compare explanations for the Three Questions and the final explanation on the process tool.

- Have students use the Three Questions 11 x 17 Poster (or Handout) as a reference. Have students check their explanations with the middle and right-hand columns of the poster or handout to make sure they are following the "rules."

6. Have students think about how biosynthesis answers the Matter Movement question.

Use slides 8-10 in the PPT to have the students discuss what is happening to matter during biosynthesis and to have them check their answers to the Matter Movement Question on their 5.4 Explanations Tool for Cow Biosynthesis.

- Show students slide 8 to have them think about where atoms are moving from and moving to during biosynthesis.
- Display slides 9-10 to have students compare their answers to the Matter Movement Question with the answers on the slide. Students only need to have arrows showing the movement of molecules into and out of the cell. Have students use a different colored writing utensil to make any needed changes to their answers. Allow students to ask questions if they do not understand why their ideas are incorrect.
- If students have model explanations to share, display student work and discuss. If students have common areas of weakness in their explanations, ask for a volunteer to share, display student work, and discuss ways of strengthening the response.

7. Have students think about how biosynthesis answers the Matter Change Question.

Show slide 11 to begin discussing the Matter Change Question.

- Display slides 12-13 to have students compare their answers to the Matter Change Question on the 5.4 Explanations Tool for Cow Biosynthesis with the answers on the slide. Have students use a different colored writing utensil to make any needed changes to their answers. Allow students to ask questions if they do not understand why their ideas are incorrect.
- If students have model explanations to share, display student work and discuss. If students have common areas of weakness in their explanations, ask for a volunteer to share, display student work, and discuss ways of strengthening the response.
- Refer to the Digestion and Biosynthesis 11 x 17 Posters in your classroom to help students visualize the biosynthesis of monomers to polymers.

8. Discuss how biosynthesis helps answer the Energy Change questions.

Display slide 14 to have students compare their answers to the Energy Change Question on the 5.4 Explanations Tool for Cow Biosynthesis with the answers on the slide. Have students use a different colored writing utensil to make any needed changes to their answers. Allow students to ask questions if they do not understand why their ideas are incorrect.

- If students have model explanations to share, display student work and discuss. If students have common areas of weakness in their explanations, ask for a volunteer to share, display student work, and discuss ways of strengthening the response.

9. (Optional) Have students critique example explanations.

Display slide 15 of the PPT for the full story of digestion. Have students look at two handouts: (a) The Three Questions Handout, and (b) the Animals Example Explanations Handout.

- Ask students to evaluate the two example explanations of cow biosynthesis on the Animals Example Explanations Handout: Which explanation is better? Why?
- Have students use the Three Questions Explanation Checklist on the back of the Three Questions Handout to justify their critiques of the explanations.

10. Have students critique and improve their full explanations.

Display slide 15 of the PPT for the full explanation. Have students use the Three Questions Explanation Checklist on the back of the Three Questions Handout to check that their story includes each of the parts (matter movement, matter change, energy change, and matter movement).

- If students don't have all four parts in their explanation, instruct them to add to their explanation using a different colored writing utensil.

If students have model explanations to share, display student work and discuss. If students have common areas of weakness in their explanations, ask for a volunteer to share, display student work, and discuss ways of strengthening the response.

11. Have students connect their atomic molecular explanations to the macroscopic scale by using the Animals Matter Tracing Tool.

Show slide 16. Have students get out their Animals Matter Tracing Tool. Have students individually:

- Draw arrows showing matter movement for biosynthesis.
- Use the steps in the Three Questions to explain how matter moves and change during biosynthesis.

Show slides 17 and 18. Have students compare their answers to the answers on the slides, discuss, and revise their answers if necessary.

12. Have students complete an exit ticket.

Show slide 19 of the 5.4 Explaining How Cows Grow: Digestion and Biosynthesis PPT.

- Conclusions: How does a cow grow on the cellular scale?
- Predictions and planning: How do you think what we have learned about cows applies to other animals?
- On a sheet of paper or a sticky note, have students individually answer the exit ticket questions. Depending on time, you may have students answer both questions, assign students to answer a particular question, or let students choose one question to answer. Collect and review the answers.
- The conclusions question will provide you with information about what your students are taking away from the activity. Student answers to the conclusions question can be used on the Driving Question Board (if you are using one). The predictions and planning question allows students to begin thinking about the next activity and allows you to assess their current ideas as you prepare for the next activity. Student answers to the predictions and planning question can be used as a lead in to the next activity.

13. Have a discussion to complete the Learning Tracking Tool for this activity.

Show slide 20 of the 5.4 Explaining How Cows Grow: Digestion and Biosynthesis PPT.

- Pass out a Learning Tracking Tool to each student.
- Explain that students will add to the tool after activities to keep track of what they have figured out that will help them to answer the unit driving question.
- Have students write the activity name in the first column, "Explaining How Cows Grow: Digestion and Biosynthesis" and their role, Explainer.
- Have a class discussion about what students did during the activity. When you come to consensus as a class, have students record the answer in the second column of the tool.
- Have a class discussion about what students figured out during the activity that will help them in answering the unit driving question. When you come to consensus as a class, have students record the answer in the third column of the tool.

- Have a class discussion about what students are wondering now that will help them move towards answering the unit driving question. Have students record the questions in the fourth column of the tool.
- Have students keep their Learning Tracking Tool for future activities.
- Example Learning Tracking Tool

Activity Chunk	What Did We Do?	What Did We Figure Out?	What Are We Asking Now?
Explaining How Cows Grow Explainer	Trace the processes involved in a cow growing, digestion and biosynthesis on a poster of a cow, construct a model of the breakdown and rebuilding of molecules through digestion and biosynthesis, and use the Explanations Tool to explain digestion and biosynthesis.	Matter goes into the body and is broken down during digestion. Some matter is used for growth (biosynthesis).	How do other animals grow, move, and function?

Assessment

Use 5.4 Grading the Explanations Tools for Cow Digestion and 5.4 Grading the Explanations Tools for Cow Biosynthesis to grade student responses. This worksheet has "grading" in the title (instead of "assessing") because at this point, students can be held accountable for correct answers. If students are still struggling with these concepts, you may want to revisit parts of the activity they are finding difficult. Use Assessing the Animals Matter Tracing Tool to grade the matter tracing tool.

Differentiation & Extending the Learning

Differentiation

- You may want students to first complete the front side of the Explanations Tool with the graphic organizer and check it together as a class to confirm that the arrows and responses to the prompts are correct. Then, students can use the corrected graphic organizer as a tool to construct their written explanation.
- After students complete the Matter Tracing Tool for Animals, post in the classroom so students can refer back to it
- Encourage students to explain verbally as well as writing on the Matter Tracing tool
- Refer to the word wall for questions on Biosynthesis related vocabulary
- Provide sentence stems to help students answer questions on Big Idea Probe: What Happens to the Fat?

Modifications

The Three Questions Explanation Checklist on the back of the Three Questions Handout can be used to scaffold students' explanations in many ways.

- Students refer to the checklist as they are constructing their explanations.
- Students use the checklist as they are sharing and revising their explanations with a partner.
- Students use the checklist to critique and revise their final explanations.
- Students use the checklist to critique the example explanations for each unit.
- Students use the checklist to create and/or evaluate a whole-class consensus explanation.

We recommend using this checklist with a gradual release. As students improve in their ability to write their own explanations, they may rely on the checklist less.

Extending the Learning

14. If there are still unanswered questions about biosynthesis, watch this video. https://study.com/academy/lesson/what-is-biosynthesis-definition-lesson-quiz.html

15. Have your students read this NY Times article to consider how scientists study snake growth to potentially help humans. This article also connects to snake growth and behavior to genetics. https://www.nytimes.com/2020/05/12/science/pythons-metabolism-animals-digestion.html