Metabolic Reactions

Lesson 13 - 15

How do things inside our bodies work together to make us feel the way we do?
How do things inside our bodies work together to make us feel the way we do?

Metabolic Reactions: Inside Our Bodies

OpenSciEd Unit 7.3
How do things inside our bodies work together to make us feel the way we do?

Metabolic Reactions: Inside Our Bodies

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**UNIT OVERVIEW**

**How do things inside our bodies work together to make us feel the way we do?**

This unit on metabolic reactions in the human body starts out with students exploring a real case study of a middle-school girl named M’Kenna, who reported some alarming symptoms to her doctor. Her symptoms included an inability to concentrate, headaches, stomach issues when she eats, and a lack of energy for everyday activities and sports that she used to play regularly. She also reported noticeable weight loss over the past few months, in spite of consuming what appeared to be a healthy diet. Her case sparks questions and ideas for investigations around trying to figure out which pathways and processes in M’Kenna’s body might be functioning differently than a healthy system and why.

Students investigate data specific to M’Kenna’s case in the form of doctor’s notes, endoscopy images and reports, growth charts, and micrographs. They also draw from their results from laboratory experiments on the chemical changes involving the processing of food and from digital interactives to explore how food is transported, transformed, stored, and used across different body systems in all people. Through this work of figuring out what is causing M’Kenna’s symptoms, the class discovers what happens to the food we eat after it enters our bodies and how M’Kenna’s different symptoms are connected.

Through these investigations, students:

- Develop and use a model to explain how food is rearranged through chemical reactions, forming new molecules that support growth and/or release energy as this matter moves through the human body.
- Develop and use a model to explain how different subsystems of the body work together to provide cells what they need to function.
- Construct and defend a scientific explanation of how M’Kenna’s condition (celiac disease) leads to weight loss and lack of energy.
- Construct a scientific explanation based on evidence for how environmental factors, such as food intake, influence the growth of animals.


**Focal Science and Engineering Practices (SEPs):** Developing and Using Models, Analyzing and Interpreting Data, Engaging in Argument from Evidence

**Focal Crosscutting Concepts (CCCs):** Systems and System Models, Structure and Function

**Building Toward NGSS Performance Expectations**

**MS-PS1-1:**
Develop models to describe the atomic composition of simple molecules and extended structures.

**MS-PS1-2:**
Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

**MS-LS1-3:**
Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

**MS-LS1-7:**
Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

**MS-LS1-5:**
Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

**How students will engage with each of the phenomena:**
# UNIT STORYLINE

How do things inside our bodies work together to make us feel the way we do?

<table>
<thead>
<tr>
<th>Lesson Question</th>
<th>Phenomena or Design Problem</th>
<th>What we do and figure out</th>
<th>How we represent it</th>
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<tbody>
<tr>
<td><strong>LESSON 1</strong></td>
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<tr>
<td>3 days</td>
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<td>M'Kenna, a 13-year-old girl, seems to be really sick and we aren't sure why. We notice she has symptoms in all different parts of her body and some symptoms started before others. We figure out:</td>
<td>M'Kenna’s Doctor’s Note describes the symptoms in different parts of her body.</td>
</tr>
<tr>
<td>What is going on inside M’Kenna’s body that is making her feel the way she does?</td>
<td>We have some ideas for possible investigations we could pursue.</td>
<td>We figured out that most of M’Kenna’s symptoms were coming from her digestive system and that those symptoms started happening first. Also, we wondered if we could “see” inside M’Kenna’s body in some way. So, we want to somehow see inside her digestive system next.</td>
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<tr>
<td>Anchoring Phenomenon</td>
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**LESSON 2**

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<thead>
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<tr>
<td>2 days</td>
<td></td>
<td>We examined M’Kenna’s endoscopy report and some graphs that show what happens to food as it travels through M’Kenna’s digestive system in comparison to a healthy one. We figure out:</td>
<td>We have evidence that something is going on in M’Kenna’s small intestine. Also, the graphs showed that some food substances seem to disappear in a healthy small intestine. Where are they going? What is the small intestine doing with food molecules?</td>
</tr>
<tr>
<td>Can we see anything inside M’Kenna that looks different?</td>
<td>The digestive system is made up of different parts called organs. The different organs have similarities and differences in their structures.</td>
<td>M’Kenna’s small intestine doesn’t look the same as a healthy one.</td>
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<tr>
<td>Investigation</td>
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<td>In a healthy person, many different substances in a graham cracker decrease as they travel through the small intestine.</td>
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<tr>
<td></td>
<td></td>
<td>Some substances in M’Kenna’s small intestine decrease, but others do not decrease as much compared to a healthy person.</td>
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Navigation to Next Lesson: We have evidence that something is going on in M’Kenna’s small intestine. Also, the graphs showed that some food substances seem to disappear in a healthy small intestine. Where are they going? What is the small intestine doing with food molecules?
**Lesson Question**
Why do molecules in the small intestine seem like they are disappearing?

**Phenomena or Design Problem**
Dialysis tube system of the small intestine allows small but not large molecules to pass through its walls.

**What we do and figure out**
We plan and conduct an investigation to determine whether food molecules can pass through or travel across a surface with a structure similar to the small intestine. We argue for how our results and molecular models of the substances we used might help explain how some kinds of food molecules could be absorbed into the body by passing through openings in the wall of the small intestine and others could not. We figure out:
- The structure of the walls of the small intestine and dialysis tubing must have microscopic openings/gates in them that let small food molecules through but not large ones.
- Sugar molecules, such as glucose, are much smaller than molecules of complex carbohydrates, such as starch, but both are made up of the same types of atoms (carbon, hydrogen, and oxygen).

**How we represent it**

*Navigation to Next Lesson:* In this lesson, we figured out that the structure of the small intestine has doors that allow some food molecules to travel through but not others. This made us wonder what happens to the food molecules in the small intestine that do not pass through the walls to the rest of the body.

**Lesson 4**

**1 day**

**What happens to food molecules as they move through the small intestine and large intestine?**

**Investigation**

**Data about what’s in the large intestine of a healthy person shows that only water and fiber remain, but M’Kenna’s large intestine still has other molecules, such as complex carbohydrates, glucose, and fatty acids.**

**We investigate food data from the mouth to the large intestine and determine that (1) most of the molecules are gone by the time they reach the large intestine, and only fiber and water remain, and (2) M’Kenna has other molecules in her large intestine. We examine poop data to confirm what molecules should be expected. We figure out:**
- As food moves through a healthy digestive system, food molecules disappear. We think they might be getting absorbed.
- Fiber always stays the same in the digestive system and leaves the body as poop.
- Most other molecules are gone when they reach the large intestine in a healthy person. Only fiber and water remain.
- M’Kenna’s poop contains some additional food molecules (glucose, starch, fatty acids), too, which are not found in a healthy person’s solid waste.

*Navigation to Next Lesson:* We figured out that fiber comes out of our bodies, but other complex carbohydrates, like starch, don’t. Where are the other complex carbohydrates going? Is it changing somehow? Sometimes when we’re not sure about what’s going on in a system, we have to go back to the beginning. Our digestive system starts in the mouth, so maybe if we start there, that will help us.
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<td><strong>LESSON 5</strong></td>
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| 3 days          |                             | We make observations about what happens to complex carbohydrates, other than fiber, in the mouth. We analyze data from a graham cracker noting how the complex carbohydrates and glucose change in the mouth. We also notice that glucose molecules look like smaller pieces of complex carbohydrates. We plan and conduct an investigation to determine whether complex carbohydrates, other than fiber, undergo a chemical reaction when mixed with a substance in saliva to produce glucose. We figure out:  
- Some types of complex carbohydrates decrease in the mouth while glucose increases.  
- Chemical reactions that occur in the mouth break down some types of complex carbohydrates into glucose, and no matter disappears when this happens. | ![Diagram](image) | ![Diagram](image) |
| Why do large food molecules, like some complex carbohydrates, seem to disappear in the digestive system? | In the mouth, some types of substances seem to decrease, and new substances increase. | ![Diagram](image) | ![Diagram](image) |
| **LESSON 6**    |                             | We analyzed food data, noting how the food changes in different parts of a healthy digestive system. We noticed patterns in which some molecules decreased by the same amount that other molecules increased. We argued that this is a sign of chemical reactions happening in the digestive system. We figured out:  
- Certain food molecules are broken down by different portions of the digestive system.  
- Different organs in the digestive system perform different functions. | ![Diagram](image) | ![Diagram](image) |
| 1 day           |                             | We think that we have figured out a lot! We can now account for one kind of molecule changing into another throughout the digestive system; in some places, like the small intestine, smaller food molecules are getting absorbed, and, in other places, like the large intestine, large food molecules are excreted. We think we should try to put all of these pieces together. | ![Diagram](image) | ![Diagram](image) |
| What happens to the different substances in food as it travels through the digestive system? | The quantity of some types of molecules (complex carbohydrates, fats, and proteins) decreases by the same amount that the quantity of other types of molecules (glucose, fatty acids, and amino acids) increases. | ![Diagram](image) | ![Diagram](image) |

**Navigation to Next Lesson:** We figured out that chemical reactions can occur in the mouth to break most complex carbohydrates down into glucose. Now we are wondering, Do chemical reactions occur anywhere else in the digestive system to break large food molecules down into smaller food molecules?
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<td>LESSON 7</td>
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| What is the function of the digestive system, and how is M'Kenna's digestive system different? | ![Image](image1.png) | We developed a model to represent the inputs, processes, and outputs of the digestive system and the role that the system plays in breaking down matter through chemical reactions, absorbing food, and excreting unused matter. We constructed an argument, based on evidence, to eliminate two of five possible conditions that could be causing the symptoms that M'Kenna is experiencing in her digestive system. We figure out:  
- In a healthy digestive system, multiple subsystems, or organs, work together to help the body break large food molecules down into smaller food molecules.  
- Large food molecules are broken down into smaller food molecules through chemical reactions that occur in the mouth, stomach, and small intestine.  
- Each organ plays a different role in the breakdown of large food molecules.  
- In a healthy person, the small intestine absorbs the small food molecules that had been broken down in preceding organs in the digestive system. | ![Diagram](image2.png) |
| Putting Pieces Together | ![Image](image3.png) | All previous phenomena | |

**Navigation to Next Lesson:** We have eliminated two of the possible gastrointestinal conditions that could be causing M'Kenna's symptoms, but we need to know more about the small intestine to figure out what is causing M'Kenna's symptoms. We decide to look more closely at the small intestine.

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| What does the surface of M'Kenna's small intestine look like up close compared with a healthy one? | ![Image](image4.png) | We zoom in on the small intestine to better understand its structure and function. First, we take stock of where we are in the body by mapping M'Kenna's system to the organization of the human body systems. We identify structures called "villi" that line the small intestine and use an interactive simulation to learn more about the villi. We figure out:  
- Body systems are organized by System > Subsystems > Tissues > Cells.  
- M'Kenna's intestinal wall surface is flat and a healthy person's is folded back and forth (forming villi).  
- Increased villi height results in more surface area that food molecules come into contact with as they flow through the small intestine; this results in a greater rate of absorption in a healthy small intestine than in M'Kenna's. | ![Diagram](image5.png) |
| Investigation   | ![Image](image6.png) | When you look closely at the lining of the small intestine, you see long finger-like projections. | |

**Navigation to Next Lesson:** We argued from evidence why M'Kenna is experiencing many of her digestive symptoms. Now we are ready to answer some questions on our Driving Question Board.
LESSON 9

1 day

How can a problem in one body system cause problems in other systems?

Problematizing

We revisit the Driving Question Board (DQB) to see the progress we have made on our initial questions. We add new questions to the DQB and reorganize them in clusters related to the system to which they are connected. We revisit M’Kenna’s Doctor’s Note to look at her symptoms in other systems and realize that, although her symptoms started in the digestive system, there are still other systems having symptoms. We add two big questions to our DQB: “How can a problem in one body system cause problems in other systems?” and “How are these different systems connected?”

We figure out:

- Although our models can explain most of M’Kenna’s digestive system symptoms, they can’t fully explain her symptoms in other body systems. However, those symptoms are connected to what is happening in her digestive system.

M’Kenna’s Doctor’s Note shows symptoms in other body systems.

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LESSON 10

2 days

Why is M’Kenna losing so much weight?

Investigation

When you burn fat, the matter seems to vanish.

When a person/animal loses weight, fat seems to go away. Some say when you lose weight you “burn” fat.

When we literally burn different types of fat, the mass seems to go down, just like when a person loses weight!

The properties of the vegetable oil and duck fat change before and after they are burned.

We analyze trends in M’Kenna’s weight and look at images of weight loss over time. It looks like the fat is disappearing, which makes us wonder, where is the fat going? We read an article that says that, when kids lose weight, the fat is being “burned.” We wonder if this is the same “burning” as when we light something on fire. We do an experiment and light different types of fats on fire, weigh them, and compare their properties before and after they burn. We figure out:

- When a person/animal loses weight, fat seems to go away. Some say when you lose weight you “burn” fat.
- When we literally burn different types of fat, the mass seems to go down, just like when a person loses weight!
- The properties of the vegetable oil and duck fat change before and after they are burned.

We do an experiment and light different types of fats on fire and see that they seem to disappear, too, just like when a person loses weight! This makes us wonder, what is actually happening to fat when it burns?

Navigation to Next Lesson: We do an experiment and light different types of fats on fire and see that they seem to disappear, too, just like when a person loses weight! This makes us wonder, what is actually happening to fat when it burns?
LESSON 11
2 days

What happens to matter when it is burned?

Investigation

Food is burned in an open system, and the mass decreases. However, when food is burned in a closed system, the mass does not decrease, while carbon dioxide and water vapor increase.

We conduct two investigations to trap the gases produced by burning food. First, we burn vegetable oil in a closed versus an open system and compare the masses of the systems. Second, we burn vegetable oil in a closed system and track carbon dioxide and water in the air within the system using a sensor. We figure out:

- Food goes through a chemical reaction when it is burned. This reaction provides energy.
- Foods require something from the air in order to make energy.
- When food reacts with air to release energy, carbon dioxide gas and water vapor are its products.

Navigation to Next Lesson: In this lesson, we figured out that a chemical reaction occurs when food is burned and that it uses air and produces carbon dioxide, water vapor, and gives off energy. This made us wonder—is this chemical reaction really happening in our bodies to provide us energy for the activities we do? Are we literally burning fat or other kinds of food inside our bodies?

LESSON 12
2 days

Does this chemical reaction to burn food happen inside our bodies?

Investigation

Percent saturation of gases in the blood changes throughout the body.

We gather evidence showing that a chemical reaction happens in the cells of the body to provide them with energy. The reaction helps us explain why certain materials that we take into our bodies, like oxygen and food, are different from the materials that leave our bodies, like carbon dioxide and water. If our activity level increases, the chemical reaction happens faster to meet cells' needs. We figure out:

- Oxygen is taken in (inhaled) through the lungs, and carbon dioxide is exhaled through them. These gases enter and exit the blood by passing through the lung membrane wall and are transported to and from the cells of the body.
- Chemical reactions that happen within cells inside the body rearrange glucose and oxygen into carbon dioxide, water, and energy that the cells in the body can use.
- This reaction, which we call cellular respiration, happens when we're resting, but it happens even more when we exercise.

Navigation to Next Lesson: We figured out a lot about how our bodies get energy to do the things we need to do! We're ready to put all these pieces together and connect what we've figured out to explain some of M'Kenna's non-digestive symptoms.
LESSON 13

2 days

How does a healthy body use food for energy and growth, and how is M’Kenna’s body functioning differently?

Putting Pieces Together

We developed a model to show how food is rearranged in the body in terms of matter inputs, processes, outputs, and energy flows within a body system. We constructed an explanation to explain the relationships between differences in M’Kenna’s digestive system and a healthy digestive system to predict symptoms (effects), such as M’Kenna’s decreased growth rate. We figured out:

- The digestive system takes in food and breaks it down through chemical reactions, and the small food molecules get absorbed into the body’s circulatory system through the small intestine.
- The respiratory and circulatory systems work together to bring food molecules and oxygen to cells in the body and to remove carbon dioxide.
- Humans need to take in food. Food is a type of fuel, which means that it can react with other substances to release energy.
- Cells rearrange food and oxygen through a chemical reaction, which creates carbon dioxide and water and releases energy that cells can use.
- The body systems’ inputs are food (molecules mainly with C,H,Os) and oxygen. Outputs are mainly carbon dioxide, water, and energy (students might also include poop, which is mostly fiber and water).
- When the body takes in excess food, it can be stored for later in the form of fat molecules in the body.
- When the body doesn’t take in enough food, it can use the stored fat or food molecules dedicated for growth to burn as fuel. Most of the matter goes into the air when fat is burned.
- M’Kenna’s body used fat molecules stored in her body when she wasn’t getting enough matter from food.
- M’Kenna is absorbing less food through her small intestine, so the cells in all the tissues in her body aren’t getting enough energy, which is causing her non-digestive symptoms.

Navigation to Next Lesson: We’ve accomplished our mission to figure out what was causing M’Kenna’s symptoms, and we’ve learned a lot about how our bodies work along the way! We can now explain things like how our bodies can get energy from eating a piece of chicken, and that got us thinking...what if we fed a dog that piece of chicken? Would their bodies do the same thing as our bodies? Would their bodies do chemical reactions to break food down and burn it for energy?
LESSON 14

2 days

Do all animals do chemical reactions to get energy from food like humans?

Investigation

Readings about different animals show that they all seem to break down and burn food for energy using chemical reactions, even though they may have different structures inside of their bodies.

We investigate an organism of our choice to see if it does metabolic reactions similar to the way humans do. We argue from evidence whether (1) our organism does chemical reactions to break down and burn food molecules the same way as humans and (2) it has the same structures inside its body that work together to do those processes. Then we come together to share our findings with other groups to give and receive feedback. We figure out:

- Animals, aside from humans, rearrange matter in food through chemical reactions to release energy.
- In animals, besides humans, oxygen reacts with food to produce carbon dioxide and provide energy.
- Other living things, such as anaerobic bacteria, don't need oxygen for chemical reactions to get energy.
- Animals might have different structures in their bodies that do the same functions.

LESSON 15

2 days

What questions on our Driving Question Board can we now answer?

Putting Pieces Together

Animals, such as bears, can do the same chemical reactions as humans do to get energy from food to use now, to use for growth, or to store for later.

We revisit the Driving Question Board and discuss all of our questions that we have now answered. Then we demonstrate our understanding by individually taking an assessment. Finally, we reflect on our experiences in the unit.

LESSONS 1-15

29 days total
What are the Disciplinary Core Ideas (DCIs) in the context of the phenomena?

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In this unit, students are introduced to the anchoring phenomenon—a 13-year-old girl named M'Kenna who feels very sick. Key symptoms are introduced in Lesson 1, specifically, M'Kenna's digestive symptoms, her weight loss, and lack of energy. Students map those symptoms onto which body system they think they are associated with. Then students are introduced to a second set of data that show key differences compared to a healthy person in (1) the structure of one of her organs and (2) the relative amounts of absorption for different substances in a sample of food she eats. Together these data sources suggest that there might be something different happening in M'Kenna's body compared to a healthy body. Through investigating M'Kenna's case, students figure out how the body processes, transports, and uses food molecules inside the body.

In the first lesson set, students figure out how a healthy digestive system breaks down food into smaller molecules, which are then absorbed into the blood in the small intestine. M'Kenna's body is breaking down food into small molecules, but not all of those molecules are absorbed by her small intestine. This is because her small intestine has a major structural difference from a healthy small intestine. M'Kenna's small intestine is smooth, and an intestine with proper function has many finger-like folds. Students figure out that the folds create more surface area through which food molecules can pass. Consequently, her solid waste contains not only fiber, like a healthy body's waste does, but also useful molecules that were not absorbed by her body, including glucose, amino acids, and fatty acids.

In the second lesson set, students develop models of various pathways showing how food molecules are rearranged in the body through chemical reactions to create energy, store matter for later use, and use matter for growth within a body system. Then they apply these ideas back to M'Kenna's case to connect to how different body systems work together and can explain the way that M'Kenna is feeling.

This unit builds towards the following NGSS Performance Expectations (PEs):
- **MS-LS1-3**: Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
- **MS-LS1-5**: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
- **MS-LS1-7**: Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

This unit applies the following NGSS PEs in a new context:
- **MS-PS1-1**: Develop models to describe the atomic composition of simple molecules and extended structures.
- **MS-PS1-2**: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

This unit reinforces these NGSS PEs that students should have previously developed. In the OpenSciEd Scope and Sequence, these are first built in Unit 7.1. In this new context of metabolic reactions, students will engage in the analysis and interpretation of various forms of data on how molecules change or do not change as they move through digestion. Chemical reactions starting in our mouths and stomachs and continuing throughout the rest of the digestive system drive this change, breaking down large food molecules into smaller ones. Some molecules, like fiber, stay the same throughout digestion and, therefore, do not undergo chemical reactions.

The current version of the unit expands students' understanding of metabolic reactions, which include these Grade 6-8 DCI elements:
- **LS1.A Structure and Function**: In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.
- **LS1.B Growth and Development of Organisms**: The growth of an animal is controlled by genetic factors, food intake, and interactions with other organisms, and each species has a typical adult size range.
- **LS1.C Organization for Matter and Energy Flow in Organisms**: Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.
- **PS3.D Energy in Processes and Everyday Life**
Cellular respiration in plants and animals involves chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.

*There is a slash through the pieces of the DCIs that are not developed in this unit. In the OpenSciEd Scope and Sequence, students will develop an understanding of genetic factors in the OpenSciEd Unit 8.5, how plants do chemical reactions to obtain and store energy in the subsequent OpenSciEd Unit 7.4 and interactions with other organisms in the ecosystem dynamics OpenSciEd Unit 7.5.

In addition, this unit introduces the concept of food as fuel and lays the groundwork for future units in which students figure out that both food and other sources of fuels are sources of matter and sources of energy, drawing connections between chemical reactions that transfer and convert energy in living and nonliving systems. This connects to the idea identified on page 196 of Framework for K–12 Science Education (National Research Council, 2012): “By middle school, a more precise idea of energy—for example, the understanding that food or fuel undergoes a chemical reaction with oxygen that releases stored energy—can emerge.”

You can view the placement of this OpenSciEd Unit 7.3 and associated units within the OpenSciEd Scope and Sequence document.

What should my students know from earlier grades or units to be successful in this unit?

This unit uses Disciplinary Core Ideas (DCIs) that students should have previously learned by working on the following NGSS performance expectations MS-LS1-1 and MS-LS1-2.

- **LS1.A Structure and Function:**
  - All living things are made up of cells.
  - Cell membranes are a boundary that controls what enters and leaves the cell.

This unit builds on disciplinary core ideas that students should have developed in working on MS-PS1-1, MS-PS1-2, MS-PS1-3, and MS-PS1-5 related to chemical reactions and molecular structure:

- **PS1.A: Structure and Properties of Matter**
  - Atoms form molecules that range in size.

- **PS1.B: Chemical Reactions**
  - The total number of each type of atom is conserved, and, thus, the mass does not change.
  - In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.

Students would benefit from having prior experience doing the following focal science and engineering practices (SEPs) at the 3-5 grade-band level. They include the following:

- **Developing and using models**
  - Identify limitations of models.
  - Develop and/or use models to describe and/or predict phenomena.
  - Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.
  - Develop a diagram or simple physical prototype to convey a proposed object, tool, or process.

- **Analyzing and interpreting data**
  - Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.
  - Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.
  - Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings.

- **Engaging in argument from evidence**
  - Respectfully provide and receive critique from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions.
  - Construct and/or support an argument with evidence, data, and/or a model.
  - Use data to evaluate claims about cause and effect.

Having students familiar with using focal crosscutting concepts (CCCs) for this unit at the 3-5 grade-band level would be helpful. They include the following:

- **Systems and system models**
  - Students understand that a system is a group of related parts that make up a whole and can carry out the functions that its individual parts cannot.
  - They can also describe a system in terms of its components and their interactions.

- **Structure and function**
  - Students learn different materials have different substructures, which can sometimes be observed; and substructures have shapes and parts that serve functions.
What are some common ideas students might have?

Students will likely bring prior ideas about digestion to this unit, including familiarity with some of the molecules found in food, such as proteins and carbohydrates. Students might have a general understanding that digestion breaks down food to make it available to our bodies. However, connecting the breakdown of some food molecules into other molecules will be new for most students. In particular, the idea that starches in food might all get turned into sugars will seem counterintuitive, since students may have heard that eating sugary foods is bad for us. Also, students may think that the proteins, fats, and carbohydrates we eat go directly to other parts of the body, from the mouth or stomach. This unit provides evidence that this may not be happening until the foods reach the small intestine, and that, instead, chemical reactions are occurring with the food before that point. The main thing this unit clarifies, which students likely take for granted, is that they know we need food to grow; but seeing that a chemical reaction is needed to rearrange the molecules of food to make materials the body can use is a key mechanism that will be new to them.

Though students may still have lingering ideas that matter can disappear, this unit will provide evidence that matter is moving from one system to another, or outside of the system. Therefore, most of the matter when losing weight leaves the body through the carbon dioxide in our breath, rather than disappearing. As in the prior unit on chemical reactions, students see that, even though the properties of the matter may change as it is rearranged through chemical reactions, all the components are still there, and mass is conserved.

Students may already know that we breathe in oxygen and breathe out carbon dioxide, although this can be leveraged in the unit. They may believe that a simple model of gas exchange happens in or near the lungs, but what happens to these gases beyond the lungs will largely be unknown to students. Some students may know that parts of the body need oxygen, like the brain, but may not connect this need for oxygen to a cellular process involving chemical reactions to burn food as fuel for energy. This unit helps students develop a richer understanding of these gases as reactants and products of a chemical reaction in cells. Students know that we need oxygen, but this unit helps students explain why we need oxygen to live.

If students have developed a model of selective permeability of cell membranes and know that organs are made of networks of interconnected tissues, this unit will help them deepen their understanding of why some, but not all, molecules can cross that surface. If they have not developed a model of selective permeability of cell membranes, this unit will lay the foundation for it and will be revisited throughout the unit.

What modifications will I need to make if this unit is taught out of sequence?

This is the third unit in 7th grade in the OpenSciEd Scope and Sequence. Given this placement, several modifications would need to be made if teaching this unit earlier in the middle school curriculum. These include:

- Introducing the students to the concept of a Driving Question Board and a shared set of classroom norms. This would not be necessary if taught after other OpenSciEd units.
- Supplemental teaching of the nature of matter, so that students see matter as made of particles.
- Supplemental teaching of the foundations for chemical reactions in PEs: (1) MS-PS1-1 Develop models to describe the atomic composition of simple molecules and extended structures and (2) MS-PS1-2 Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. This unit is designed to come directly after two units involved in the foundations of chemical reactions and explicitly builds on those understandings. It is critical to note that students need the idea of chemical reactions and the idea that matter can be rearranged through these reactions yielding resultant materials with different properties to develop the explanations in this unit.
- Supplemental teaching of PEs: (1) MS-LS1-1 Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells and (2) MS-LS1-2 Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function. This unit does not introduce cells to students. It uses that prerequisite knowledge to build understanding that the organization of the body goes from cells, to tissues, to organs, to subsystems to multiple subsystems working together in one body system.
What are prerequisite math concepts necessary for the unit?

In Lesson 8 students use a NetLogo simulation to discover the relationship between the rate of food absorption and the height of villi that line the small intestine. Prerequisite math concepts that may be helpful include:

- **CCSS.MATH.CONTENT.6.NS.C.8**: Solve real-world and mathematical problems by graphing points in all four quadrants of the coordinate plane.
- **CCSS.MATH.CONTENT.6.RP.A.2**: Understand the concept of a unit rate $a/b$ associated with a ratio $a:b$ with $b \neq 0$, and use rate language in the context of a ratio relationship.
- **CCSS.MATH.CONTENT.7.SP.C.6**: Approximate the probability of a chance event by collecting data on the chance process that produces it and observing its long-run relative frequency, and predict the approximate relative frequency given the probability.
- **CCSS.MATH.CONTENT.7.SP.C.8.C**: Design and use a simulation to generate frequencies for compound events.

Students analyze and interpret M'Kenna's height and weight growth charts in Lesson 10. Prerequisite math concepts that may be helpful include:

- **CCSS.MATH.CONTENT.6.SP.B.5.C**: Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.

In addition, within the domain of Measurement and Data in the Common Core Mathematics Standards, students will be drawing on what they have learned across a number of standards under the category of Represent and Interpret data for grades 1-5 when they are generating and interpreting the tables and graphs of their data collected from the simulation and during analysis of several food molecule graphs in many lessons across the unit.
**ASSESSMENT SYSTEM OVERVIEW**

Each OpenSciEd unit includes an assessment system that offers many opportunities for different types of assessments throughout the lessons, including pre-assessment, formative assessment, summative assessment, and student self assessment. Formative assessments are embedded and called out directly in the lesson plans. Please look for the “Assessment Icon” in the teacher support boxes to identify places for assessments. In addition, the table below outlines where each type of assessment can be found in the unit.

### Overall Unit Assessment

<table>
<thead>
<tr>
<th>When</th>
<th>Assessment and Scoring Guidance</th>
<th>Purpose of Assessment</th>
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<tbody>
<tr>
<td>Lesson 1</td>
<td>Initial Model</td>
<td><strong>Pre Assessment</strong>&lt;br&gt;The student work in lesson 1 available for assessment should be considered a pre-assessment. It is an opportunity to learn where students are coming in and what ideas they have that you can build on in this unit. The more ideas in your classroom the better. Use students' initial models to highlight the range and diversity of ideas the class as a whole has. Also, use the Consensus Discussion about the initial class model to assess which ideas students are bringing up in their models to explain the cause or underlying mechanism of M'Kenna's symptoms. Look for agreement on key components of the models, such as (1) the digestive system, (2) input of food, and (3) some connections to other body systems.&lt;br&gt;&lt;br&gt;Students have opportunities to pose and build on other students' questions during the construction of the Driving Question Board (DQB). Look for how or why questions about phenomena that seek to investigate interactions inside of the body, either within a system or between different systems.&lt;br&gt;&lt;br&gt;Use your judgement on how to press students to form how and why questions. If a student struggles with sharing, choose to celebrate going public with questions over getting to a how or why question. If students do not ask questions about the phenomenon that seek to investigate how different body systems work together, that's okay at this point. They will have another opportunity to add questions to the DQB in Lesson 9. Also, questions can be added to the DQB at any point throughout the unit. We recommend always having sticky notes or index cards on hand to capture students' evolving questions.</td>
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<td>Lesson 7</td>
<td>Student (group sensemaking) Formative Assessment Teacher Key</td>
<td><strong>Formative</strong>&lt;br&gt;This lesson is a group or pair formative assessment. Its intent is to give you information about where students are at with using evidence to begin to reason about the cause and effect of M'Kenna's illness. The key is meant to support you in facilitating students, there are no correct answers. In this formative lesson you should be listening for students use of evidence from the unit so far and students' understanding of what that evidence can tell them and not tell them. &lt;br&gt;&lt;br&gt;This lesson is also providing motivation for lesson 8, where students receive the definitive piece of evidence that helps them to make a confident diagnosis.</td>
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<td>Lesson 8</td>
<td>Student Assessment Teacher Key- Sample Student Response Argument Rubric</td>
<td><strong>Summative+Formative</strong>&lt;br&gt;This lesson is a putting the pieces together lesson. It includes a summative midpoint assessment that can provide formative information for moving forward in the unit. There is an argument rubric specific to this unit that should be used to score student responses. The goal of this assessment is to get students writing complex arguments on their own. You can decide how much or how little scaffolding your students need. Some prompts are included in the assessment. &lt;br&gt;&lt;br&gt;This midpoint assessment is important formatively to make sure the class is on the same page and ready to move forward in the unit. At this point, students should be comfortable with the evidence and reasoning laid out in the rubric for this assessment.</td>
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<td>Lesson 10</td>
<td>Initial Ideas Discussion</td>
<td><strong>Formative / Pre Assessment</strong>&lt;br&gt;This lesson connects Lesson Set 1 with Lesson Set 2. As a formative, pre-assessment for Lesson Set 2, use the Initial Ideas Discussion in the Navigation activity about what could be causing M’Kenna’s weight loss to see if students could connect to what was figured out in Lesson Set 1 when she could not get enough matter inside her body because her villi in her small intestine are damaged. If students do not make this connection, that’s OK. They will have the opportunity to do so later on.</td>
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<td>Lesson 14</td>
<td>Self Assessment Argumentation rubric with Gotta-Have-It Checklist</td>
<td><strong>Formative and Self Assessment</strong>&lt;br&gt;Student have an opportunity to develop arguments using evidence from their Gotta-Have-It Checklists. Then students do a gallery walk to provide each other with specific feedback using an argumentation rubric. With feedback from their peers, students can revise their work with a group. Although students can use the self-assessment rubric for giving and receiving feedback at any time, this is a designated spot for having students reflect. <strong>Peer Assessment</strong>&lt;br&gt;In this lesson, students use a general argumentation rubric paired with their co-constructed Gotta-Have-It Checklist from the previous lesson to provide peer feedback to small groups on their arguments.</td>
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<td>Lesson 15</td>
<td>Student Assessment Modified Student Assessment Teacher Reference Modeling Rubric</td>
<td><strong>Summative</strong>&lt;br&gt;This lesson includes a transfer task to give students an opportunity to use the 3 dimensions to make sense of a different phenomenon. This is meant to be a summative assessment task for the unit and it gives you a grading opportunity. The task includes a teacher reference with a scoring guide as well as a modeling rubric for scoring the modeling question. Scoring guides are meant to highlight important ideas students should be including in their responses to the prompts. They are listed as bullet points so you can decide how to score them appropriate to the norms in your classroom. If students share these ideas elsewhere in the assessment, it is up to you to decide if that understanding is sufficiently demonstrated. <strong>If your students are struggling or you think they will need support in creating the model, there is a modified student assessment that gives students the components and interactions they will need in their model.</strong></td>
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<td>Occurs in most lessons</td>
<td>Progress Tracker</td>
<td><strong>Formative and Student Self Assessment</strong>&lt;br&gt;The Progress Tracker is a thinking tool that was designed to help students keep track of important discoveries that the class makes while investigating phenomena and figure out how to prioritize and use those discoveries to develop a model to explain phenomena. It is important that what the students write in the Progress Tracker reflects their own thinking at that particular moment in time. In this way, the Progress Tracker can be used to formatively assess individual student progress or for students to assess their own understanding throughout the unit. Because the Progress Tracker is meant to be a thinking tool for kids, we strongly suggest it is not collected for a summative ‘grade’ other than for completion.</td>
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<td>Anytime after a discussion</td>
<td>Student Self Assessment Discussion Rubric</td>
<td><strong>Student Self Assessment</strong>&lt;br&gt;The student self-assessment discussion rubric can be used anytime after a discussion to help students reflect on their participation in the class that day. Choose to use this at least once a week or once every other week. Initially, you might give students ideas for what they can try next time to improve such as sentence starters for discussions. As students gain practice and proficiency with discussions, ask for their ideas about how the classroom and small group discussions can be more productive.</td>
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When Assessment and Scoring
Guidance Purpose of Assessment

After Students Complete Substantial, Meaningful Work Peer Feedback Facilitation: A Guide

**Peer Feedback**

There will be times in your classroom when facilitating students to give each other feedback will be very valuable for their three-dimensional learning and for learning to give and receive feedback from others. We suggest that peer review happen at least two times per unit. This document is designed to give you options for how to support this in your classroom. It also includes student-facing materials to support giving and receiving feedback along with self-assessment rubrics where students can reflect on their experience with the process.

Peer feedback is most useful when there are complex and diverse ideas visible in student work and not all work is the same. Student models or explanations are good times to use a peer feedback protocol. They do not need to be final pieces of student work, rather, peer feedback will be more valuable to students if they have time to revise after receiving the peer feedback. It should be a formative, not summative type of assessment. It is also necessary for students to have experience with past investigations, observations, and activities where they can use these experiences as evidence for their feedback.

For more information about the OpenSciEd approach to assessment and general program rubrics, visit the OpenSciEd Teacher Handbook.

**Lesson-by-Lesson Assessment Opportunities**

Every OpenSciEd lesson includes one or more lesson-level performance expectations (LLPEs). The structure of every LLPE is designed to be a three-dimensional learning, combining elements of science and engineering practices, disciplinary core ideas and cross cutting concepts. The font used in the LLPE indicates the source/alignment of each piece of the text used in the statement as it relates to the NGSS dimensions: alignment to Science and Engineering Practice(s), alignment to Cross-Cutting Concept(s), and alignment to the Disciplinary Core Ideas.

The table below summarizes opportunities in each lesson for assessing every lesson-level performance expectation (LLPE). Examples of these opportunities include student handouts, home learning assignments, progress trackers, or student discussions. Most LLPEs are recommended as potential formative assessments. Assessing every LLPE listed can be logistically difficult. Strategically picking which LLPEs to assess and how to provide timely and informative feedback to students on their progress toward meeting these is left to the teacher’s discretion.

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<td>Lesson 1</td>
<td><strong>Develop models</strong> based on evidence to predict the relationships between components of a system (organs and body systems) to explain what is causing M'Kenna to feel the way she does (effect). <strong>Ask questions</strong> that arise from careful observation of M'Kenna’s Doctor’s Note to clarify and seek additional information about what is going on inside the body of M'Kenna that is causing her symptoms (effect).</td>
<td><strong>Developing and Using Models; Cause and Effect; Systems and System Models</strong> Teachers can use students’ initial models to highlight the range and diversity of ideas the class as a whole has. See more information about how to use initial models in the Overall Unit Assessment table above. Also, use the Consensus Discussion about the initial class model to assess which ideas students are bringing up in their models to explain the cause or underlying mechanism of M’Kenna’s symptoms. Look for agreement on key components of the models, such as (1) the digestive system, (2) input of food, and (3) some connections to other body systems. Do not worry if students do not know the function of each body system. There will be other opportunities to build understanding of other body systems. See the teacher guide in this section for some guidance to help students if they are struggling when developing their initial models. <strong>Asking Questions; Cause and Effect</strong> Students have opportunities to pose and build on other students’ questions during the construction of the Driving Question Board (DQB). Look for how or why questions about phenomena that seek to investigate interactions inside of the body, either within a system or between different systems. Use your judgement on how to press students to form “how” and “why” questions. If a student struggles with sharing, encourage them to go public with questions rather than focusing specifically on forming a “how” or “why” question. If students do not ask questions at this point about the phenomenon that seek to investigate how different body systems work together, this is okay. They will have another opportunity to add questions to the DQB in Lesson 9. Also, questions can be added to the DQB at any point throughout the unit. We recommend always having sticky notes or index cards on hand to capture students’ evolving questions.</td>
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<td>Lesson 2</td>
<td><strong>Analyze and interpret data</strong> to identify patterns in how the structures of the digestive system and relative amounts of substances in a food sample appear in a healthy person as compared to in M'Kenna.</td>
<td><strong>Analyze and Interpreting Data; Structure and Function; Systems and</strong> While students are examining the illustrations of the organs of the digestive system, circulate among them to listen to group and/or pairs conversations to determine the prior knowledge and the similarities and differences between the different organs. Listen for students noticing the similarity that each organ is hollow inside based on the illustrations. However, you should avoid taking this as an opportunity to grade students on their understanding of these structures. It is more important to begin to determine how well students can analyze and draw comparisons using the illustrations. Students are not using the term “subsystem” at this point, even while they are examining organs, which are subsystems, but they are beginning to make connections between the structure of an organ and its ability to perform a job inside of the digestive system. They are just seeing the body as one system that has a digestive system, and that digestive system is made up of different structures. This understanding will be critical for future discussions of subsystems. <strong>Analyze and Interpreting Data; Patterns</strong> Students should be examining the endoscopy images in an attempt to determine if there are any patterns in the images that will help support their idea that M’Kenna’s symptoms are centered in the digestive system. When attempting to determine if a cause and effect relationship exists, students need to realize that phenomena may have more than one cause and the fact that two events are happening at the same time doesn’t necessarily imply causation. When students are analyzing the graph or food molecules in the small intestine, they will need to pay attention to the patterns in data that indicate that some of the molecules are not leaving M’Kenna’s small intestine. If some students are struggling with the data analysis, provide additional support by gathering them in a small group to facilitate a more structured analysis of the endoscopy images.</td>
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| Lesson 3 | **Plan and conduct an investigation** in order to produce data to determine whether food molecules can travel from one side of a system to the other side separated by a solid structure with properties similar to the walls of the small intestine. | **Planning and Carrying Out Investigations; Systems and System Models; Structure and Function**  
During the Plan Our Investigation section, while students write individually in their notebooks, walk around and look for them to make connections between the inside of the dialysis tube system as a representation of the inside of the small intestine. Therefore, students should place the food molecules inside the dialysis tube. If students struggle to connect their system to the small intestine, have them revisit their Lesson 2 data that showed differences in food within the small intestine.  
At the end of day 1, look at Part 2 of Dialysis Tube Investigation to see students make their predictions about which molecule(s) will go through the structure of the dialysis tube system. Look at the connections between student predictions and the reasoning they use to justify their explanations. Student answers will vary based on their ideas from Lesson 2. If students struggle to connect their predictions with reasoning, prompt them to think about why they set up the pieces of the dialysis tube system in the way they did. |
| | **Argue from evidence to revise a model** to show how the results of this investigation and graphs of different types of food molecules traveling through the small intestine explain how the structure of the walls impacts the function of the small intestine. | **Developing and Using Models; Structure and Function**  
When students make sense of the results (Part 6 of Dialysis Tube Investigation), look at questions 2 and 3 to see if students connect their results from the dialysis tube investigation. Students should add the idea of openings/gates to the dialysis tube structure and that there must be something different about the structure of food molecules that allows glucose to fit through but not starch. If students struggle with connecting the glucose moving through the dialysis tube to the openings, ask them if they have ever experienced one material going through a barrier of some kind while another material did not, such as when sifting sand.  
At the end of day 2, students argue from evidence with their partners about what to add to their models in their Progress Trackers. Look for students to argue that, because glucose went from the inside of the dialysis tubing to the outside of the dialysis tubing, this must imply that there are openings or gates in the dialysis tubing and, thus, the small intestine. Students will also argue from evidence that using the molecular representations of starch and glucose show that starch is the larger structured molecule, impacting it from functioning by moving through the gates of the small intestine.  
If students struggle with the use of evidence, you might provide sentence starters or fill in the blanks for the reasoning part. See the teacher reference for an example. |
| Lesson 4 | **Analyze and interpret data** to determine patterns and limitations of the relative amounts of different molecules in food as it moves through the digestive system of a healthy person versus M’Kenna. | **Analyzing and Interpreting Data; Patterns**  
During the Follow the Graham Cracker section, while students are using the I² sensemaking strategy to analyze and interpret data, circulate and guide students to look at one type of food molecule from one graph to the next, noting patterns in the quantities that change from one graph to the next in a healthy person versus M’Kenna. Support students in sensemaking by guiding them to look at one type of food molecule at a time to recognize any patterns. If students are struggling to notice patterns, use two sheets of paper to help them cover extraneous information so that they can isolate one type of food molecule on both graphs. Ask guiding questions to help students identify patterns, such as “What do you notice about the amount of ____ in the mouth compared to what it is in the small intestine?” Keep track of the patterns students notice on a chart that is visible to all students in the group. Breaking the information down into smaller chunks will make it easier for them to analyze.  
During the Add to Our Progress Tracker section, you’ll examine students’ Progress Trackers for evidence of the data analysis that they did earlier. Prompt students to refer back to the evidence presented in the graphs so that their models are based on evidence. If students’ models do not show conclusions from the data analysis, ask guiding questions, such as “What did X data tell us?” and “Where do you have that learning represented in your model?” |
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<td>Lesson 5</td>
<td>Analyze and interpret data to identify a relationship within the data that shows that the amount of certain food molecules (complex carbohydrates) decrease, and other food molecules (glucose) increase as they move through the mouth, which is a correlational relationship. Students argue that we need more data to determine the cause of the observed increases and decreases in food molecules. Plan and conduct an investigation to produce data to determine whether food containing complex carbohydrates, but not glucose, undergoes a chemical reaction in the mouth and that this reaction turns the complex carbohydrates into glucose when mixed with a substance found in saliva (amylase), which is identified by a pattern change in the color of the food indicator.</td>
<td>Analyzing and Interpreting Data: Cause and Effect; Patterns After analyzing data from eating a graham cracker on Analyze Data from Eating a Graham Cracker, students record their analyses in their science notebooks. Look for students’ ability to recognize the pattern in the data that shows that, as complex carbohydrates decrease in the mouth, glucose increases. In addition, students should note that the relative quantities of the other food molecules in the mouth do not change. Students should be able to argue that the relationships that they observe are correlations, but not causations. If students struggle to identify patterns in the data, consider providing additional support in reading the graph provided. If students struggle to distinguish between causal and correlational relationships in the data, consider taking the time to distinguish between causal and correlational relationships. Planning and Conducting Investigations: Patterns Students record their plans and findings from an investigation that they have planned and conducted on Chemical Reactions in the Mouth Data Table. Prior to conducting the investigation, check student work to make sure that they have planned an investigation similar to the one provided on Unknown material with identifier: mr.15.tref. After conducting the investigation and recording their results, check student work using Unknown material with identifier: mr.15.tref to determine if students have identified the anticipated patterns in the data. During the Making Sense discussion, listen for students to connect their findings to their data analysis of the graham cracker graph. If students struggle to plan the investigation, consider spending more time framing the goals of the investigation. If students struggle to interpret their findings, consider returning to the investigation in Lesson 3 so that students can remind themselves about the use of the various indicators.</td>
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| Lesson 6 | Analyze and interpret data to **identify patterns** in the amount that certain **food molecules** (complex carbohydrates, proteins, and fats) decrease and other **food molecules** (glucose, amino acids, and fatty acids) increase as they move through different organs in the digestive system. Analyze and interpret these data as evidence that the **digestive system** is a system of interacting subsystems composed of organs that each perform different functions. | **Analyzing and Interpreting Data; Patterns**  
Students will have the opportunity to use Progress Tracker to look for the idea that large food molecules are broken down into smaller food molecules through chemical reactions. This presents an opportunity to determine how well students understand and make connections to this key idea partially developed as part of Lesson 5.  
If students are struggling with this key idea, consider pulling the class together to interpret the multiple lines of evidence identified in Lesson 5 to support this claim. The multiple lines of evidence include: observations from eating a cracker, data analysis from eating a graham cracker, reading about digestion and amylase, and an investigation to determine if chemical reactions occur in the mouth. Consider suggesting a way to represent this idea to students by showing several large boxes attached to one another being broken down into separate boxes. Understanding that large molecules can be broken down into smaller molecules is central to students' understanding of what is taking place in the digestive system.  
**Analyzing and Interpreting Data; Structure and Function**  
Use the analysis and interpretation of data on **Data of Food Molecules for a Healthy Person** in students' science notebooks to look for analysis and interpretation of the data that can serve as evidence for the claim that each organ in the digestive system performs a different function. If students are struggling to analyze the data, consider modeling analysis of the data with the whole class. Redirect student attention to the helpful tips for interpreting the bars in the graph found in **Food Molecule Data for a Healthy Person** and help students make sense of one organ in the digestive system.  
As students are analyzing the graphs, circulate and support students as they look for patterns that can help them explain why the amount of one type of molecule (e.g., protein) might be decreasing by the same amount that another type of molecule (e.g., amino acids) is increasing in the graham cracker in the mouth.  
**Analyzing and Interpreting Data; Patterns, Structure, and Function**  
Use the Building Understandings Discussion at the end of the lesson to determine if students have come to key conclusions related to MS-LS1-3. First, students should have analyzed data to identify patterns in the functions of each of the organs in the digestive system. Second, students should have interpreted these data as evidence that the digestive system is a system of interacting subsystems that each perform different functions.  
If students struggled to analyze the data, consider returning to the data analysis and providing more scaffolding to support students in the analysis. If students struggle to make the connection that the digestive system is a system made up of interacting subsystems, consider physically showing how a piece of food moves through the different organs in the digestive system. Stop the food at each “stop” along the way (as indicated by the graphs) and then analyze each graph. |
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| Lesson 7 | **Develop a model** based on multiple lines of evidence to represent the inputs, processes, and outputs of the digestive system and the role that the system, and the subsystems within it, play in breaking down matter inputs through chemical reactions, absorbing food, and excreting unused matter. | **Developing and Using Models: Systems and System Models** Students will develop models throughout this lesson individually, in small groups, and as a whole group. Students should identify the following ideas in their models:  
- The digestive system is a long tube with different parts to it.  
- In one part of the digestive system, the small intestine, small food molecules are absorbed, and large food molecules aren’t.  
- Absorption means that the molecules cross the lining of the small intestine.  
- Fiber is not digested at all and is excreted from the body.  
- Large food molecules can be broken down into smaller food molecules.  
- In another part of the digestive system, the mouth, some types of complex carbohydrates are broken down into smaller pieces through chemical reactions.  
- Other types of food molecules (proteins and fats) are broken down in other parts of the digestive system (stomach and small intestine).  

**Respectively provide and receive critiques** about small-group models developed to explain how various subsystems in a healthy digestive system interact to move food through a series of chemical reactions to break down large food molecules.  

**Engage in an argument from evidence** to eliminate two of the five possible gastrointestinal conditions that could be causing the symptoms that M’Kenna is experiencing in her digestive system, based upon how they affect the body as a whole system.  

If students are missing ideas, prompt them to revisit their Progress Trackers or science notebooks for key ideas that they are missing. During small-group modeling time, there are suggested prompts to help students when develop their models. In addition to including ideas about the breakdown of food in the digestive system, make sure students are incorporating key ideas about systems and system models, specifically as they relate to the digestive system. Prompt students to include these ideas by asking questions, such as: "What are the inputs, processes, and outputs that you will need to include in your model?" and "How can we differentiate between the processes happening in different parts of the digestive system?" and "Why do the processes need to occur in different parts of the system?" After students develop their Gotta-Have-It Checklists, students use the ideas in the list to develop a model to describe what is happening in a healthy digestive system.  

After students update their 3-column Progress Trackers at the end of day 1 of this lesson, collect their Progress Trackers to provide formative feedback to students on their ideas. First, look for all of the ideas from the Gotta-Have-It Checklist represented. Second, provide feedback on the DCIs LS1.A and LS1.C, the CCC systems and system models, and the SEP developing and using models. Specifically, look for students representing ideas that the digestive system is one system within the human body and that it is made up of smaller parts called organs, which are viewed as subsystems in the digestive system. Students should also show that food is digested through a series of chemical reactions that break large food molecules down into smaller food molecules. The chemical reactions involved in digestion occur in different parts of the digestive system. Students should also use the model to show which component they think may function differently in M’Kenna’s digestive system. Finally, students should show the inputs, processes, and outputs of the digestive system. This is a key moment to provide formative assessment. If students struggle to include all of the key ideas in the model, consider working individually or in small groups with struggling students to return to previous investigations and make sense of the findings.  

**Engaging in Argument from Evidence: Systems and System Models** Use Task Parts 1 and 2: Eliminate Possible Conditions and Identify Missing Evidence to assess students' ability to construct an argument, based on evidence, to eliminate two of five possible gastrointestinal conditions that could be causing the symptoms that M’Kenna is experiencing in her digestive system. Look for students to share ideas referenced on Task Parts 1 and 2: Eliminate Possible Conditions and Identify Missing Evidence. If choosing from five possible conditions is overwhelming to students, consider eliminating one condition by modeling the process for students. If students struggle to back up their claims with evidence, consider revisiting Lessons 1–6 to provide more time for students to make sense of the ideas in those lessons. |
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| Lesson 8 | Engage in an argument from evidence supported by scientific reasoning for how a healthy digestive system rearranges matter through chemical reactions and absorbs food, and how and why M'Kenna's digestive system is functioning differently. | Engaging in an Argument from Evidence; Systems and System Models; Structure and Function  
In the Part 3: Argue from Evidence What's Causing M'Kenna's Symptoms, students argue from evidence that M'Kenna's symptoms can be explained by her having celiac disease. Look for students to argue that M'Kenna has celiac because the villi in M'Kenna's small intestine cause her to have a reduced number of cells since taller villi in the small intestine cause there to be more cells, and this does not allow her body to absorb food molecules as effectively as a healthy digestive system. Students combine this evidence with the understanding that the data from her large intestine indicated that food molecules, other than fiber and water, remained in the large intestine after digestion, while in a healthy large intestine only fiber and water remain. While the assessment should be completed independently, some students might benefit from assistance with the organization of their writing. Additional guidance is provided in regard to how to support students with this organization. Then, students exchange written arguments with a peer and provide a critique of their argument based on the sufficiency of evidence provided. Look for students who attend closely to the strength of the argument and identify key pieces of evidence that support it. Provide a review for a small group of students or for the whole class about the key features of a strong scientific argument using Argument Rubric - Part 3 - M'Kenna's Disease for guidance. In Revisit the Driving Question Board, students select three questions from the DQB that they have made progress toward answering. They argue the answer to those questions using evidence that they have collected throughout the unit.  
Analyzing and Interpreting Data; Structure and Function  
In Examine the Function of the Villi, students collect data from the NetLogo interactive simulation of the small intestine. Students organize data into a table and create graphical displays of the data to demonstrate that villi height increases the number of cells, which has a direct relationship to the rate of absorption of food molecules into the bloodstream. Circulate and observe students to determine whether they are drawing a connection between villi height and the rate of absorption of food molecules into the bloodstream. Listen for students who explain that the cause of the food molecules that remain in M'Kenna's large intestine are a result of her villi being flat and, therefore, having fewer cells. If students are not drawing a connection between villi height, number of cells, and rate of absorption, gather them into a small group and adjust the simulation together, making the villi height 0, then 5, then 10. After each adjustment, count the number of cells together, writing them down in a public space for comparison. Ask students what they notice about the data, guiding them to see that taller villi have more cells. Have students run three trials—one for each of these villi height adjustments—and add the rate of absorption to the data table. Ask students what they notice about the relationship between the number of cells and the rate of absorption. Scaffolding the activity in such an explicit manner should help students come to the conclusion that taller villi = more cells = higher rate of absorption. Some students may struggle to visualize a data table, and, therefore, have trouble initiating the task of creating a data table to organize their data. Additional guidance is provided to support students who are not constructing an organized data table.  
In Add to the 3-Column Progress Tracker, students use all that they have figured out to develop a model to represent what is happening in M'Kenna's digestive system as compared with a healthy digestive system. Look for students who incorporate the items in the bulleted list into their models in words and pictures. If students do not include an element, ask a targeted question to help students recall something that they figured out in this lesson. For example, if a student does not include something about villi height affecting the number of cells and, therefore, the rate of absorption of food molecules into the bloodstream, ask, "Where can I find information in your model about the villi? How did you show what you learned about the height of the villi from the NetLogo simulation?" This should remind students without giving away key learning. |

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| Lesson 9 | **Ask questions** to gather more information about how problems in one body system interact with other systems after revisiting M’Kenna’s symptom list. | **Asking Questions and Defining Problems:** Teachers can collect *Let’s Answer Questions from Our DQB!* after revising the DQB. Look for every student to select questions from careful observation of the phenomenon with M’Kenna’s doctor’s note that pertain to the initial digestive system cluster of symptoms (on the DQB) and use evidence from lesson investigations. If students are unable to select digestive system questions and connect them to collected evidence, help students pick one lesson and explain how what they figured out in that lesson helps explain one of the questions listed. Students can look at their Progress Trackers from each lesson to help them identify what was figured out in each lesson.

After revisiting M’Kenna’s doctor’s note and their mapping of her symptoms, students are problematizing M’Kenna’s symptoms in other systems. This is a place to formatively assess if they are able to see that not only is the digestive system a subsystem of other systems but that it is also interacting with other systems. Look for students to notice that their must be a connection between her digestive system problems with absorption and her other symptoms, since her symptoms seem to start in her digestive system. Students will return to this thinking throughout this lesson and in other lessons. If students are unable to come up with the idea that problems in one system could be caused by problems in another system have them look back at their system mapping. If students don't suggest that their might be a connection between systems that we haven't figured out yet, ask them to think about which systems we have we have collected evidence to explain and which symptoms remain unexplained.

At the end of the lesson, students individually fill out their Progress Trackers for Lesson 9. Look for students to explain that we have figured out why most of M’Kenna’s digestive system symptoms occur (due to issues with absorption of food in her small intestine), but we can’t yet explain how that is causing her symptoms in other body systems, such as brain fog, fatigue, and weight loss. If students struggle to make this connection between systems, have them walk over to the DQB and look at the clusters of questions that don’t have any dots on them yet. If they are still not able to make the connection, take out M’Kenna’s Doctor’s Note to see which symptoms and systems are still not explained. |
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<td>Lesson 10</td>
<td><strong>Analyze and interpret data</strong> using graphical displays and statistics to identify temporal relationships to provide evidence for how M’Kenna’s pattern of body growth and weight have changed over time compared with typical children her age.</td>
<td>As a formative, pre-assessment for Lesson Set 2, use the Initial Ideas Discussion in the Navigation activity about what could be causing M’Kenna’s weight loss to see if students could connect to what was figured out in Lesson Set 1 when she could not get enough matter inside her body because her villi in her small intestine are damaged. If students do not make this connection, that’s OK. They will have the opportunity to do so later on. <strong>Analyzing and Interpreting Data; Stability and Change</strong> Students are introduced to using statistics in order to identify temporal relationships in M’Kenna’s growth chart. Look for students to identify that M’Kenna’s growth remained stable for about 11 years, and then began to slow down when she turned 13. If students don’t make this connection, you can pull them into small groups to do a more guided data analysis. Also, you might pull different student work samples of their WIS/WIM statements and have the whole class look at what classmates have written. Next, students examine DEXA scans of a human and/or a dog that have lost weight. Look for students to identify that fat was lost over time. This should prompt students to begin to think about where the fat goes when someone loses weight. If students are identifying this, you might ask a question like, “If the animal weighed 60 pounds in this photograph, but 45 pounds in the next photograph, what is the difference in weight? Let’s think about a 15-pound dumbbell you might lift at the gym—that’s quite heavy! Where do you think all that weight went?” <strong>Obtaining, Evaluating, and Communicating Information; Energy and Matter</strong> After the students read the article <em>Children Need More Fat in Their Diets Compared to Adults</em> for the second time, they answer questions with a partner and discuss those questions as a whole class. During that discussion, look for students thinking about one way people use fat is to “burn” it, but what does burning fat really mean? Students should be wondering where the matter really goes when fat is burned. If this idea does not come out, ask if they have ever heard people say that they are “burning calories” when they exercise, and what do they think that means? <strong>Planning and Carrying Out Investigations; Energy and Matter</strong> During part 3 of the investigation, students will be answering the “Making Sense” questions to start to think through what happens to the matter when fat is burned. Look for students being able to make connections from their understanding of chemical reactions from a previous unit with the data they collected during this experiment. For students who are having difficulty with the “Making Sense” questions in Part 3, you could ask additional questions, such as: “What do the changes in the substance color, odor, or state of matter indicate about what happened?” and “Where did the matter in the vegetable oil/animal fat go?”</td>
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<td>Lesson 11</td>
<td>Construct an explanation using both qualitative and quantitative data and scientific reasoning (that burning food produces energy, in the form of heat and light, and products, such as carbon dioxide and water) to describe why the mass of oil burned in an open system changes, while it stays the same in a closed system.</td>
<td><strong>Constructing Explanations; Stability and Change; Energy and Matter</strong>&lt;br&gt;After burning fat in the closed and open systems, students turn and talk with their partner to make sense of their results. This is a great mid-point formative assessment for teachers to listen to small group discussions and see if students are putting together that, when burning fat and releasing energy, the mass of the open system is changing and the closed system is stable due to matter being trapped within the system.&lt;br&gt;&lt;br&gt;At the end of day 1, students will complete Making Sense of Burning Fat Investigation Results part 3 to make sense of their results from burning fat in open and closed systems and measuring changes in the composition of air during the burning of fat in a closed system. Look for students to be able to explain that, due to changes in the mass and amounts of different substances in a closed system and the production of energy, a chemical reaction must have occurred. For students who are having difficulty with the Making Sense questions in part 3, you could ask additional questions like, “How did what we started with compare to what we ended with?” and “Do you have any evidence from our investigation to support that a change has occurred in the system?”&lt;br&gt;&lt;br&gt;On day 2, after a Scientists Circle, students will return to their seats and individually process what they have figured out in their Consensus Discussion on their Progress Tracker. Look for students being able to make the connection that burning food undergoes a chemical reaction that produces energy. In order for the energy to be released, the reaction requires oxygen. If students do not make this connection, ask them to look back at Burning Fat in Open and Closed Systems. Remind students that using the evidence that they have collected helps support their arguments. When doing so, ask them to think about what changes they noticed from the beginning to the end of the investigation. Ask them to consider if this reminds them of any other chemical reactions they have seen (such as with the bath bombs and rusting iron) or the graphs of changing amounts of food molecules in M’Kenna’s digestive system.</td>
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Lesson 12

**Lesson-Level Performance Expectation(s)**

- **Analyze and interpret data to identify spatial and temporal relationships in order to determine causes for changes to blood glucose, oxygen, and carbon dioxide levels in the body.**
- **Obtain, evaluate, and communicate information to clarify a claim that a chemical reaction that produces energy in the body is occurring in different parts of the body and that the body uses more glucose and oxygen to provide energy to cells (effect) during exercise (cause) than while resting.**

**Assessment Guidance**

**Analyzing and Interpreting Data; Cause and Effect**

In the activity, **Collect Evidence of a Chemical Reaction: BTB Investigation**, students collect data to determine whether the air they breathe out contains carbon dioxide. They also collect data to answer questions about the presence of a chemical reaction in the body that may be related to the chemical reaction they experienced in Lesson 11. Look for students who interpret the data from the investigation to understand that, because we breathe in oxygen (reactant) and we breathe out carbon dioxide (product), a chemical reaction is taking place inside the body. If students do not draw this parallel to the chemical reactions from Lesson 11 during which they burned food, ask students to revisit the models they created in their Progress Trackers. Guide students to examine the reactants and products in their Progress Trackers for reactions that occurred when they burned food outside of the body. Then, ask “Do we have food as fuel? Do we have evidence of carbon dioxide being released as a product?”

In the activity, **Analyze Oxygen and Carbon Dioxide Levels in the Blood for Evidence of a Chemical Reaction**, students are given data that tracks oxygen and carbon dioxide levels at different locations coming to and from the heart and lungs. Look for students who notice that the point at which oxygen levels decrease is the same point at which carbon dioxide levels increase. Students should also note the significance of the location being between blood going to other parts of the body and returning back to the heart and lungs. Students should infer that oxygen that travels in the blood is being transferred to other parts of the body, which accounts for the decrease. Students use their knowledge of the products of chemical reactions to assume the increase in carbon dioxide is the result of chemical reactions occurring in other parts of the body. If students do not demonstrate this understanding then return again to the Progress Tracker from Lesson 11, which details the reactants and products of a chemical reaction. Work with students in a small group or individually to connect the decrease in oxygen with the concept of oxygen acting as an input in a chemical reaction. Do the same with carbon dioxide as an output of a chemical reaction. If students are unsure of how to answer question 7 on **Oxygen and Carbon Dioxide in the Blood - Part 1**, you may need to use a picture of the circulatory system to show students where the blood vessels travel in the body. Say, “If the blood is full of oxygen here (point to Location 1) and that amount decreases as it travels throughout the body (trace pattern that outlines where blood travels in the system before bringing it back to Location 4), where else in the body could the oxygen be going?”

**Obtaining, Evaluating, and Communicating Information; Cause and Effect**

In Interpreting Activity Data, students receive oxygen and glucose data over time they must interpret to determine that the body uses more oxygen and glucose to provide energy to different parts of the body when the body is active versus at rest. Look for students who notice that the muscles, brain, and digestive organs use the bulk of the oxygen when the body is at rest because, even when the body is not active, these parts of the body are necessary to keep you alive. Students may claim that increased activity causes the body to need more energy. They identify data they would need to analyze to clarify and support their claim and then interpret data that tracks glucose levels in the blood over a 24-hour period, both with and without exercise after every meal. Students should notice glucose levels drop significantly after exercise, indicating more glucose is needed to provide energy to the body when it is active than at rest. If students do not come to this conclusion, try connecting to students’ past experiences with exercise. Ask students to consider a time when they have exercised, such as during P.E. class or outside playing with friends. Ask students what they noticed about the way their breathing changed as compared to when they are sitting quietly, at rest. Help students understand that the body takes in more oxygen by breathing rapidly because the body needs it when active. Similarly, students may have experienced a time when they have worked very hard or been very active, and it has made them feel hungry. This is a signal the body is in need of glucose because it is used more quickly when the body is active. Review the claims that students have written after examining the data described above. Look for students who include specific data or refer explicitly to the data to write a clear claim. If students do not write a clear claim, provide a sentence stem as support, such as: “The parts of the body that use the most energy when active are ___. I know this because ___.”
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<td>Lesson 13</td>
<td><strong>Develop models</strong> of three possible pathways showing how food is rearranged in the body to create energy, store matter for later use, and use matter for growth within a body system. <strong>Construct an explanation</strong> to explain the relationships between differences in M'Kenna's digestive system and a healthy digestive system in order to predict symptoms (effects), such as M'Kenna's decreased growth rate.</td>
<td><strong>Developing and Using Models; Systems and System Models</strong> Students work in small groups to develop models of three different pathways that food entering a body system could take: (1) how the body uses food for energy, (2) how the body uses food not needed right now, and (3) how the body uses food for growth. As groups develop these models, look for them to identify different matter inputs, such as food and oxygen, processes, such as digestion, storage, growth, and cellular respiration, and matter outputs, such as carbon dioxide, water, and fat. Models should also identify different energy flows; for example, in pathway 1, food is broken down and used for energy by the body right away. In pathways 2 and 3, energy from food, and molecules, is stored for later use or to be used in the growth of new tissues. Look for groups to generalize the processes for how healthy bodies use food in each of the three pathways. In pathway 1, models should indicate that food and oxygen enter the body system and are broken down to be used for energy. In pathway 2, models should indicate that excess food is used to create storage molecules, like fat and glucose stored in muscle and liver, which can be used later for energy or growth. In pathway 3, models should indicate that molecules from food can be rearranged to create different tissues in the body like muscle and bone. If groups struggle to identify how food is used differently in each of the pathways, refer them back to their Progress Trackers for Lessons 10-12 when we figured out that the body needs food for growth and that food can be burned for energy. <strong>Constructing Explanations; Cause and Effect</strong> After developing a classroom consensus model, students write an explanation for how M'Kenna's body is functioning differently than a healthy body. In addition, students return to their Progress Trackers to update them with a 3-column entry. In this update, students use the model they built as a class to develop an explanation for how the systems in a healthy body work together to process matter and energy inputs, processes, and outputs. Students add to their explanations about how M'Kenna's digestive system is functioning differently and how her digestive condition contributes to the symptoms that she experiences in other systems of her body. Use this opportunity to look for students to identify the cause and effect relationship between decreased food absorption affecting M'Kenna's energy levels. Students should also explain the relationship between decreased food absorption causing M'Kenna to rely on stored food, or fat, leading to her slowed growth rate or decrease in weight. If students are struggling to make these connections, refer them back to their Progress Trackers for Lesson 12 when they figured out that, when we are active, our body needs more energy, which requires more food.</td>
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| Lesson 14 | Engage in an argument from evidence that, in animals, oxygen reacts with carbon-containing molecules to provide energy and produce carbon dioxide and that organisms might have different structures that work together to do similar functions. | Engaging in Argument from Evidence; Energy and Matter; Structure and Function  
Students will be constructing an argument from evidence in small groups and getting an opportunity to revise their arguments. Look for students seeing similarities between their organism and humans by using the evidence connected from the readings that their animal does basically the same chemical reactions as humans to get energy from food, but they might have different structures inside their bodies that are involved. If students are struggling with their arguments, look for the callout box in the activity section of “Research How Other Organisms Get Energy” for questions to help them get started. During the time for students to revise their arguments, if students are struggling to identify how similar and different structures are functioning, help them map those structures to the human structures that they have previously studied.  
When students are giving and receiving feedback, you will have an opportunity for students to self assess their ability to give and receive feedback using a rubric. Look for students to honestly assess themselves and their growth throughout the unit. There is a place in Lesson 7 during which students could have used the rubric to self assess their peer feedback. |
| Lesson 15 | Develop a model to explain how bears can rearrange matter in food through chemical reactions to release energy and use stored food in the form of fat to survive during hibernation.  
Construct an explanation by applying scientific ideas and evidence to show how bears obtain energy to survive for several months without eating during hibernation. | Developing and Using Models; Energy and Matter  
This lesson includes a transfer task to give students an opportunity to use the three dimensions to make sense of a different phenomenon. This is meant to be a summative assessment task for the unit and gives you a grading opportunity. The task includes a scoring guide, as well as a modeling rubric for scoring the modeling question. Scoring guides are meant to highlight important ideas that students should be including in their responses to the prompts. They are listed as bullet points, so you can decide how to score them appropriately to the norms in your classroom. If students share these ideas elsewhere in the assessment, it is up to you to decide if that understanding is sufficiently demonstrated.  
If your students are struggling or you think they will need support in creating the model, there is a modified student assessment that gives students the components and interactions they will need in their models.  
Reviewing what the class has figured out through answering the questions on the Driving Question Board is one way to help students to prepare for the summative assessment. Reviewing these questions is also a good formative assessment to see if there are any pieces that need to be revisited. |
LESSON 13: How does a healthy body use food for energy and growth, and how is M'Kenna’s body functioning differently?

PREVIOUS LESSON
We gathered evidence showing that a chemical reaction happens in the cells of the body to provide them with energy. The reaction helps us explain why certain materials that we take into our bodies, like oxygen and food, are different from the materials that leave our bodies, like carbon dioxide and water. If our activity levels increase, the chemical reaction happens faster to meet our cells' needs.

THIS LESSON
PUTTING PIECES TOGETHER
2 days
We build small-group models, drawing primarily on what we figured out in Lessons 8–12, to explain how food is rearranged in the body to create energy, store matter for later use, and use matter for growth. We compare our models and then develop a consensus model to explain how a healthy body uses energy and how M’Kenna’s body could be functioning differently. We develop explanations to show how M’Kenna’s symptoms might be connected to what we’ve figured out.

NEXT LESSON
We will investigate different organisms and argue from evidence whether (1) our organism does chemical reactions to break down and burn food molecules and (2) it has the same structures inside its body that work together to do those processes. Then we will come together to share our findings and generalize across organisms.
WHAT STUDENTS WILL DO
 DEVELOP MODELS of three possible pathways showing how food is rearranged in the body to create energy, store matter for later use, and use matter for growth within a body system.

CONSTRUCT AN EXPLANATION to explain the relationships between differences in M’Kenna’s digestive system and a healthy digestive system in order to predict symptoms (effects), such as M’Kenna’s decreased growth rate.

WHAT STUDENTS WILL FIGURE OUT

- The digestive system takes in food and breaks it down through chemical reactions. The small food molecules get absorbed into the body’s circulatory system through the small intestine.
- The respiratory system and circulatory system work together to bring food molecules and oxygen to cells in the body and to remove carbon dioxide.
- Humans need to take in food. Food is a type of fuel, which means that it can react with other substances to release energy.
- Cells rearrange food and oxygen through a chemical reaction, which creates carbon dioxide and water and releases energy that cells can use.
- The body system’s inputs are food (molecules mainly with C,H,O’s) and oxygen. Outputs are mainly carbon dioxide, water, and energy (students might also include poop, which is mostly fiber and water).
- When the body takes in excess food, it can be stored for later use in the form of fat molecules in the body.
- When the body doesn’t take in enough food, it can use the stored fat or food molecules dedicated for growth to burn as fuel. Most of the matter goes into the air when fat is burned.
- M’Kenna’s body used fat molecules stored in her body when she wasn’t getting enough matter from food.
- M’Kenna is absorbing less food through her small intestine, so the cells in all the tissues in her body aren’t getting enough energy, which is causing her non-digestive symptoms.
<table>
<thead>
<tr>
<th>Part</th>
<th>Duration</th>
<th>Summary</th>
<th>Slide</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10 min</td>
<td>NAVIGATION AND REVIEW THE PROGRESS TRACKER FROM LESSONS 8-12&lt;br&gt;Review the ideas we've figured out so far on the Progress Tracker that might help us answer our questions about how the body uses food for energy, and what we have noticed so far in our investigations.</td>
<td>A-C</td>
<td>Progress Tracker, highlighter</td>
</tr>
<tr>
<td>2</td>
<td>15 min</td>
<td>DEVELOP SMALL-GROUP MODELS TO EXPLAIN HOW A HEALTHY BODY USES FOOD&lt;br&gt;Develop small-group models to explain: &quot;How do our bodies use food not needed right now? How do our bodies use food needed for growth?&quot;</td>
<td>D</td>
<td>chart paper, markers, Three Pathways Inside Our Bodies</td>
</tr>
<tr>
<td>3</td>
<td>8 min</td>
<td>COMPARE MODELS WITH ANOTHER SMALL GROUP&lt;br&gt;Have students compare their models with another small group.</td>
<td>E</td>
<td>small-group models</td>
</tr>
<tr>
<td>4</td>
<td>7 min</td>
<td>START TO BUILD A CLASSROOM CONSENSUS MODEL&lt;br&gt;Have students share similarities and differences in their models and come to a consensus. Visually represent the classroom consensus model on the board or a poster.</td>
<td>F</td>
<td>Three Pathways Inside Our Bodies, colored pencils, chart paper, markers</td>
</tr>
<tr>
<td>5</td>
<td>15 min</td>
<td>CONTINUE TO BUILD A CLASSROOM CONSENSUS MODEL&lt;br&gt;Have students come to a consensus on pathways 2 and 3 and visually represent the classroom consensus model on the board or a poster.</td>
<td>F-J</td>
<td>Three Pathways Inside Our Bodies, colored pencils, chart paper, markers</td>
</tr>
<tr>
<td>6</td>
<td>15 min</td>
<td>CONNECT WHAT WE'VE FIGURED OUT TO M'KENNA'S OTHER SYMPTOMS&lt;br&gt;Review M'Kenna's symptoms and explain how they might be connected to what we've figured out.</td>
<td>K</td>
<td>colored pencils, consensus model</td>
</tr>
<tr>
<td>7</td>
<td>13 min</td>
<td>DEVELOP INDIVIDUAL EXPLANATIONS FOR M'KENNA'S OTHER SYMPTOMS&lt;br&gt;Have students individually use the consensus model and Gotta-Have-It Checklist to write an explanation of how a shortage of food entering M'Kenna's bloodstream could have caused her other symptoms.</td>
<td>L</td>
<td>colored pencils, consensus model</td>
</tr>
<tr>
<td>8</td>
<td>4 min</td>
<td>ADD TO OUR PROGRESS TRACKERS&lt;br&gt;Using the classroom consensus model, students individually add to their 3-column Progress Tracker or Gotta-Have-It Checklist.</td>
<td>M</td>
<td>Progress Tracker, colored pencils</td>
</tr>
<tr>
<td>9</td>
<td>3 min</td>
<td>HOW IS M'KENNA NOW? (OPTIONAL)&lt;br&gt;Conclude the class investigation into M'Kenna's symptoms by learning more about who M'Kenna is and how she is doing now.</td>
<td>N</td>
<td>Who is M'Kenna, and what happened to her?</td>
</tr>
</tbody>
</table>

End of day 1

End of day 2
### Lesson 13 • Materials List

<table>
<thead>
<tr>
<th>Lesson materials</th>
<th>per student</th>
<th>per group</th>
<th>per class</th>
</tr>
</thead>
<tbody>
<tr>
<td>• science notebook</td>
<td></td>
<td></td>
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<tr>
<td>• Progress Tracker</td>
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<tr>
<td>• highlighter</td>
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<tr>
<td>• chart paper</td>
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<td></td>
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<tr>
<td>• markers</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>• Three Pathways Inside Our Bodies</td>
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<tr>
<td>• colored pencils</td>
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<tr>
<td>• Progress Tracker</td>
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<td></td>
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<tr>
<td>• Who is M’Kenna, and what happened to her?</td>
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<td></td>
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<tr>
<td>• small-group models</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>• chart paper</td>
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<td></td>
<td></td>
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<tr>
<td>• markers</td>
<td></td>
<td></td>
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<tr>
<td>• consensus model</td>
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</tbody>
</table>

### Materials preparation (25 minutes)

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

Gather materials for the classroom consensus model.

Make extra copies of *Three Pathways Inside Our Bodies* for students to use in small-group modeling and again while developing the consensus model.
Lesson 13 • Where We Are Going and NOT Going

Where We Are Going

This lesson addresses a key Disciplinary Core idea that food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy (LS1C). Specifically, students develop understandings that energy is released through a chemical reaction that rearranges food (sugar) and oxygen into carbon dioxide and water. Cells use that energy to move, make stuff, and react to stimuli. Cells will die if they don't get either food or oxygen. Students also develop understandings that (1) the blood transports food and oxygen to the cells and takes carbon dioxide and water out of the cells and (2) oxygen is taken into and carbon dioxide and water leave the blood through the lungs and respiratory system.

Students also put the pieces together to explain that carbon leaving the body in the carbon dioxide is how the organism loses weight. Excess food molecules that aren't used for energy can immediately be stored for energy at a later point in time.

Students may believe that M'Kenna's weight loss is coming from her bouts of diarrhea and vomiting, as opposed to tapping into stored fat to use in a chemical reaction to meet cells' energy needs. The idea that stored fat can be lost as gases through the air through a chemical reaction may be counterintuitive to students who tend to focus on macroscopic ways of accounting for weight loss (e.g., sweat and poop).

Where We Are NOT Going

Students don't need to know the chemical reaction for cellular respiration. They will build upon the ideas developed in this unit when they address more complex ideas related to cellular respiration in high school.

Students do not need to know the mechanisms behind how the body breaks down excess glucose and converts it into fat or how the body uses fat stores to produce energy. This is a very complex series of chemical reactions, which is beyond the middle-school assessment boundary that the details of chemical reactions are not needed, and "Emphasis is on describing that (food) molecules are broken apart and put back together and that in this process, energy is released."
LEARNING PLAN for LESSON 13

1 · NAVIGATION AND REVIEW THE PROGRESS TRACKER FROM LESSONS 8-12

MATERIALS: science notebook, Progress Tracker, highlighter

Navigate to the focus for this lesson. Project slide A. Have students look back at what the class figured out last time and use that to motivate looking back through the Progress Trackers for Lessons 8-12.

Say, We figured out some big punchlines last class about how a healthy body uses food for energy! Let’s look back at our Progress Trackers to make sure we are all on the same page with what we just figured out.

ADDITIONAL GUIDANCE

A strategy for differentiation is to start this lesson with an extended allotment of time of looking back through what the class has figured out so far. This helps students prepare to add on to the models built in Lesson 12. This can be beneficial for students who may need more time synthesizing the major punchlines of lesson set two. If your students are ready to move forward, you can move along more quickly here to the small-group model building.

Review ideas from the Progress Tracker. Have students turn to their Progress Trackers. Have students highlight the ideas that might help us explain the question, “How do our bodies use food for energy?” Then students should add them to their developing list on Gotta-Have-It Checklist.

Record a Gotta-Have-It Checklist of agreed-upon ideas from the Progress Tracker that students nominate. Project slide B. As a class, determine which ideas from the list seem as though they will be the most useful for our current question. Students can put a check mark near their own version of that idea in their Progress Trackers and update their Gotta-Have-It Checklist. This Gotta-Have-It Checklist is not exhaustive. Students will continue adding to their checklist over the next couple of days.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can someone suggest an idea that we figured out from Lessons 8 through 12 that</td>
<td>Food molecules that get absorbed from the small intestine go into the blood. (Lesson 8)</td>
</tr>
<tr>
<td>could help us explain how a healthy body uses food for energy?</td>
<td>The blood moves food molecules to cells. (Lesson 12)</td>
</tr>
<tr>
<td>Record students’ ideas (on the right) in a class version of a Gotta-</td>
<td>The blood brings oxygen to cells from the respiratory system. (Lesson 12)</td>
</tr>
<tr>
<td>Have-It Checklist.</td>
<td>The blood removes carbon dioxide and water from cells through the respiratory system. (</td>
</tr>
<tr>
<td></td>
<td>Lesson 12)</td>
</tr>
<tr>
<td></td>
<td>The body burns food by using oxygen, which produces water, carbon dioxide, and energy</td>
</tr>
<tr>
<td></td>
<td>for cells to use. This chemical reaction occurs inside of cells. (Lessons 10-12)</td>
</tr>
</tbody>
</table>
**ADDITIONAL GUIDANCE**

Co-creating a public representation of ideas that the class plans to use in its explanation will be an important reference for students as they build their models and use them to explain what is going on with M’Kenna. The public representation of the Gotta-Have-It Checklist allows you to reference it on Day 2 of model building. Having students put check marks in their own science notebooks also gives them a personal representation of the important ideas.

**Build out the first part of the classroom consensus model if you have not already.** If your class has not already come to this agreed-upon representation in Lesson 12 for the question, “How do our bodies use food for energy?” Use the ideas from the Gotta-Have-It Checklist to build this part of the model out with your class now. Present slide C. Here is a representation of that model.

If your class has already built this out on a public representation, just pull out that representation from Lesson 12. Students should individually write the question that the class is working on and record a representation of this model on the top part on *Three Pathways Inside Our Bodies.*

1. “How do our bodies use food for energy?”
Use the prompts below if needed to help students clarify their thinking during model development.

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>How a healthy body uses food for energy is a piece of the puzzle we've been figuring out! What happens to small food molecules, like glucose, after they are absorbed by the body?</strong></td>
<td>They go into the bloodstream. We saw that in the simulation and images of the small intestine.</td>
</tr>
<tr>
<td><strong>How do food molecules get to the cells?</strong></td>
<td>Food molecules go into the blood which goes to cells. We saw this in the simulation.</td>
</tr>
<tr>
<td><strong>What happens to food molecules once they reach a cell? What evidence do you have to support this idea?</strong></td>
<td>In a healthy body, the cell uses oxygen to burn the food, which produces energy that the body can use. This is a chemical reaction. We saw that this could happen outside of the body when we burned the food. We inferred that it happens in the body when we exercised and breathed out less oxygen and more water and carbon dioxide.</td>
</tr>
<tr>
<td><strong>How does oxygen for the chemical reaction get to the cells?</strong></td>
<td>Oxygen goes into the blood from the lungs.</td>
</tr>
<tr>
<td><strong>What is left over from the chemical reaction, and how does it leave the body?</strong></td>
<td>Carbon dioxide and water are produced. They leave through the blood and lungs, and then people breathe those out. We saw evidence for this when we saw our breath change the color of the BTB solution. We also saw that data that tracked carbon dioxide and oxygen levels in the blood. The oxygen levels decreased at the same point that carbon dioxide increased in the body due to the chemical reactions occurring to burn food.</td>
</tr>
</tbody>
</table>

### 2 · DEVELOP SMALL-GROUP MODELS TO EXPLAIN HOW A HEALTHY BODY USES FOOD

**MATERIALS:** science notebook, chart paper, markers, *Three Pathways Inside Our Bodies*

Motivate trying to answer why M’Kenna was losing weight and not growing.

<table>
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</thead>
<tbody>
<tr>
<td><strong>After we checked in on the DQB, we were focused on figuring out one particular non-digestive symptom of M’Kenna’s. What was that again? (If students need extra help, ask them to recall the growth charts they analyzed.)</strong></td>
<td>We were trying to figure out—why was M’Kenna losing weight and not growing?</td>
</tr>
</tbody>
</table>

Say, I wonder if anything we’ve figured out can help us answer those questions. For example, in Lessons 10-11, I think we may have made some progress on the question, “Where does matter in a person go when it’s lost?” Let’s think about those two pieces—weight/matter and growth for any person—and then we can apply it back to M’Kenna’s specific case. We can work in small groups to build models to answer the questions:

2. How do our bodies use food not needed right now?
3. How do our bodies use food needed for growth?

**Prepare to build small-group models.** Project slide D. Have students record those questions in the next two blank lines on *Three Pathways Inside Our Bodies*. Once students have reviewed what we’re trying to explain and the ideas that can help us, get them ready to build their small-group models.
Students will create three total pathways to represent: (1) how the body uses food for energy, (2) how the body uses food not needed right now, and (3) how the body uses food for growth. Students already developed the first model to show how the body uses food for energy.

Work in small groups to develop a model to explain how a healthy body uses food not needed right now (pathway 2) and food needed for growth (pathway 3). While students are working, walk around the room and look at their models. Where needed, use questions to help students fully articulate their thinking and prepare to defend their ideas. Prompt students to remember the evidence from previous investigations for each of the ideas they’ve figured out.

Students will use Three Pathways Inside Our Bodies again during the Consensus Discussion, so you may wish to make extra copies if they use the second and third circles for brainstorming.

It may help to explain to students that, after they create their models for a healthy body and come to consensus on the models, we will use a different color to add our ideas about how M’Kenna’s body is functioning differently. During the small-group modeling work, though, students should just focus on what is going on in a healthy body.

As you circulate, keep track of each group’s progress on model development. When you feel that a group is ready to move on to the next pathway, prompt them to do so. You may choose to either prompt each small group to move on or pause the class and provide instructions for the whole class using slide D.

Use the prompts below to help students clarify their thinking during model development.

### ADDITIONAL GUIDANCE

**Prompts for eliciting and probing student proposals for what should go in the model:**
- How did your group explain what happens to food molecules not used right away?
- How could the food molecules be used to support growth?
- Where does growth occur inside the body?
- What parts inside the body are developed when you are growing?
- What evidence do you have to support your idea(s)?
- How should we represent this?

**Prompts to ask students to support or challenge proposals:**
- What ideas are we in agreement about?
- Are there still places where we disagree? Can we clarify these?
- Are there still areas of confusion or discontent?
- Who feels like their idea is not quite represented here?
3 · COMPARE MODELS WITH ANOTHER SMALL GROUP

MATERIALS: science notebook, small-group models

- **Remind students of discussion norms.** Show students the classroom poster with discussion norms and sentence frames to use when having scientific discussions. Emphasize the importance of having a space in which students can share their ideas and push each other's thinking.

- **Set the purpose for comparing models.** Tell students that the purpose of the discussion is to surface areas of agreement, disagreement, or any lingering questions. Students' jobs are to place ideas on the table, clarify other students' perspectives, and evaluate their own ideas and the ideas of others. At the end of their discussion, they should be prepared to share their ideas with the whole group as part of the class Consensus Discussion.

- **Make a table for comparing small-group models.** Project slide E and have students make a table in their science notebooks to record similarities and differences among their models. If students hear ideas they like from their peers, they can revise their small-group models.

- **Give students time to share ideas in small groups.** Circulate among the small groups and help students with productive talk by encouraging them to use the sentence starters from the Communicating in Scientific Ways poster. If you hear important ideas, encourage students to share those ideas in the whole-class Consensus Discussion. Give time updates so that students remember to take stock of ideas they agree upon and ideas that they are unsure about. Have students revise their small-group models if they hear ideas from group members that they want to add to their models.

**ADDITIONAL GUIDANCE**

Sharing in small groups is important to ensure that all students have the opportunity to articulate their ideas to someone else to help deepen their understanding and begin the process of considering their ideas in the context of other's ideas. This also creates a safer space for students who might be less willing to participate in a whole-class setting. This helps students identify ideas or features that small groups want to bring to the classroom consensus model.

4 · START TO BUILD A CLASSROOM CONSENSUS MODEL

MATERIALS: science notebook, *Three Pathways Inside Our Bodies*, colored pencils, chart paper, markers

- **Form a Scientists Circle for a Consensus Discussion.** Have students bring their small-group models to the Scientists Circle. The purpose of this discussion is to put the pieces together about what we’ve figured out from Lessons 8 through 12. Have extra copies of *Three Pathways Inside Our Bodies* if students need another copy and instruct students to keep track of the classroom consensus model on their own.

  You will not have enough time to finish the Consensus Discussion by the end of this class. In the next class, you will resume the Consensus Discussion in your Scientists Circle.

  Present slide F and say, We’re going to take stock of the ideas in everyone’s models and build a classroom consensus model that everyone agrees upon to explain how a healthy body uses food. After coming to a consensus on what is happening in a healthy body, we are going to try to figure out what could be functioning differently in M’Kenna’s body.

- **Remind students of discussion norms.** Reinforce the positive ways you heard students sharing ideas in small groups. Highlight important ways to talk with one another, including frames for how to agree or disagree respectfully and how to push for justification. Encourage students that it’s OK to share an idea that they’re not sure about or to disagree with a group’s idea.

**ATTENDING TO EQUITY**

Not all students are comfortable being the “only one” who voices a disagreement or a potentially wrong idea. Ask students to think about what they heard their group members saying, and ask the room if their group members’ ideas are represented in the class discussion. This supports all students to share, to listen, to be heard, and to be represented.
**Purpose of this discussion:** At the end of this learning set, the purpose of this Consensus Discussion is to build a common, class-level model to explain how a healthy body uses food, drawing on all the ideas learned in Lessons 8–12. The teacher's role is to prompt students to share what needs to be in the model, evidence they have to support their ideas, and how to represent it. The students' role is to offer proposals for a model, support or challenge proposals, and come to a consensus about what should be included in the model.

**Look for these ideas to include in the class’ Gotta-Have-It Checklist:**
- The digestive system takes in food and breaks it down through chemical reactions, and the small food molecules get absorbed into the body's circulatory system through the small intestine.
- The respiratory and circulatory systems work together to bring food molecules and oxygen to cells in the body and to remove carbon dioxide.
  - Some organs in the respiratory system that work together include the following: nose, mouth, and lungs.
  - Some organs in the circulatory system that work together include the following: blood and heart.
    - The blood moves food molecules to cells (optional).
    - The blood brings oxygen to cells from the respiratory system (optional).
    - The blood removes carbon dioxide and water from cells through the respiratory system (optional).
- Humans need to take in food. Food is a type of fuel, which means that it can react with other substances to release energy.
- Cells rearrange food and oxygen through a chemical reaction, which creates carbon dioxide and water and releases energy that cells can use.
- The body system's inputs are food (molecules mainly with C,H,O's) and oxygen. The outputs are mainly carbon dioxide, water, and energy (students might also include poop, which is mostly fiber and water).

**Facilitate a Consensus Discussion about how a healthy body uses food not needed right now (pathway 2).** Students should offer proposals for what should go in the model, support or challenge these proposals based on evidence, and propose modifications.

When the class is over, tell students you will pick up where you left off on the next day.

**End of day 1**
Re-form a Scientists Circle to continue the Consensus Discussion. Remind students of the purpose of the Consensus Discussion to build a class representation of how a healthy body uses food and what could be functioning differently in M’Kenna’s body.

Continue the Consensus Discussion about how our bodies use food needed for growth (pathway 3). Create a public representation of agreed-upon ideas as the class puts them together on the whiteboard or on poster paper.

<table>
<thead>
<tr>
<th>ADDITIONAL GUIDANCE</th>
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<tbody>
<tr>
<td><strong>Prompts for eliciting student proposals for what should go in the model:</strong></td>
</tr>
<tr>
<td>• What is one of the key components of your model that explains how the body uses food?</td>
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<tr>
<td>• What evidence do you have to support your idea?</td>
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<tr>
<td>• How should we represent this?</td>
</tr>
<tr>
<td><strong>Prompts to ask students to support or challenge proposals:</strong></td>
</tr>
<tr>
<td>• What ideas are we in agreement about?</td>
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</tr>
<tr>
<td>• Are there still areas of confusion or discontent?</td>
</tr>
<tr>
<td>• Who feels like their idea is not quite represented here?</td>
</tr>
<tr>
<td><strong>Prompts for proposing modifications to the proposal or coming to a consensus with conflicting ideas:</strong></td>
</tr>
<tr>
<td>• How are these explanations similar? How are they different?</td>
</tr>
<tr>
<td>• How could we modify what we have so that we account for the evidence we agree is important to consider?</td>
</tr>
<tr>
<td>• Is there more evidence or clarification we need before coming to an agreement? What is that?</td>
</tr>
</tbody>
</table>

STRATEGIES FOR THIS BUILDING UNDERSTANDINGS DISCUSSION

Some students may quickly agree that, because fat and glucose share the same types of atoms, fat can be used as a fuel in place of glucose. Other students may not be as easily convinced given the difference in size and structure of the molecules. Point students back to the fuel lessons in which they burned duck fat and vegetable oil as evidence that fat molecules can be a fuel source. Support students in connecting their ideas to evidence gathered across the unit using the following prompts:

• Is there evidence we’ve seen that fat can be a fuel?
• What other explanation can explain a person losing weight from their body?
  • If fat turned to energy, what happened to all the carbon, hydrogen, and oxygen atoms?
  • If fat turned to sweat, which is mostly water, what would happen to the carbon atoms?
Have students record the final representation of the classroom consensus model on Three Pathways Inside Our Bodies. Your representation will look something like the next image, but representations can vary. The main idea is to establish a pathway so that food molecules can become fat stores or be used for growth, muscle building, nutrients for cells between meals, and so forth. Add these additional details if it seems to make sense for your model, even though students will not have evidence to back up those details at this point in the unit.

Shift the Consensus Discussion to focus specifically on M’Kenna’s weight loss.

Say, We did a great job developing a model for how healthy bodies process food; now let’s see if we can use these three pathways in our model to try to explain M’Kenna’s weight loss.

Point out that pathway 1 shows us how we use food molecules broken down by our digestive system as a source of fuel that our cells can do chemical reactions with to get usable energy. Pathways 2 and 3 show us that, if we have extra food molecules in our blood that aren’t needed for energy, those food molecules can be converted to fat molecules or to support growth and are converted to bone, muscle, and other tissues our body needs.

Then say, But, does M’Kenna have a lot of food molecules in her blood? (Refer to squares representing the food molecules, such as glucose).
Have students **Turn and Talk to a partner about the question on the slide**. Present slide G. Students should talk about the question, “Does M’Kenna have a lot of food molecules in her blood; why or why not?”

Have students share their thoughts with the whole group.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
<th>Follow-up questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Does M’Kenna have a lot of food molecules in her blood; why or why not?</strong></td>
<td>No, she doesn’t have a lot of food molecules in her blood because her small intestine is damaged from her celiac disease and isn’t allowing all food molecules inside her body.</td>
<td>Where did we figure out what the underlying cause was for M’Kenna’s symptoms?</td>
</tr>
<tr>
<td><strong>So, then how are her cells getting the energy they need?</strong></td>
<td>Our model currently doesn’t have a way to explain where her cells would get energy from.</td>
<td>How could a shortage of food entering M’Kenna’s bloodstream have caused her other symptoms?</td>
</tr>
<tr>
<td>Let’s use our consensus model to try and explain that, if you don’t have enough glucose molecules in your blood, where do your cells get the energy they need?</td>
<td>Maybe we could add one in.</td>
<td>How did M’Kenna’s body build up fat stores for later use? How did M’Kenna’s cells tap into the fat stores when she needed them?</td>
</tr>
<tr>
<td><strong>So then where could the cells in her body use energy from?</strong></td>
<td>Her cells can use her fat stores from pathway 2 for energy. So the output for pathway 2, fat molecules, could be the input.</td>
<td>So are you saying that a fat molecule stored in an arm, leg, or stomach (pathway 2) could be used in this chemical reaction (pathway 1)?</td>
</tr>
</tbody>
</table>

Work with students to come to a consensus and add the red arrow shown in the image depicting that her cells could burn her fat stores for energy.

**Turn and talk about the following question. Show slide H.** Have students talk with a partner about the following questions: So what if her body ran out of fat stores? Where might her body use energy from instead?

![Diagram of food and energy pathways](Diagram.png)
### Suggested prompt

| What did glucose have in it? | Carbon, hydrogen, and oxygen. |
| What are the differences between glucose and fat molecules? | Fat is bigger than glucose.  
Fat has long chains, and glucose is more compact (and/or round). |
| What are similarities between glucose and fat molecules? | They are both made from carbon, hydrogen, and oxygen atoms.  
They are both molecules found in foods.  
They burned when we tested them. |
| What do you think about this question now? Do you think a fat molecule stored in our arm, leg, or stomach could be used as fuel for a chemical reaction? | Probably, because the duck fat was a fuel and vegetable oil was a fuel.  
If it has carbon and hydrogen, it can provide the same reactants for the chemical reaction. |
| So, where does the matter go when a person loses weight? | When someone loses weight, they burn fat. We learned that when you burn fat the products are carbon dioxide, which is breathed out, and water. So I guess we mostly breathe the matter out into the air! |
Update the class Gotta-Have-It Checklist. Project slide J. Summarize the class findings and update the class Gotta-Have-It Checklist with these additional ideas:

- When the body takes in excess food, it can be stored for later in the form of fat molecules in the body.
- When the body doesn't take in enough food, it can use the stored fat or food molecules dedicated for growth to burn as fuel.

Most of the matter goes into the air when fat is burned.

Have students update their own Gotta-Have-It Checklist and return to their seats.

6 · CONNECT WHAT WE’VE FIGURED OUT TO M’KENNA’S OTHER SYMPTOMS

MATERIALS: science notebook

Take stock of where the class is by reviewing M’Kenna’s symptoms. Project slide K with M’Kenna’s symptoms and have students open their science notebooks to their home learning on Revisiting Symptoms and Systems.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which of M’Kenna’s symptoms could be connected to what we have figured out?</td>
<td>We think that weight loss, fatigue, rapid heartbeat with exercise, brain fog, and difficulty breathing with exercise may all be related because they all have to do with cells using energy. Last lesson we saw that come cells need more energy than others. For example, muscles need the most, then the digestive organs, then the brain. When you exercise, your muscles would need to use up more oxygen for the chemical reaction to provide energy for the cells in our muscles to use.</td>
</tr>
<tr>
<td>What would you predict would happen if your muscles couldn’t get enough energy?</td>
<td>We’d get tired. We would also get sore muscles. Maybe that’s why we start breathing faster?</td>
</tr>
<tr>
<td>You said that other organs in our body, like our brain and heart, also need energy, what do you think would happen if those didn’t get enough energy either?</td>
<td>Maybe our brain would get tired, too? Our heart would beat faster. Maybe our heart gets tired?</td>
</tr>
</tbody>
</table>
M’Kenna absorbing less food could be related to her feeling fatigued and tired. What parts of her body need energy that might not be getting enough, which could be related to her symptoms?

She's not absorbing as much food in her small intestine. She's using food as fuel in the same way; but she just doesn't have as much food, so she can't get as much energy. Her brain, her muscles, and her heart.

7 · DEVELOP INDIVIDUAL EXPLANATIONS FOR M’KENNA’S OTHER SYMPTOMS

MATERIALS: science notebook, colored pencils, consensus model

Project slide L

Have students use the classroom consensus model and Gotta-Have-It Checklists to individually write explanations. Students should use the symptoms mapping that they did in Map M’Kenna’s Symptoms to Her Body Systems, the consensus model, and the Gotta-Have-It Checklist to explain: “How could a shortage of food entering M’Kenna’s bloodstream be connected to so many different symptoms in different systems of her body?” Assign each student to develop one of the body systems with associated symptoms of M’Kenna.

The goal of the explanation is not to have a detailed description of the cause of all her symptoms; that is beyond the scope of this unit. Rather, the focus should be on being able to reason through a connection between what the class has figured out about how things inside our bodies work together and how that might have impacted the way M’Kenna is feeling.

ALTERNATE ACTIVITY

Depending on class time availability, instead of assigning students to one body system and having them report out what they find, you can assign each student to develop an explanation for symptoms in each of the body systems. This might really allow students to better see multiple connections within the body.

Bring the class together to share out potential connections. By the end, each body system should have its own short explanation for how a food shortage in M’Kenna might be connected to the related symptoms in that body system. Invite different students to share out with the whole class.
An example of a connection students might make is having students think about how her slowed growth rate would help them connect this symptom to the skeletal system. They could refer back to the article they read in Lesson 10 about how kids need more fat in their diets because they use it for growth. If M’Kenna is using fat to maintain daily functions because she’s not getting enough from her food, this could cause her to lose weight. As a result, as she uses up her fat stores, she would have a slowed growth rate because she’s using everything already in her body for daily functions needed by cells. Evidence of this was shown in her weight and height growth charts. So, food molecules going into pathways 2 and 3 would get shut down so that pathway 1 could continue.

While students are sharing out, add to the class Gotta-Have-It Checklist with any new ideas students are bringing in.

Connect digestion to cellular respiration. You may want students to add individual final versions of the models of pathways 2 and 3 on *Three Pathways Inside Our Bodies* using colored pencils. Students should tape the handout into the right side of their notebooks. Then have students connect it to the digestion model built out in Lesson 7. This would help students see the connection between the food molecules being absorbed into the small intestine from Lessons 1-7 and how that builds on the models for the three pathways in Lessons 8-13. See the example in the table below.

<table>
<thead>
<tr>
<th>Left side of science notebook</th>
<th>Right side of science notebook</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Digestion Model" /></td>
<td><img src="image2.png" alt="Cellular Respiration Model" /></td>
</tr>
</tbody>
</table>
Here is a final version of the Gotta-Have-It Checklist ideas students might use in their explanations:

- The digestive system takes in food and breaks it down through chemical reactions, and the small food molecules get absorbed into the body's circulatory system through the small intestine.
  - Some structures (organs) in the digestive system that work together are the following: mouth, esophagus, stomach, small intestine, and large intestine.
- The respiratory and circulatory systems work together to bring food molecules and oxygen to cells in the body and to remove carbon dioxide.
  - Some organs in the respiratory system that work together are the following: nose, mouth, and lungs.
  - Some organs in the circulatory system that work together are the following: blood and heart.
  - The blood moves food molecules to cells (optional).
  - The blood brings oxygen to cells from the respiratory system (optional).
  - The blood removes carbon dioxide and water from cells through the respiratory system (optional).
- Humans need to take in food. Food is a type of fuel, which means that it can react with other substances to release energy.
- Cells rearrange food and oxygen through a chemical reaction, which creates carbon dioxide and water and releases energy that cells can use.
- The body system's inputs are food (molecules mainly with C,H,O's) and oxygen. Outputs are mainly carbon dioxide, water, and energy (students might also include poop, which is mostly fiber and water).
- When the body takes in excess food, it can be stored for later in the form of fat molecules in the body.
- When the body doesn't take in enough food, it can use the stored fat or food molecules dedicated for growth to burn as fuel. Most of the matter goes into the air when fat is burned.

8 · ADD TO OUR PROGRESS TRACKERS

MATERIALS: science notebook, Progress Tracker, colored pencils

Present slide M and pass out the Progress Tracker. Tell students that, as they know, when we figure out something big, we add it to our Progress Tracker in the form of the 3-column tracker. Provide time for students to individually update their Progress Trackers based on the classroom consensus model.

ALTERNATE ACTIVITY

Instead of using the 3-column Progress Tracker in this lesson, you can choose to have students tape in their updated Gotta-Have-It Checklist in their notebooks in the Progress Tracker section for Lesson 13.
Below is one suggested representation for the Progress Tracker. Students will come back to their Progress Trackers again and add a second question.

<table>
<thead>
<tr>
<th>Question</th>
<th>Source of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>How does a healthy body use food for energy needed now? Needed for growth? Not needed now?</td>
<td>Evidence for all investigations in Lessons 1-12</td>
</tr>
<tr>
<td>How did M’Kenna’s body function differently?</td>
<td></td>
</tr>
</tbody>
</table>

What I figured out in words/pictures

- The digestive system takes in food and breaks it down through chemical reactions, and the small food molecules get absorbed into the body’s circulatory system through the small intestine.
  - Some structures (organs) in the digestive system that work together are the following: mouth, esophagus, stomach, small intestine, and large intestine.
- The respiratory and circulatory systems work together to bring food molecules and oxygen to cells in the body and to remove carbon dioxide.
  - Some organs in the respiratory system that work together are the following: nose, mouth, and lungs.
  - Some organs in the circulatory system that work together are the following: blood and heart.
    - The blood moves food molecules to cells (optional).
    - The blood brings oxygen to cells from the respiratory system (optional).
    - The blood removes carbon dioxide and water from cells through the respiratory system (optional).
- Humans need to take in food. Food is a type of fuel, which means that it can react with other substances to release energy.
- Cells rearrange food and oxygen through a chemical reaction, which creates carbon dioxide and water and releases energy that cells can use.
- The body system's inputs are food (molecules mainly with C,H,O's) and oxygen. Outputs are mainly carbon dioxide, water, and energy (students might also include poop, which is mostly fiber and water).
- When the body takes in excess food, it can be stored for later in the form of fat molecules in the body.
- When the body doesn’t take in enough food, it can use the stored fat or food molecules dedicated for growth to burn as fuel.

Students may also wish to take this time to update their table of contents.
9 · HOW IS M’KENNA NOW? (OPTIONAL)

MATERIALS: Who is M’Kenna, and what happened to her?

Conclude the investigation into M’Kenna’s symptoms by sharing more about her. At this point, students have probably been wanting to know more about M’Kenna. Present slide N and tell students that now that we have figured out what is causing all of her symptoms, we are going to learn a little bit more about who M’Kenna is and what happened to her. Hand out Who is M’Kenna, and what happened to her? and give students time to read about M’Kenna. Offer time for open conversations about M’Kenna, what happened to her, and any lingering questions that students may have.

ALTERNATE ACTIVITY
Doing the reading Who is M’Kenna, and what happened to her? is an optional activity. You can decide if this reading is something your students would enjoy. Also, this reading can be done any time after Lesson 13 and could be used on a substitute day or for home learning.
Navigation

We figured out some big punchlines last class about how a healthy body uses food for energy! Let’s look back at our Progress Trackers to make sure that we are all on the same page with what we’ve just figured out.

On your own

1. Review your ideas from Lessons 8–12 in your Progress Tracker.
2. Make notes and highlight ideas on your Progress Tracker that might help explain the question, “How do our bodies use food for energy?”
3. Add those ideas to your Gotta-Have-It Checklist.

What Can We Explain Now?

As a class, determine which ideas seem the most useful to help us answer the question:

- How do our bodies use food for energy?

Record a class list of agreed-upon ideas in a Gotta-Have-It Checklist.

Develop a Model to Answer Our Question

Build an Individual Model to explain:

Pathway 1: How do our bodies use food for energy?

Use the top third of your handout to show how the body uses food needed for energy.

Build a Small-Group Model

Add two pathways to explain:

Pathway 2: How do our bodies use food not needed right now?

Pathway 3: How do our bodies use food needed for growth?

Using chart paper, build your models in small groups for the next two pathways.

→ Record questions in your notebook that come to mind as you are creating your model.
Compare Models with Another Small Group

Pair up with another small group and share your model. As you share your models, record similarities and differences in the inputs, processes, and outputs that each group has represented in their model.

Make a T-chart in your notebook to record your thoughts.

<table>
<thead>
<tr>
<th>Comparing energy and matter inputs, outputs, and processes in a healthy body</th>
</tr>
</thead>
<tbody>
<tr>
<td>Similarities</td>
</tr>
<tr>
<td>Differences</td>
</tr>
</tbody>
</table>

Developing a Consensus Model for a Healthy Body

As a class, develop a consensus model to answer the questions for a HEALTHY body:

- **Pathway 2**: How do our bodies use food not needed right now?
- **Pathway 3**: How do our bodies use food needed for growth?

As you do, consider the following questions:
- What ideas should we include?
- How should we represent them?
- Do we have evidence to support them?
- What is our reasoning?

Gather in a Scientists Circle and place your small-group posters in the middle of the circle.

How Can We Explain M’Kenna’s Weight Loss?

Let’s try to use the pathways in our model to explain M’Kenna’s weight loss.

Turn and Talk

- Does M’Kenna have a lot of food molecules in her blood? Why or why not?
Compare Fat Molecules to Glucose Molecules

- Carbon
- Hydrogen
- Oxygen
- Nitrogen
- Sulfur
- Two kinds of fatty acid molecules
- Two kinds of protein molecules
- Two kinds of amide molecules
- Two kinds of fat molecules
- Two kinds of glucose molecules
- The tail end of one kind of complex carbohydrate backbone molecule
- The tail end of one kind of complex fat molecule
- The tail end of one kind of complex protein molecule

Update Our Gotta-Have-It Checklist

As a class, summarize your findings to answer the question:

**Why was M’Kenna losing weight?**

Update the Gotta-Have-It Checklist with your new ideas.

Revisit M’Kenna’s Symptoms

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intense headaches</td>
<td>Headaches in the morning, afternoon, or evening</td>
</tr>
<tr>
<td>Fatigue</td>
<td>Feeling run down, weak, or tired</td>
</tr>
<tr>
<td>Loss of appetite</td>
<td>Feeling less interested in eating</td>
</tr>
<tr>
<td>Weight loss</td>
<td>Sudden and significant weight loss</td>
</tr>
<tr>
<td>Muscle weakness</td>
<td>Feeling weak or乏力</td>
</tr>
<tr>
<td>Constipation</td>
<td>Difficulty passing stool</td>
</tr>
<tr>
<td>Gastrointestinal (GI) symptoms</td>
<td>Nausea, vomiting, or diarrhea</td>
</tr>
</tbody>
</table>

How Can We Explain M’Kenna’s Other Symptoms?

**Turn and Talk**

Use your ideas on Lesson 12 - Handout 3 to answer the following question:

1. Which of M’Kenna’s symptoms could be connected to what we have figured out?

On your own

Using everything we’ve figured out so far, explain: **How could a shortage of food entering M’Kenna’s bloodstream be connected to so many different symptoms in different systems of her body?**
Add to Our Progress Trackers

Work individually to update your Progress Tracker. Focus on the key ideas to go along with your models to explain:

- How does a healthy body use food for energy needed now? Needed for growth? Not needed now?
- How is M’Kenna’s body functioning differently?

<table>
<thead>
<tr>
<th>Question</th>
<th>Source of evidence</th>
<th>What we figured out in words/pictures</th>
</tr>
</thead>
</table>

Who is M’Kenna, and How is She Doing Now?

You’ve figured out a lot about how the things inside M’Kenna’s body were working together to make her feel the way she did! Let’s conclude our investigations into M’Kenna’s symptoms by learning a little bit more about who M’Kenna is and how she is doing now.

Read the article Who is M’Kenna, and what happened to her?
Lesson 13: How does a healthy body use food for energy and growth, and how is M’Kenna’s body functioning differently?

Navigation

We figured out some big punchlines last class about how a healthy body uses food for energy! Let’s look back at our Progress Trackers to make sure we are all on the same page with what we’ve just figured out.

On your own

1. Review your ideas from Lessons 8-12 in your Progress Tracker.
2. Make notes and highlight ideas on your Progress Tracker that might help explain the question, “How do our bodies use food for energy?”
3. Add those ideas to your Gotta-Have-It Checklist.

What Can We Explain Now?

With your class

4. As a class, determine which ideas seem the most useful to help us answer the question: How do our bodies use food for energy?
5. Record a class list of agreed-upon ideas in a Gotta-Have-It Checklist.

Develop a Model to Answer Our Question

On your own

6. Use the top third of your Three Pathways Inside Our Bodies to build an individual model to explain:
   - Pathway 1: How do our bodies use food for energy?
7. Record questions in your science notebook that come to mind as you are creating your model.

Build a Small-Group Model

Develop small-group models to explain: “How do our bodies use food not needed right now? How do our bodies use food needed for growth?”

With your group

8. Using chart paper, build your models in small groups for the next two pathways.
   a. Pathway 2: How do our bodies use food not needed right now?
   b. Pathway 3: How do our bodies use food needed for growth?
9. Record questions in your science notebook that come to mind as you are creating your model.

Compare Models with Another Small Group

The purpose of our small-group discussions are to surface areas of agreement and areas of lingering questions or disagreement. Your jobs are to place ideas on the table, clarify other students’ perspectives, and evaluate your own ideas and the ideas of others. At the end of the discussion, you should be prepared to share your ideas with the whole group as part of the class Consensus Discussion.
10. Pair up with another small group and share your model.

11. Make a T-chart in your notebook to record your thoughts.

<table>
<thead>
<tr>
<th>Comparing energy and matter inputs, outputs, and processes in a healthy body</th>
</tr>
</thead>
<tbody>
<tr>
<td>Similarities</td>
</tr>
<tr>
<td>----------------</td>
</tr>
</tbody>
</table>

12. Before you share, review our discussion norms and sentence frames.
   Remember, it is important for us to have a space in which we can share our ideas and push each other's thinking.

13. As you share your models, use the T-chart you created to record similarities and differences in the inputs, processes, and outputs that each group has represented in their model.

Developing a Consensus Model for a Healthy Body

Gather in a Scientists Circle and place your small-group posters in the middle of the circle. We're going to take stock of the ideas in everyone's models and build a classroom consensus model that everyone agrees upon to explain how a healthy body uses food. After coming to a consensus on what is happening in a healthy body, we are going to try to figure out what could be functioning differently in M’Kenna's body.

13. As a class, develop a consensus model to answer the questions for a HEALTHY body:
   a. Pathway 2: How do our bodies use food not needed right now?
   b. Pathway 3: How do our bodies use food needed for growth?

14. As you develop your consensus model, consider the following questions:
   a. What ideas should we include?
   b. How should we represent them?
   c. Do we have evidence to support them?
   d. What is our reasoning?

How Can We Explain M’Kenna’s Weight Loss?

Let's try to use the pathways in our model to explain M’Kenna's weight loss.

15. Turn and talk with your partner about the following questions:
   a. Does M’Kenna have a lot of food molecules in her blood? Why or why not?
   b. So what if her body ran out of fat stores? Where might her body use energy from instead?
   c. Be prepared to share your ideas with the class.
Compare Fat Molecules to Glucose Molecules

**With your class**

16. Use slide I or the food molecule cards to compare a glucose with a fat molecule.
17. Report out similarities and differences between the glucose and fat molecules.
18. Do you think a fat molecule stored in our arm, leg, or stomach could be used for a chemical reaction?

Update Our Gotta-Have-It Checklist

**With your class**

19. As a class, summarize your findings to answer the question:
   a. Why was M’Kenna losing weight?
20. Update the Gotta-Have-It Checklist with your new ideas.

Revisit M’Kenna’s Symptoms

**Turn and talk**

21. Use your ideas on M’Kenna’s Doctor’s Note to answer the following question:
   a. Which of M’Kenna’s symptoms could be connected to what we have figured out?

How Can We Explain M’Kenna’s Other Symptoms?

The focus should be on being able to reason through a connection between what we have figured out about how things inside our bodies work together and how that might have impacted the way M’Kenna is feeling. By the end, each body system should have its own short explanation for how a food shortage in M’Kenna might be connected to the related symptoms in that body system.

**On your own**

22. Using everything we’ve figured out so far, explain: How could a shortage of food entering M’Kenna’s bloodstream be connected to so many different symptoms in different systems of her body?
23. As we share out connections, update the Gotta-Have-It Checklist with our new ideas.

Add to Our Progress Trackers

**In your notebook**

25. Work individually to update your Progress Tracker. Focus on the key ideas to go along with your models to explain:
   a. How does a healthy body use food for energy needed now? Needed for growth? Not needed now?
   b. How is M’Kenna’s body functioning differently?

Who is M’Kenna, and How is She Doing Now? (Optional)

You’ve figured a lot out about how the things inside M’Kenna’s body were working together to make her feel the way she did! Let’s conclude our investigations into M’Kenna’s symptoms by learning a little bit more about who M’Kenna is and how she is doing now.
26. Obtain the *Who is M’Kenna, and what happened to her?* reading.
27. Read about M’Kenna.
28. Take some time to have open conversations about M’Kenna, what happened to her, and answer any lingering questions that the class may have.
### Progress Tracker

<table>
<thead>
<tr>
<th>Question</th>
<th>Source of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>What we figured out in words/pictures</th>
</tr>
</thead>
<tbody>
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<td></td>
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</table>

### Progress Tracker

<table>
<thead>
<tr>
<th>Question</th>
<th>Source of evidence</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What we figured out in words/pictures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>
Build a revised model to explain the following questions that your class has agreed upon:

1. __________________________________________
2. __________________________________________
3. __________________________________________
Who is M’Kenna, and what happened to her?

Who is M’Kenna?
M’Kenna was born in Oklahoma but soon moved to West Texas. She attends a small rural school and is active in all sports and her local FFA (Future Farmers of America) chapter. In the summers, she works for her family business cleaning new houses that her dad has built.

What happened when M’Kenna got sick?
Around the time that M’Kenna turned 13, she started to get really sick. M’Kenna had always been healthy, so this was unusual for her. She complained of constant stomach pain, diarrhea, and vomiting, especially after eating. She started to lose weight quickly, and she and her parents were worried. She also struggled to run cross-country and to play basketball, her favorite sport. M’Kenna didn’t have the energy to keep up in basketball practice and had to sit out from cross-country track meets.

While M’Kenna had an average weight and height most of her life, her weight dropped a lot in just a few months. The photograph on the left was taken in late August just as school began. The photograph on the right was taken just a few months later in November. While M’Kenna tried to eat healthy foods, eating only made her feel sick.

What made her sick?
Similar to what you did, M’Kenna’s doctor collected evidence from M’Kenna and from medical tests to diagnose her problem. Like you already figured out earlier in the unit, M’Kenna has celiac disease. A person with celiac disease has an immune response when they eat food with a protein called gluten in the food. Gluten is found in foods with
wheat and other grains but is also a common ingredient in many other foods. The immune response causes damage to the lining of the small intestine, flattening the villi, which are important for absorbing nutrients from food. The disease can become very serious because the person cannot get enough nutrients from food and risks using all of their stored food molecule sources.

M’Kenna’s doctor did an endoscopy exam to look at the villi in her small intestine. Similar to what you found, the doctor also found, “decreased folds and flattening of the villi in the beginning and middle of the small intestine.” The endoscopy exam confirmed that M’Kenna did have celiac disease. The only known treatment to help someone like M’Kenna is to avoid gluten and all foods that may contain gluten.

How is M’Kenna now?
M’Kenna was prescribed a gluten-free diet. The doctor said that if she avoided gluten, her small intestine would heal, and over time it did heal. M’Kenna’s abdominal pain, vomiting, and diarrhea stopped, and she regained weight. M’Kenna is at average weight and height again. She also regained energy to play sports like basketball. M’Kenna still sees her doctor for regular blood tests to make sure she is keeping gluten out of her system. If M’Kenna ever eats something with gluten, she can quickly tell because her symptoms return.
Name: ___________________________  Date: ______________

**Gotta-Have-It Checklist**

**Instructions:** Use your Progress Tracker and your science notebook to make a checklist of the most important ideas you need to make a new model to explain this question:

1. *How do our bodies use food for energy?*

<table>
<thead>
<tr>
<th>What our model needs to have to answer the question,</th>
<th>Check off pieces of the model as you use them.</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>How do our bodies use food for energy?</em></td>
<td>Used</td>
</tr>
<tr>
<td>1.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
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<tr>
<td>3.</td>
<td></td>
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<td>4.</td>
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<td>5.</td>
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<tr>
<td>6.</td>
<td></td>
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<tr>
<td>7.</td>
<td></td>
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<td>10.</td>
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</table>

Use your checklist to make a new model for answering your question. As you use ideas from your checklist, put a check in the “Used” column and label the concept on your model with its row number from the checklist. If you do not use an idea, place a check in the “Didn’t use” column.
Then add ideas to your Gotta-Have-It Checklist that explain the other questions your class is trying to figure out.

2. 

3. 

**LESSON 14: Do all animals do chemical reactions to get energy from food like humans?**

**PREVIOUS LESSON**
We built small-group models to explain how food is rearranged in the body to create energy, store matter for later use, and use matter for growth. We compared our models and then developed a consensus model to explain how M’Kenna’s body could be functioning differently. We developed explanations to show how M’Kenna’s symptoms might be connected to what we’ve figured out.

**THIS LESSON**
INVESTIGATION
2 days

We investigate an organism of our choice to see if it does metabolic reactions similar to the way humans do. We argue from evidence whether (1) our organism does chemical reactions to break down and burn food molecules the same way as humans and (2) it has the same structures inside its body that work together to do those processes. Then we come together to share our findings with other groups and generalize out that all animals do chemical reactions to get energy from food and have the same inputs and outputs of those reactions; however, their bodies might have different structures that do similar functions.

**NEXT LESSON**
We will revisit the Driving Question Board and discuss all of our questions that we answered. Then we will demonstrate our understanding by individually taking an assessment. Finally, we will reflect on our experiences in the unit.

**BUILDING TOWARD NGSS**
MS-LS1-3, MS-LS1-5, MS-LS1-7, MS-PS1-1 (applied in a new context), MS-PS1-2 (applied in a new context)

**WHAT STUDENTS WILL DO**
Engage in an argument from evidence that, in animals, oxygen reacts with carbon-containing molecules to provide energy and produce carbon dioxide and that organisms might have different structures that work together to do similar functions.

**WHAT STUDENTS WILL FIGURE OUT**
- Animals, aside from humans, rearrange matter in food through chemical reactions to release energy.
- In animals, besides humans, oxygen reacts with food to produce carbon dioxide and provide energy.
- Animals might have different structures inside of their bodies to perform the same functions.
- Other living things, such as anaerobic bacteria, don’t need oxygen for chemical reactions to get energy.
### Lesson 14 • Learning Plan Snapshot

<table>
<thead>
<tr>
<th>Part</th>
<th>Duration</th>
<th>Summary</th>
<th>Slide</th>
<th>Materials</th>
</tr>
</thead>
</table>
| 1    | 5 min    | **NAVIGATION**  
Motivate needing to look at how other animals, besides humans, get energy to do the things they need to do.                                                                                                                                                                                                       | A-B                                                                 | Gotta-Have-It Checklist from Lesson 13                                                              |
| 2    | 15 min   | **RESEARCH ABOUT YOUR ANIMAL**  
Students read about other organisms and use their Gotta-Have-It Checklists to argue whether their animal gets energy in the same way as humans do.                                                                                                                                                  | C-D                                                                 | Investigating Other Animals, computer access (optional), two pieces of chart paper, markers         |
| 3    | 8 min    | **GALLERY WALK TO COMPARE ACROSS ORGANISMS**                                                                                                                                                                                                                                                                                    | E                                                                  | Peer Feedback Guidelines, Self-Assessment: Giving and Receiving Feedback                           |
| 4    | 12 min   | **CONSENSUS DISCUSSION ABOUT OUR ANIMALS**                                                                                                                                                                                                                                                                                  | F                                                                  | arguments on chart paper                                                                            |
| 5    | 3 min    | **PROGRESS TRACKER: WHAT HAVE YOU FIGURED OUT?**  
Allow students to add what they have figured out to their Progress Trackers.                                                                                                                                                                                  | G                                                                  | Progress Tracker                                                                                    |
| 6    | 2 min    | **NAVIGATION**  
Transition to the next lesson and assign home learning to look back at DQB questions.                                                                                                                                                                                                                               | H                                                                  | Let’s Answer Questions from Our DQB!                                                               |

**End of day 1**
**Lesson 14 • Materials List**

<table>
<thead>
<tr>
<th></th>
<th>per student</th>
<th>per group</th>
<th>per class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesson materials</td>
<td></td>
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<tr>
<td>• science notebook</td>
<td></td>
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<tr>
<td>• Gotta-Have-It Checklist from Lesson 13</td>
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<td>• Investigating Other Animals</td>
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<td>• computer access (optional)</td>
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<td>• Peer Feedback Guidelines</td>
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<td>• Self-Assessment: Giving and Receiving Feedback</td>
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<td>• Progress Tracker</td>
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<td>• Let’s Answer Questions from Our DQB!</td>
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<td></td>
<td>arguments on chart paper</td>
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</table>

**Materials preparation (25 minutes)**

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

Gather the classroom consensus model and Progress Tracker developed in Lesson 13. Prepare *Let’s Answer Questions from Our DQB!* with questions from the Driving Question Board for students to evaluate. You can also update the handout started in Lesson 8 for Driving Question Board questions.
Lesson 14 • Where We Are Going and NOT Going

Where We Are Going

This lesson helps students generalize out to other animals, aside from humans, as called for in the DCI LS1.C. When our bodies need nutrients for cellular processes that are not available through digestion, as in M'Kenna's case, we can tap into stored body tissue, such as fat. This lesson addresses a key NGSS idea that food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, which supports growth or releases energy (LS1.C). Specifically, students develop an understanding that food molecules can be absorbed and rearranged into a variety of carbon-based molecules that can be stored in the body for later use. In times of need, cells can mobilize these stored molecules to be used by cells for energy.

Students might think that animals only include birds or mammals. Here, students will be reminded that animals include a wide variety of living things, such as fish, insects, reptiles, and crustaceans. And all animals need to obtain food from their environment and then break down and burn that food for energy through the same chemical reactions.

Where We Are NOT Going

This unit does not get into how plants get energy from metabolizing the sugars they make through photosynthesis. The next OpenSciEd unit 7.4 addresses this. Students don't need to know the intricacies of how simple molecules are rearranged into more complex molecules (e.g., glucose into glycogen) or the glucose-fatty acid cycle.
LEARNING PLAN for LESSON 14

1 · NAVIGATION

Problematize the next lesson question.

Say, "We've figured out how stuff inside our bodies works together to make us feel the way we do! We've accomplished our mission to figure out what was causing M'Kenna's symptoms and learned a lot about how our bodies work along the way! We can now explain things like how our bodies can get energy from eating a piece of chicken, and that got me thinking... I was cleaning up from dinner the other night, and I fed our dog some leftover chicken. That made me wonder... does my dog's body do chemical reactions to burn food in the same way our bodies do? What about other animals? Do they do this, too?"

**Stop and Jot in the science notebook.** Present slide A. Give students two minutes to think of an animal of their choice and answer the questions on the slide individually in their science notebooks:

1. Do you think this animal does chemical reactions to break down and burn food molecules like humans? Why or why not?
2. Does it have the same structures as humans inside its body that work together to do those functions? Why or why not?

**Turn and talk with a partner.** Present slide B. Have students share out their ideas with a partner. Each person should talk for one minute for a total of two minutes.

**Go public with the Turn and Talk activity.** Have a few students share out what their partner has said. The goal here is to get a variety of ideas out in public and generate some controversy and uncertainty.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
</table>
| What did your partner say? Do they think their animal (1) does chemical reactions to break down and burn food molecules? and (2) has the same structures inside its body that work together to do those things? | Answers will vary.  
We don't really know if all animals do this! |
| What could we do to figure this out? | We could maybe look up or research other animals to see what they do? |

Say, "We can do some research on other animals, but we should know what we're looking for in our research. Let's bring out our Gotta-Have-It Checklist to see how animals compare with what humans do."
The Gotta-Have-It Checklist should have these key ideas:

- The digestive system takes in food and breaks it down through chemical reactions, and the small food molecules get absorbed into the body through the small intestine and into the circulatory system.
  - Some structures (organs) in the digestive system that work together are the following: mouth, esophagus, stomach, small intestine, and large intestine.
- The respiratory system and circulatory system work together to bring food molecules and oxygen to cells in the body and to remove carbon dioxide.
  - Some organs in the respiratory system that work together are the following: nose, mouth, and lungs.
  - Some organs in the circulatory system that work together are the following: blood and heart.
- Humans need to take in food. Food is a type of fuel, which means that it can react with other substances to release energy.
- Cells rearrange food and oxygen through a chemical reaction, which creates carbon dioxide and water and releases energy that cells can use.
- The body system's inputs are food (molecules mainly with Cs, Hs, and Os) and oxygen. Outputs are mainly carbon dioxide, water, and energy (students might also include poop, which is mostly fiber and water).

Say, I have some brief information on several different organisms. We can use this to look more closely at other animals and compare them with what we've figured out about humans, which are another type of animal.

2 · RESEARCH ABOUT YOUR ANIMAL

**MATERIALS:** Investigating Other Animals, computer access (optional), two pieces of chart paper, markers

Read about different organisms. Hand out copies of Investigating Other Animals or have students access information about an animal of their choice not listed in the reading.*

**ADDITIONAL GUIDANCE**

One organism included in the reading is anaerobic bacteria. This organism does not do cellular respiration like humans do. We recommend having one group pick this organism so that students can see that not all organisms get energy in the same way as humans, but all animals do (bacteria are not considered part of the animal kingdom).

Present slide C. Allow students to pick an animal they would like to know more about. One idea to help facilitate the choice of animals is to have a sign-up list with only three slots per animal to have a wide diversity of animals represented.

**ADDITIONAL GUIDANCE**

Students may only think of animals as mammals. Encourage a wide variety of animals to be investigated, such as fish, crustaceans, insects, reptiles, and amphibians. Also, you can have non-animals in the mix, such as anaerobic bacteria, which does not do chemical reactions to break down and burn food the same as humans.

Have students individually read about their animal and use their Gotta-Have-It Checklist to compare their animal with humans to figure out what are the similarities and differences between the organisms.

* ATTENDING TO EQUITY

To encourage students to connect with their own interests and surroundings, you could allow kids to choose to research animals outside of the list provided in Investigating Other Animals and report what they find to the class. Provide kids with access to additional sources for information and/or the internet.

**ATTENDING TO EQUITY**

If students are struggling with their arguments, here are some questions that might help them get started.

Does your organism:
1. Obtain energy from eating food?
2. Have the same inputs and outputs of metabolic reactions as humans?
3. Have the same structures and body systems involved in these processes as humans?
Use the Gotta-Have-It Checklist to construct an argument in small groups. Place students in like-animal groups. For example, everyone who chose to research about dogs should sit together. Groups of no more than 3-4 students is recommended. Present slide D. Have students construct two arguments in response to these two questions:

1. Do you think this animal does chemical reactions to break down and burn food molecules like humans? Why or why not?
2. Does your animal have the same structures as humans inside its body that work together to do those functions? Why or why not?

Groups should use everything they’ve learned so far and their Gotta-Have-It Checklists to make a claim and back it up with evidence and reasoning for both of the questions. Give each small group two pieces of chart paper to write on because groups will share out their arguments with classmates.★

Students will have an opportunity to give and receive feedback in a gallery walk next.

3 · GALLERY WALK TO COMPARE ACROSS ORGANISMS

**MATERIALS:** Peer Feedback Guidelines, Self-Assessment: Giving and Receiving Feedback

Introduce peer evaluation guidelines and rubrics. Present slide E. When groups are finished with their arguments, have them put their posters around the room. Then hand out copies of Peer Feedback Guidelines. Review the guidelines and share that, at the end of this activity, we will get a chance to evaluate ourselves on giving and receiving feedback using Engaging in Argument from Evidence. All rubrics are provided as handouts to print as needed.

**Gallery walk to provide feedback to other groups.** Use the general Engaging in Argument from Evidence and the Gotta-Have-It Checklists for this unit as a way for students to assess each other’s work and give feedback on how to improve. Have several copies available so that students can go around in groups of two or on their own filling out the rubric for different groups. This is not only to help provide feedback for this activity, but it will also help prepare students for the summative assessment for this unit.★

Modify arguments after peer feedback. After students have a chance to review several posters, instruct them to look at their feedback with their groups and allow them a chance to modify their work based upon that feedback. If students are struggling to identify how similar and different structures are functioning, help them map those to the human structures they have previously studied.★

**SUPPORTING STUDENTS IN ENGAGING IN ARGUMENT FROM EVIDENCE**

For additional ideas for peer feedback to support argumentation from evidence, refer to Ambitious Science Teaching Tools [https://ambitiousscienceteaching.org/sticky-note-student-feedback/](https://ambitiousscienceteaching.org/sticky-note-student-feedback/)

**SUPPORTING STUDENTS IN THREE-DIMENSIONAL LEARNING**

In this activity, students created an argument using evidence from prior learning and research in order to determine whether food moves through organisms in a series of chemical reactions that breaks down food to form new molecules, like humans do. Students look at this in terms of two different crosscutting concept lenses. First, they identify whether energy and matter are moving through organisms the same way as humans. Secondly, they identify how similar or different the structures in each animal function in a similar manner to those same structures in humans.
### CONSENSUS DISCUSSION ABOUT OUR ANIMALS

**MATERIALS:** science notebook, arguments on chart paper

Present slide F. Gather students together in a Scientists Circle. Remind students of classroom discussion norms. Have these two questions visible:

1. Do you think this animal does chemical reactions to break down and burn food molecules like humans do? Why or why not?
2. Does your animal have the same structures as humans inside its body that work together to do those functions? Why or why not?

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
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<tbody>
<tr>
<td>As you were walking around and viewing other students’ arguments, did you notice any patterns in the arguments for question 1?</td>
<td>Yeah, every group but one claimed that their animal did chemical reactions similar to humans to break down and burn food for energy. The only one that didn’t was the anaerobic bacteria.</td>
</tr>
<tr>
<td>Did all of the organisms you looked at have to eat something for energy?</td>
<td>Sort of. The animals all had different ways of taking in stuff. Some didn’t have mouths. So not all organisms “eat” like we think of eating, but all organisms, except for the bacteria, had to take something into their bodies to get energy. Some of the bacteria could make their own food, so they didn’t have to take anything in.</td>
</tr>
<tr>
<td>What was different about the bacteria?</td>
<td>All the other animals do basically the same kind of inputs and outputs as humans, but anaerobic bacteria don’t need to take in oxygen to get energy.</td>
</tr>
<tr>
<td>What are the inputs and outputs that you have found that all of the animals do?</td>
<td>They take in oxygen and some kind of food and then give off carbon dioxide and water. They also give out other kinds of wastes. The anaerobic bacteria aren’t animals, and they didn’t do this.</td>
</tr>
<tr>
<td>So, let’s look back at our first question. Do we have evidence to say that all animals do chemical reactions to break down and burn food molecules the same way as humans?</td>
<td>Yes!</td>
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</tbody>
</table>

Create a public record of what the class has figured out.

Say, OK, so it’s not just humans that do this! Actually, all animals do chemical reactions to break down and burn food molecules for energy. Now let’s turn our focus to the second question.

<table>
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<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
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<tbody>
<tr>
<td>Let’s think about this second question with our structure and function lens. Do all of our organisms have the same structures inside their bodies that work together to break down and burn food for energy?</td>
<td>No, a lot of animals had different structures compared to humans. But it did seem like the structures were still doing the same functions!</td>
</tr>
<tr>
<td>Suggested prompt</td>
<td>Sample student response</td>
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</tbody>
</table>
| **What's your evidence?** | For example, we found out that a shark needs oxygen and gives off carbon dioxide like humans, but it just uses gills instead of lungs to exchange those gases in the water.  
Also, a spider does chemical reactions to break down food, but it actually starts that process before it even eats! We humans have digestive enzymes in our mouths and other organs in our digestive system, but a spider squirts digestive enzymes on the food to break it down and then eats it.  
Many other examples are possible. |

Wow! So all animals take in food and oxygen, break it down, and rearrange it through chemical reactions, which make carbon dioxide and water and release energy that their cells can use; but they have different structures involved to do the same basic thing.

Add this idea to the public record of what the class has figured out.

### 5 · PROGRESS TRACKER: WHAT HAVE YOU FIGURED OUT?

**MATERIALS:** Progress Tracker

**Update Progress Trackers.** Show slide G. Have students individually update their 2-column Progress Trackers. In the example Progress Tracker row for this lesson, each of the columns has been completed with possible student ideas.

<table>
<thead>
<tr>
<th>Question</th>
<th>What I figured out in words/pictures</th>
</tr>
</thead>
</table>
| Do all animals do chemical reactions to get energy from food like humans? | • All animals take in food and oxygen, break it down, and rearrange it through chemical reactions.  
• The inputs of these reactions are food and oxygen, while the outputs are carbon dioxide, water, and release of energy that their cells can use.  
• But animals have different structures inside of their bodies to do the same basic functions.  
• Other living things, such as anaerobic bacteria, don't need oxygen for chemical reactions to get energy. |

### 6 · NAVIGATION

**MATERIALS:** Let's Answer Questions from Our DQB!

Say, We've figured out so much! I bet we can answer many of our questions on the Driving Question Board.

Present slide H. Next, the class will revisit their Driving Question Board and celebrate all that they have figured out.
Assign reviewing the DQB questions for home learning. Have students evaluate which questions the class has answered from the DQB for home learning. Hand out a copy of Let’s Answer Questions from Our DQB, which you created to contain all of the student questions from the DQB, and have students tape it into their science notebooks. You may also have students add to the Lesson 8 version Let’s Answer Questions from Our DQB for which students evaluated their questions at the end of Lesson 8.

Have students mark questions that they think the class has answered by putting different symbols next to each question:
- We did not answer this question or any parts of it yet: 0
- Our class answered some parts of this question, or the ideas we developed help me see how I could now answer some parts of this question: ✓
- Our class answered this question, or the ideas we developed help me see how I could now answer this question: ✓ +

Then students should pick three of the questions you marked and write what they think that answer would be.

**HOME LEARNING OPPORTUNITY**

Students can evaluate their questions for home learning, or you can choose to allow class time for students to review questions with a partner at the start of the next class.

---

### Additional Lesson 14 Teacher Guidance

**SUPPORTING STUDENTS IN MAKING CONNECTIONS IN ELA**

Students are reading and researching about an animal of their choice to use their findings to argue if their animal does chemical reactions similar to humans and if they have the same structures inside their body that work together to carry out those metabolic reactions. Students will cite textual evidence to support their argument. This connects to CCSS.ELA-LITERACY.RST.6-8.1: Cite specific textual evidence to support analysis of science and technical texts.

Students write an argument from evidence to explain if their animal does chemical reactions to get energy from food like humans. This connects to the Common Core standard: CCSS.ELA-LITERACY.WHST.6-8.1.B Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.

As they read about their selected animal, students must compare what they are learning from the text to the knowledge they have gathered through investigations and experiences in previous lessons. This connects to the Common Core Standard: CCSS.ELA-LITERACY.RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.
Lesson-Specific Teacher Materials
Lesson 14: Rubric 1

Rubric: Giving and Receiving Feedback

Giving Feedback

How well did you give feedback today?

Today, I…

YES NO

I gave feedback that was specific and about science ideas.

I shared a suggestion to help improve my peer's work.

I used evidence from investigations, observations, activities, or readings to support the feedback or suggestions I gave.

One thing I can do better next time when I give feedback is:

Receiving Feedback

How well did you receive feedback today?

Today, I…

YES NO

I read the feedback I received carefully.

I asked follow-up questions to better understand the feedback I received.

I said or wrote why I agreed or disagreed with the feedback.

I revised my work based on the feedback.

What is one piece of feedback you received?

What did you add or change to address this feedback?

How well did you receive feedback today?

Rubric: Giving and Receiving Feedback

Lesson 14: Rubric 1

Page 309
# Lesson 14: Rubric 2

## Rubric: Engaging in Argument from Evidence

<table>
<thead>
<tr>
<th>Claim</th>
<th>Category</th>
<th>Feedback</th>
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</thead>
<tbody>
<tr>
<td>• There is a claim that is relevant to the question, problem, or solution posed.</td>
<td>Missing Developing Mastered</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Justification</th>
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<tbody>
<tr>
<td>Clearly represents or describes the following:</td>
<td>Missing Developing Mastered</td>
<td></td>
</tr>
<tr>
<td>• evidence or empirical data that supports the claim</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• scientific principles or ideas that explain how each piece of evidence supports the claim (reasoning)</td>
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<thead>
<tr>
<th>Rebuttal</th>
<th>Category</th>
<th>Feedback</th>
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<tbody>
<tr>
<td>Clearly represents or describes the following:</td>
<td>Missing Developing Mastered</td>
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<tr>
<td>• a critique of the evidence of an alternate claim</td>
<td></td>
<td></td>
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<tr>
<td>• a critique of the reasoning of an alternate claim</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Stop and Jot
Think of an animal of your choice. In your notebook write about the following questions:

1. Do you think this animal does chemical reactions to break down and burn food molecules the same way as humans?

2. Does it have the same structures as humans inside its body that work together to do those functions? Why or why not?

Turn and Talk
Share your thoughts with a partner about the following questions:

1. Do you think this animal does chemical reactions to break down and burn food molecules the same way as humans?

2. Does it have the same structures as humans inside its body that work together to do those functions? Why or why not?

Research about Your Animal
Choose an animal that you would like to know more about.

Read about your animal and use your Gotta-Have-It Checklist to figure out:

1. Do you think your animal does chemical reactions to break down and burn food molecules the same way as humans?

2. Does it have the same structures as humans inside its body that work together to do those functions? Why or why not?

Make an Argument from Evidence
In your small group, use your Gotta-Have-It Checklist to write an argument from evidence about the following two questions:

1. Do you think your animal does chemical reactions to break down and burn food molecules the same way as humans?

2. Does it have the same structures as humans inside its body that work together to do those functions? Why or why not?
You will have a chance to provide your peers with feedback about their argumentations.

- Post work around the room.
- Review rubrics and guidelines for giving peer feedback.
- Use the argumentation from evidence rubric and your Gotta-Have-It Checklist to provide feedback to other groups with a partner.
- Modify your work after looking through your feedback.

Gather in your Scientists Circle and bring your science notebooks.

1. Do you think your animal does chemical reactions to break down and burn food molecules the same way as humans?
1. Does it have the same structures as humans inside its body that work together to do those functions? Why or why not?

Write the question we are working on in the left column:
14. Do all animals do chemical reactions to get energy from food like humans?

Write what you have figured out so far in the column on the right. You can write in pictures or words. Take as much space as you need to record your thoughts.

Look through our questions on our DQB. Mark questions that you think the class has answered by putting different symbols next to each question:
- ❖ We did not answer this question or any parts of it yet: o
- ❖ Our class answered some parts of this question, or the ideas we developed help me see how I could now answer some parts of this question: ✓
- ✚ Our class answered this question, or the ideas we developed help me see how I could now answer this question: ✓+

Then pick three of the questions you marked and write what you think that answer would be.
Lesson 14: Do all animals do chemical reactions to get energy from food like humans?

Navigation: Stop and Jot

In your notebook

1. Think of an animal of your choice. In your notebook, write about the following questions:
   - Do you think this animal does chemical reactions to break down and burn food molecules the same way as humans?
   - Does it have the same structures as humans inside its body that work together to do those functions? Why or why not?

Navigation: Turn and Talk

With a partner

2. Share your thoughts with a partner about the following questions:
   - Do you think this animal does chemical reactions to break down and burn food molecules the same way as humans?
   - Does it have the same structures as humans inside its body that work together to do those functions? Why or why not?

Research about Your Animal

On your own

3. On your own, choose an animal you would like to know more about.
   - Read about your animal.

Make an Argument from Evidence

With your group

4. In your small group, use your Gotta-Have-It Checklist to construct two arguments in response to the following questions:
   - Do you think your animal does chemical reactions to break down and burn food molecules the same way as humans?
   - Does it have the same structures as humans inside its body that work together to do those functions? Why or why not?

5. Write each argument on a separate piece of chart paper. Be ready to share with your classmates.
**Gallery Walk to Compare across Organisms**

**On your own**
6. Working with a partner or on your own, post your arguments around the room.
7. Review rubrics and guidelines for giving peer feedback.

**With a partner**
8. Work with a partner and use the general argumentation from evidence rubric and your Gotta-Have-It Checklist to provide feedback to other groups.
9. Modify your work after looking through your feedback.

**Consensus Discussion about Our Animals**

**With your class**
10. Gather in your Scientists Circle and bring your science notebooks.
11. Work with the members of your Scientists Circle to answer the following questions:
   - Do you think your animal does chemical reactions to break down and burn food molecules the same way as humans?
   - Does it have the same structures as humans inside its body that work together to do those functions? Why or why not?

**Progress Tracker: What have you figured out?**

**In your notebook**
12. Individually update your 2-column Progress Tracker:
   - Write the question we are working on in the left column: Do all animals do chemical reactions to get energy from food like humans?
   - Write what you have figured out so far in the column on the right. You can write in pictures or words. Take as much space as you need to record your thoughts.

**Navigation**

**Home learning**
13. Look through our questions on our DQB. Mark questions you think the class has answered by putting different symbols next to each question:
   - We did not answer this question or any parts of it yet: o
   - Our class answered some parts of this question, or the ideas we developed help me see how I could now answer some parts of this question: ✓
   - Our class answered this question, or the ideas we developed help me see how I could now answer this question: ✓+
14. Pick three of the questions you marked and write what you think that answer would be.
Investigating Other Animals

Dog - *Canis lupus* (Beagle)

A dog’s respiratory system is responsible for taking in oxygen and eliminating waste gases like carbon dioxide. The more a dog moves around, its muscle cells will use oxygen and glucose more quickly than when it is resting. This causes an increase in heart rate, rate of breathing, and how deeply the dog breathes. The increase in heart rate and blood flow around the dog’s body are important for carrying out chemical reactions during which oxygen and glucose are changed, releasing carbon dioxide and water and making energy available for the dog’s body. Because dogs and cats do not sweat through the skin, the respiratory system also plays an important role in the regulation of temperature.

The cardiovascular system includes the heart and blood vessels and performs the function of pumping and carrying blood to the rest of the body. The blood contains nutrients and oxygen to provide energy to allow the cells of the body to perform work.

When your dog swallows its food, it passes through the esophagus, or gullet. While in the mouth, food is mixed with saliva. The saliva has no enzymes, however it is important for lubricating the passage of food to the stomach, moistening the mouth, and helping dogs stay cool. Strong muscles along the length of the esophagus help to push the food down into the stomach, as part of the chewing process. When food reaches the stomach, the process of dog digestion begins.
Bird - *Cardinalis cardinalis* (Cardinal)

The respiratory system of birds creates a very efficient exchange of carbon dioxide and oxygen via one-way airflow. Bird respiratory systems have lungs, but they also have air sacs. The air sacs keep oxygen-rich blood moving in one direction. A breath of oxygen-rich inhaled air remains in the respiratory system for two complete inhalation and exhalation cycles before it is fully spent (used) and exhaled from the body. The exchange of carbon dioxide and oxygen takes place in the lungs. The air capillaries in the walls of the lungs have a much larger overall surface area than that found in the mammalian respiratory system. The greater the surface area, the more oxygen and carbon dioxide can be passed between blood and tissues, which also makes for more efficient breathing.

The cardiovascular system not only delivers oxygen to body cells and removes metabolic wastes but also plays an important role in maintaining a bird’s body temperature. The avian circulatory system consists of a heart plus vessels that transport nutrients, oxygen, carbon dioxide, other waste products, and hormones.

The gizzard performs the same function as mammalian teeth, grinding and disassembling the food, making it easier for the digestive enzymes to break down the food. Birds have a two-part stomach that includes a gizzard. In most birds, the gizzard contains sand grains or small rocks that the bird eats to aid in the grinding process. The bird stomach also has acid and a digestive enzyme called pepsin that are involved in the chemical reactions that change food into a form that the bird can use.

Jellyfish - *Aurelia aurita* (Moon jellyfish)

Jellyfish don't use their body energy often to swim around. The current of the water moves jellyfish from one location to the next. Jellyfish have no special structures for respiration or circulation. They also don't have a brain! However, they still need oxygen. They are able to take up oxygen, and even store it. Jellyfish have such thin tissue that they can get most of the oxygen they need by absorbing it directly from the water that they live in.

Jellyfish eat foods, such as mollusks, plankton, and fish eggs. The Moon Jellyfish has a hearty appetite and will consume food as often as it can. They have a very large stomach that allows them to swallow food whole, and then it is broken down. They need protein, carbs, and fats to survive. Food that makes it into the jellyfish's stomach is broken down by digestive enzymes.

A jellyfish body is made up of an outer layer of tissue and an inner layer of tissue, which lines their two-way gut. This means that they take food in, digest it, and expel it through the same opening. Cells in the gut can then absorb and move nutrients around the jellyfish body.
Sponge - *Aplysina fistularis* (Yellow tube sponge)

Sponges are a type of aquatic animal whose body is covered in tiny pores. Each of a sponge’s individual cells can transform to complete the job of any other cell in the body. This lack of specialization means that sponges do not have tissues or organs. As a matter of fact, if you took a sponge and put it in a blender, it could reform itself as the cells swim back together and take on any form and job needed to recover!

All sea sponges are attached to the reef surface and are unable to move. If pieces of an individual are broken off by predators or during a storm, they can reattach and begin growing a new sponge. Since sponges do not move around to get food, food has to come to them. They filter water into and out of the pores. Cells in the pores capture the food, which is digested by each individual cell.

The pores also help flush waste products out of their bodies. The filtered water, including waste products, exits the sponge. These waste materials could poison the sponge if it is left inside their bodies for too long. They also obtain oxygen from the water during this process.

Shark - *Carcharodon carcharias* (Great white shark)

Sharks are fish and use gills to breathe rather than lungs. Sharks use gill slits to add oxygen to their blood. As the shark moves around, water is taken into the mouth and moves over the gills that absorb oxygen from the water and release carbon dioxide back out. When at rest, the shark actively pumps water over its gills.

When oxygen is needed, blood travels to the s-shaped heart, which has only two chambers compared to the four found in mammals and birds.

Most sharks are carnivores, eating foods like fish, seals, sea lions, and turtles, but scientists have found that one type of shark, the bonnethead, eats a large amount of seagrass. When sharks eat their prey, there are no digestive juices released into the mouth. Sharks don't chew their food, so the food does not need to begin to undergo chemical reactions until it reaches the stomach. The stomach of a shark has very strong enzymes and other digestive juices including hydrochloric acid. By the time that food leaves the stomach, on its way to the intestine, there is nothing left but mush because the stomach acid dissolves the stomach contents.
Lizard - *Furcifer pardalis* (Panther chameleon)

The respiratory system of the chameleon has two lungs, but they are like sacks with many finger-shaped bulges. Their lungs are divided into different air sacs. With a single breath, a chameleon can achieve twice the oxygen supply into its blood as mammals because the exchange of carbon dioxide, water, and oxygen in these animals takes place during the time that they inhale and also when they exhale.

Chameleons eat insects and birds. To catch their prey, they creep along very slowly. Once the prey is in reach, their suction cup tongue shoots out and sticks to the insect. Their tongues can be as twice as long as their bodies when stretched out to catch prey.

In chameleons, leftover waste is expelled through a structure called the vent, which does the same job as a mammal's anus. The digestive tract of chameleons consists of the mouth, stomach, intestines, and vent.

Spider - *Nephila* (Golden Orb Weaver)

Spiders do not take a breath through their mouths like humans. Instead, they breathe through their skin on the underside of their bodies. Book lungs are a form of respiratory organ found in spiders and scorpions and is where the exchange of carbon dioxide, water, and oxygen takes place.

They don't have true blood or veins to move blood around. Instead, their bodies are filled with a substance called hemolymph, which is pumped by the heart into the spaces surrounding their internal organs. Hemolymph is a clear fluid that transports nutrients, oxygen, and cells. Hemolymph also has another unusual function, as it is used to raise pressure inside the spider's body during the time that it sheds its skin and when stretching the legs.

Spiders are the only animals that digest their food before they eat it. Spiders capture their prey then release digestive enzymes from their intestinal tract into the bodies of the animals they capture. These enzymes break down the body tissue of prey, and, after a few seconds, the spider sucks up the predigested, liquid food.
Archaebacteria-Methanosphaera (Methanogens)

Archaebacteria are single-celled organisms that were discovered in 1977. They are sometimes called extremophiles because they are found in very harsh conditions, such as in volcanic vents at the bottom of the oceans.

Archaea do a wide variety of chemical reactions to get the energy they need. Some types of archaebacteria make their food from sunlight, and some take in molecules like carbon dioxide, while some take in molecules that do not contain carbon as a source of energy, such as sulfur. Methanogens are bacteria that live in swamps and the gut of animals. They are anaerobic bacteria, which do not need oxygen. In fact, they are killed when exposed to oxygen! These bacteria do chemical reactions with carbon dioxide and hydrogen as reactants and give off methane gas and water as products. This reaction is responsible for producing swamp gas and flatulence in humans.

Archaea's body structure can be in various shapes, such as spheres, rods, spirals, or plates. The cells of archaea lack interior membranes and organelles. They do have a cell wall. Many types of archaea have flagella, which is a long stalk that spins around to help the bacterium move around.
Peer Feedback Guidelines

Giving feedback to your peers is an important skill. Use this document to help you give and receive feedback from others in your class.

Giving Feedback

Feedback needs to be specific and actionable. That means it needs to be related to science ideas and should provide your own suggestions for improvement.

Productive examples:
- “Your argument from evidence has a claim that you think your animal burns food molecules the same way as humans, but I think you should add in some evidence and reasoning for why you think that.”
- “You make the claim that you don’t think birds and humans do similar chemical reactions to break down food, but we disagree because they both have the same inputs of oxygen and food and outputs of carbon dioxide and water. We suggest looking at the inputs and outputs of cells again.”

Non-productive examples:
- “I like your drawing.”
- “Your poster is really pretty.”
- “I agree with everything you said.”
- “I disagree.”

How to Give Feedback.

Your feedback should give ideas for specific changes or additions that the person or group can make. Use the sentence starters below if you need help writing feedback.

- The poster said _________________. We disagree because ___________________. We think you should change ___________________.
- I like how you _______________. It would be more complete if you added _______________.
- We agree that ___________________. We think you should add more evidence from the ________________ investigation.
- We agree/disagree with your claim that ___________________. However, we do not think that the ________________ (evidence) you used matches your claim.
- Do you think you should add _______?

Receiving Feedback

The purpose of feedback is to get ideas from your peers about things you might improve or change to make your work more clear, more accurate, or better supported by the evidence that you have collected.

When you receive feedback, you should:
- Read it carefully, and ask someone else to help you understand it, if needed.
- Decide if you agree or disagree with the feedback and say why you agree or disagree.
- Revise your work to address the feedback.
Self-Assessment: Giving and Receiving Feedback

### Giving Feedback

**How well did you give feedback today?**

<table>
<thead>
<tr>
<th>Today, I...</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gave feedback that was <strong>specific</strong> and about <strong>science ideas</strong>.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Shared a suggestion</strong> to help improve my peer's work.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Used evidence from</strong> investigations, observations, activities, or readings to support the feedback or suggestions I gave.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

One thing I can do better next time when I give feedback is:

__________________________

__________________________

### Receiving Feedback

**How well did you receive feedback today?**

<table>
<thead>
<tr>
<th>Today, I...</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Read the feedback</strong> I received carefully</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Asked follow up questions</strong> to better understand the feedback I received</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Said or wrote why I agreed or disagreed</strong> with the feedback</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Revised</strong> my work based on the feedback</td>
<td></td>
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</tr>
</tbody>
</table>

What is one piece of feedback you received?

__________________________

__________________________

What did you add or change to address this feedback?

__________________________

__________________________

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### Engaging in Argument from Evidence

<table>
<thead>
<tr>
<th>Claim</th>
<th>Category</th>
<th>Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Missing</td>
<td>Developing</td>
</tr>
<tr>
<td>• There is a claim that is relevant to the question, problem, or solution posed.</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Justification</th>
<th>Category</th>
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</tr>
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<tbody>
<tr>
<td>Clearly represents or describes the following:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• evidence or empirical data that supports the claim</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• scientific principles or ideas that explain how each piece of evidence supports the claim (reasoning)</td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Rebuttal</th>
<th>Category</th>
<th>Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearly represents or describes the following:</td>
<td></td>
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<tr>
<td>• a critique of the evidence of an alternate claim</td>
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<tr>
<td>• a critique of the reasoning of an alternate claim</td>
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</tr>
</tbody>
</table>
Let's Answer Questions from Our DQB!

Look through the list of questions from our DQB. Mark questions that you think the class has answered by putting different symbols next to each question:

- We did not answer this question or any parts of it yet: o
- Our class answered some parts of this question, or the ideas we developed help me see how I could now answer some parts of this question: ✓
- Our class answered this question, or the ideas we developed help me see how I could now answer this question: ✓ +

Then pick three new questions you marked and write what you think that answer would be.

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer and Supporting Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>
# LESSON 15: What questions on our Driving Question Board can we now answer?

## PREVIOUS LESSON
We investigated an organism of our choice and argued from evidence whether it does metabolic reactions similar to the way humans do. Then we came together to share our findings and generalized out that all animals do chemical reactions to get energy from food and have the same inputs and outputs of those reactions; however, their bodies might have different structures that do similar functions.

## THIS LESSON
**PUTTING PIECES TOGETHER**

2 days

We revisit the Driving Question Board and discuss all of the questions that we have now answered. Then we demonstrate our understanding by individually taking an assessment. Finally, we reflect on our experiences in the unit.

## NEXT LESSON
There is no next lesson.

## BUILDING TOWARD NGSS

- MS-LS1-3, MS-LS1-5, MS-LS1-7, MS-PS1-1 (applied in a new context), MS-PS1-2 (applied in a new context)

## WHAT STUDENTS WILL DO

- Develop a model to explain how bears can rearrange matter in food through chemical reactions to release energy and use stored food in the form of fat to survive during hibernation.

- Construct an explanation by applying scientific ideas and evidence to show how bears obtain energy to survive for several months without eating during hibernation.

## WHAT STUDENTS WILL FIGURE OUT

- We can answer many of our Driving Question Board questions!
<table>
<thead>
<tr>
<th>Part</th>
<th>Duration</th>
<th>Summary</th>
<th>Slide</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10 min</td>
<td>NAVIGATION: EVALUATE OUR DQB QUESTIONS&lt;br&gt;Prepare to gather around the DQB by having students share with a partner which questions they've marked from their home learning. Then students place sticky dots on the questions that they think we have made progress on and move into their Scientists Circle.</td>
<td>A-B</td>
<td>Let's Answer Questions from Our DQB, 5 sticky dots, Driving Question Board</td>
</tr>
<tr>
<td>2</td>
<td>30 min</td>
<td>REVISIT OUR DRIVING QUESTION BOARD (DQB)&lt;br&gt;Students revisit the DQB and take stock of all the questions we've now answered with the whole class.</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>5 min</td>
<td>ADD TO OUR PROGRESS TRACKERS&lt;br&gt;Allow time for students to update their 2-column Progress Trackers.</td>
<td>D</td>
<td>Progress Tracker</td>
</tr>
<tr>
<td>4</td>
<td>37 min</td>
<td>DEMONSTRATE UNDERSTANDING ON AN ASSESSMENT TASK&lt;br&gt;Students individually demonstrate understanding on an assessment to explain the phenomenon of how bears can survive in the winter without eating.</td>
<td>E</td>
<td>Black Bear Hibernation Task, Black Bear Hibernation Task - Modified</td>
</tr>
<tr>
<td>5</td>
<td>8 min</td>
<td>QUICK WRITE: REFLECT ON OUR EXPERIENCES&lt;br&gt;Students discuss what was challenging and rewarding about this unit.</td>
<td>E</td>
<td></td>
</tr>
</tbody>
</table>

End of day 1

End of day 2
Lesson 15 • Materials List

<table>
<thead>
<tr>
<th></th>
<th>per student</th>
<th>per group</th>
<th>per class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesson materials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• science notebook</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Let's Answer Questions from Our DQB!</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 5 sticky dots</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>• Progress Tracker</td>
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<tr>
<td></td>
<td>• Black Bear Hibernation Task</td>
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<tr>
<td></td>
<td>• Black Bear Hibernation Task - Modified</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• Driving Question Board</td>
</tr>
</tbody>
</table>

Materials preparation (25 minutes)

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

Gather the classroom consensus models developed in Lessons 7, 13, and 14 and post them at the front of the room.
Lesson 15 • Where We Are Going and NOT Going

Where We Are Going

This lesson provides a final opportunity for students to explain how food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy (LS1.C). This lesson also highlights that the growth of an animal is controlled by environmental factors, such as food intake (LS1.B).

Where We Are NOT Going

Students do not need to understand genetic factors at this time. The genetics component of the DCI LS1.B will be revisited in 8th grade during the genetics unit. Also, plants are not addressed this unit. In the following OpenSciEd Unit 7.4, students will learn how plants make their food through photosynthesis and then use that food in cellular respiration just like animals.
LEARNING PLAN for LESSON 15

1 · NAVIGATION: EVALUATE OUR DQB QUESTIONS

**MATERIALS:** science notebook, Let's Answer Questions from Our DQB!, 5 sticky dots, Driving Question Board

Have students work in pairs to evaluate what questions the class has answered from the DQB. Project slide A. Ask students to take out their home learning, Let's Answer Questions from Our DQB!, which you created to contain all of the student questions from the DQB, and have students tape it into their science notebook. Have students compare which questions they marked to indicate what they think the class has answered:

- We did not answer this question or any parts of it yet: O
- Our class answered some parts of this question, or I think I could answer some parts of this question: ✓
- Our class answered this question, or using the ideas we have developed, I could now answer this question: ✓ +

Review and share the questions that students think we have answered. Present slide B and have students mark, with sticky dots, the questions that they think we have made progress on. You may want to use a different color sticky dot if you also did this activity in Lesson 9.

Then have students move into their Scientists Circle.

**ATTENDING TO EQUITY**

Revisiting the Driving Question Board is important for students to feel as though their questions are valued and recognized. While not all questions will have been addressed (it's more likely that 50–75 percent will be at least partially answered), this helps students see that they have done this hard work to answer many of their own questions.

2 · REVISIT OUR DRIVING QUESTION BOARD (DQB)

**MATERIALS:** science notebook

**ATTENDING TO EQUITY**

Discuss the questions the class can now answer. Present slide C if needed. Have the class discuss the answers to those questions as a group. If you have space, you might make a "Take Aways" board that has a record of the answers with which the class comes up.

**ASSESSMENT OPPORTUNITY**

While students are answering questions from the Driving Question Board, this is an excellent formative assessment opportunity to address partial understandings and see if any pieces need to be revisited. This is also a good way to help students prepare for the summative assessment.

Celebrate the class's accomplishments. Students should prepare to demonstrate their understanding on an individual assessment.

3 · ADD TO OUR PROGRESS TRACKERS

**MATERIALS:** Progress Tracker

**ATTENDING TO EQUITY**

Add any new insights to the Progress Trackers. Present slide D. During the time students were revisiting the Driving Question Board and working together to answer questions, new ideas or insights may have surfaced for individual students. Have the class update the 2-column Progress Trackers with any additional ideas they think are important.

End of day 1
### 4 · DEMONSTRATE UNDERSTANDING ON AN ASSESSMENT TASK

**MATERIALS:** Black Bear Hibernation Task, Black Bear Hibernation Task – Modified

Administer individually to students. This will take students about a full class period to complete. A modified task is also available.

### 5 · QUICK WRITE: REFLECT ON OUR EXPERIENCES

**MATERIALS:** science notebook

Have students reflect on their experiences with the unit. They should begin on their own and then with the whole class. Project slide E.

- What was most challenging in this unit?
- What was most rewarding?
- Think about how you engage in sensemaking discussions with classmates. How would you want to engage with those experiences the next time around?
  - What would you do the same?
  - What would you do differently?

### ADDITIONAL GUIDANCE

This unit asks students to do meaning-making that is very difficult but potentially very rewarding. Taking time to reflect upon the process of this unit can allow students to think about what works well for them as learners. Consider giving more time to answer these questions if needed.
Lesson-Specific Teacher Materials
Lesson 15: Rubric

**Bears Assessment Modeling Rubric**

<table>
<thead>
<tr>
<th>Component</th>
<th>Category</th>
<th>Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearly represents or describes the system (digestion and cells burning fat for energy) components and must include at least:</td>
<td>Missing</td>
<td>Developing</td>
</tr>
<tr>
<td>• Bite of food</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Small food molecules</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Blood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Cells</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Fat stores</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Food molecules (role in making energy)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Lungs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Oxygen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Carbon Dioxide</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interactions Between Components</th>
<th>Category</th>
<th>Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearly represents or describes the following:</td>
<td>Missing</td>
<td>Developing</td>
</tr>
<tr>
<td>• the digestion of food chemically breaks down food from big molecules into small molecules</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• the digested food molecules are absorbed by cells and/or travel around the body through the blood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• cells use the energy they need from food right away through a chemical reaction that uses oxygen from the lungs and releases carbon dioxide (matter/energy)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• when there are extra food molecules, they are stored as fat that animals can use for energy later (matter/energy)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Lesson 15: Answer Key

Key for Black Bear Hibernation Task

Each winter black bears in North America spend an average of 5 months inside of dens in a low activity state known as hibernation. During this time, they experience drastic body changes. They also do not eat, drink, urinate, or defecate (food, water, urine, poop). During this time, they wonder that the bears can survive each winter in this state without performing these essential body functions.

In Katmai National Park in Alaska, the first picture was taken on June 29, and the second picture was taken on September 30.

Above: This is Bear 499, nicknamed "Beadnose," from Katmai National Park in Alaska. The first picture was taken on June 29, and the second picture was taken on September 30.

<table>
<thead>
<tr>
<th>Season</th>
<th>Description</th>
<th>Temperature</th>
<th>Breathing Rate &amp; Heart Rate</th>
<th>Heart Rate</th>
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<td>Normal</td>
<td>40-50 beats per min</td>
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Adult Male Black Bear

Average Stats for an Adult Male Black Bear
Use what you've learned from our investigations related to M'Kenna's case and the data above to explain this phenomenon.

1. During hibernation, bears do not eat for 5 to 6 months in a row. How can the bear stay alive without eating for this long? Use patterns in the data table and science ideas developed throughout this unit to support your answer.

Even though the bears are not eating, their cells can still get the energy they need because, during hibernation, bears can use stored fat for energy.

Evidence to support this claim includes the decrease in body fat percentage (bears are burning body fat) and decreased weight (probably related to the decrease in body fat percentage).

The stored fat can sustain them for the entire hibernation because they are sleeping and not using very little energy—bears don’t use any energy to move around and are just sitting in their burrow.

2. To prepare for winter in the den, a bear will gain up to 30 pounds a week (in extra mass) by eating grass, roots, and small animals. Use your model to explain how a bear can gain so much weight so quickly.

The components you should include in your model are:

- Food molecules
- Bite of food
- Energy
- Carbon Dioxide
- Oxidation
- Lungs
- Fat stores
- Cells
- Blood

The interactions you should include in your model are:

- Digestion
- Absorption
- Eating
- Excretion
- Delivery to cells
- Inhaling and exhaling

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- Cells
- Blood

The interactions you should include in your model are:

- Digestion
- Absorption
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You run out of space.

Evidence to support this claim includes the decrease in body fat percentage (bears are burning body fat) and decreased weight (probably related to the decrease in body fat percentage).

The stored fat can sustain them for the entire hibernation because they are sleeping and don’t use any energy to move around.

For this lesson, use patterns in the data table and science ideas developed throughout this unit to support your answer:

During hibernation, bears do not eat for 5 to 6 months in a row. How can the bear stay alive without eating for this long?
A bear takes in a lot of food. Those food molecules get broken down through digestion, and absorbed into the blood. Some of the food molecules are needed for energy. The extra food molecules not needed right now are converted as fat and stored for later. When this happens the bear gains weight.

1. In spring, when the bears emerge from their dens, they have lost between 15% and 30% of their body weight (mass) - that could be around 120 pounds for a large black bear! Using your model above, explain where all the mass went when it was „lost.”

- Since the bear used the fat for energy the bear lost the weight of the fat and it went into the air
- The bear had extra mass stored as fat
- The bear used that mass stored as fat to make energy
- Since the bear was not eating he bear used the stored fat for energy.
- The bear had extra mass stored as fat
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- The bear used that mass stored as fat to make energy
- Since the bear was not eating he bear used the stored fat for energy.

2. In the last few years, scientists and citizens have noticed that bears in North Carolina are getting larger. In the past, black bears in North Carolina are usually about 400 pounds maximum but recently scientists have found bears greater than 700 pounds. Make a prediction about food availability in North Carolina in the last few years. Use your model to support your prediction.

Prediction: There is more food available to bears in North Carolina than there used to be.

Model Supports: If a bear can eat more food, then more food molecules get broken down through digestion and absorbed into the blood. When bears are eating more food, they are using what they need right away for energy and then storing the rest as fat. This is shown in the “Not needed right now” pathway for food in the model. The stored fat is one reason bears are getting so big in North Carolina.
Navigation: Evaluate our DQB questions

With a partner

Compare your notes about which questions you think we’ve answered on our DQB.

Symbols:
- We did not answer this question or any parts of it yet: O
- Our class answered some parts of this question, or I think I could answer some parts of this question: ✓
- Our class answered this question, or using the ideas we have developed, I could now answer this question: ✓+?

What Questions Have We Made Progress On?

- Take your handout and 10 sticky dots over to the Driving Question Board.
- Place your sticky dot on the sticky notes that match questions you think we’ve made progress on.
- Once you have placed your 10 dots, step back to form the Scientists Circle.
- As you are waiting for others to place their sticky dots:
  - Be prepared to share out your evidence for what the answers to the questions might be.
  - Notice and wonder about which questions have the most sticky dots.

Revisit Our Driving Question Board

- Which questions have we made the most progress on?
- What have we figured out?

Add to Our Progress Trackers: What have you figured out?

- During your time revisiting the DQB, new ideas that you want to include on your Progress Trackers may have surfaced.
- Write the question we are working on in the left column:
  - 15. What questions on our DQB can we now answer?

Add any additional ideas you want to review on your Progress Trackers. Go back and revise any previous rows as well.
Quick Write: Reflect on our Experiences

Quick write

Answer the following questions in your science notebook.

1. What was most challenging in this unit?
2. What was most rewarding?

1. Think about how you engage in sensemaking discussions with classmates. How would you want to engage in those experiences the next time around?
   a. What would you do the same?
   b. What would you do differently?

⇒ Be ready to share these ideas when you return to class.
Lesson 15: What questions on our Driving Question Board can we now answer?

Navigation: Evaluate our DQB questions

With a partner 1. Take out your home learning *Let’s Answer Questions from Our DQB!* and tape it into your science notebook. Compare your notes about which questions you think we’ve answered on our DQB.

Symbols:
- We did not answer this question or any parts of it yet: O
- Our class answered some parts of this question, or I think I could answer some parts of this question: ✓
- Our class answered this question, or using the ideas we have developed, I could now answer this question: ✓ +

What Questions Have We Made Progress On?

On your own 2. Take your handout and 10 sticky dots over to the DQB.
3. Place your sticky dots on the sticky notes that match questions that you think we’ve made progress on.
4. Once you have placed your 10 dots, step back to form the Scientists Circle.
5. As you are waiting for others to place their sticky dots
   - Be prepared to share out your evidence for what the answers to the questions might be, and
   - Notice and wonder about which questions have the most sticky dots.

Revisit Our Driving Question Board

With your class 6. In your Scientists Circle, look for patterns in the sticky dots. Work together to answer the following questions:
   - Which questions have we made the most progress on?
   - What have we figured out?

Add to Our Progress Trackers: What have you figured out?
During your time revisiting the DQB, new ideas that you want to include on your Progress Trackers may have surfaced.

In your notebook 7. Individually update your 2-column Progress Tracker:
   - Write the question we are working on in the left column: What questions on our DQB can we now answer?
   - Add any additional ideas you want to review in the column on the right. Go back and revise any previous rows as well. You can write in pictures or words. Take as much space as you need to record your thoughts.
Demonstrate Understanding on an Assessment Task

**On your own**  8. Use what you’ve figured out to demonstrate your learning on an end of unit assessment.

Quick Write: Reflect on our experiences

**On your own**  9. Answer the following questions in your science notebook:

- What was most challenging in this unit?
- What was most rewarding?
- Think about how you engage in sensemaking discussions with classmates. How would you want to engage in those experiences the next time around?
  - What would you do the same?
  - What would you do differently?

10. Be prepared to share your thoughts out with your class.
Let's Answer Questions from Our DQB!

Look through the list of questions from our DQB. Mark questions that you think the class has answered by putting different symbols next to each question:

- We did not answer this question or any parts of it yet: o
- Our class answered some parts of this question, or the ideas we developed help me see how I could now answer some parts of this question: ✓
- Our class answered this question, or the ideas we developed help me see how I could now answer this question: ✓ +

Then pick three new questions you marked and write what you think that answer would be.

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Black Bear Hibernation Task

Each winter black bears in North America spend an average of 5 months inside of dens in a low activity state known as hibernation. During this time, they experience drastic body changes. They also do not eat, drink, defecate (poop), or urinate (pee) during this time. It is a wonder that the bears can survive each winter in this state without performing these essential body functions!

Above: This is bear 409, nicknamed “Beadnose,” from Katmai National Park in Alaska. The first picture was taken on June 29, and the second picture was taken on September 30.

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Use what you’ve learned from our investigations related to M’Kenna’s case and the data above to explain this phenomenon.

1. During hibernation, bears do not eat for 5 to 6 months in a row. How can the bear stay alive without eating for this long? Use patterns in the data table and science ideas developed throughout this unit to support your answer.

2. To prepare for winter in the den, a bear will gain up to 30 pounds a week (in extra mass) by eating grass, roots, berries, fish, insects, and small animals. Using everything you’ve learned from the unit, develop a model that explains how a bear can gain so much weight so quickly. Some important components or interactions to include in your model are: food molecules, matter, energy, chemical reactions. Use extra sheets of paper if you run out of space.

Model
3. In spring, when the bears emerge from their dens, they have lost between 15% and 30% of their body weight (mass)—that could be around 120 pounds for a large black bear!

Using your model above, explain where all the mass went when it was “lost.”

__________________________________________________________

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4. In the last few years, scientists and citizens have noticed that bears in North Carolina are larger than ever. Black bears in North Carolina are usually about 400 pounds maximum, but recently scientists have found bears greater than 700 pounds.

Make a prediction about food availability in North Carolina in the last few years. Use your model to support your prediction.

__________________________________________________________

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Modified Black Bear Hibernation Task

Each winter black bears in North America spend an average of 5 months inside of dens in a low activity state known as hibernation. During this time, they experience drastic body changes. They also do not eat, drink, defecate (poop), or urinate (pee) during this time. It is a wonder that the bears can survive each winter in this state without performing these essential body functions!

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The components you should include in your model are:

- Blood
- Cells
- Fat stores
- Lungs
- Oxygen
- Carbon Dioxide
- Energy
- Bite of food
- Food molecules

Some interactions you should include in your model are:

- Digestion
- Absorption
- Eating
- Excretion
- Delivery to cells
- Inhaling and exhaling
3. In spring, when the bears emerge from their dens, they have lost between 15% and 30% of their body weight (mass)—that could be around 120 pounds for a large black bear!

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