Metabolic Reactions

Lesson 7-8

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
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Metabolic Reactions: Inside Our Bodies

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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>
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<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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<tr>
<td>What is going on inside M’Kenna’s body that is making her feel the way she does?</td>
<td>M’Kenna’s Doctor’s Note describes the symptoms in different parts of her body.</td>
<td>We think that it has to do with her digestive system, but we have a lot of questions that we need to answer in order to figure out what is causing M’Kenna’s symptoms.</td>
<td>We have some ideas for possible investigations we could pursue.</td>
</tr>
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**Anchoring Phenomenon**

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:

1. We think that it has to do with her digestive system, but we have a lot of questions that we need to answer in order to figure out what is causing M’Kenna’s symptoms.
2. We have some ideas for possible investigations we could pursue.

**Navigation to Next Lesson:** 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.

| **LESSON 2**    |                           |                          |                     |
| 2 days          |                           |                          |                     |
| Can we see anything inside M’Kenna that looks different? | There are differences between M’Kenna’s small intestine and the small intestine from a healthy person. | 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: |

1. The digestive system is made up of different parts called organs. The different organs have similarities and differences in their structures.
2. M’Kenna’s small intestine doesn’t look the same as a healthy one.
3. In a healthy person, many different substances in a graham cracker decrease as they travel through the small intestine.
4. Some substances in M’Kenna’s small intestine decrease, but others do not decrease as much compared to a healthy person.

**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.
# LESSON 5

**Why do large food molecules, like some complex carbohydrates, seem to disappear in the digestive system?**

**Investigation**

In the mouth, some types of substances seem to decrease, and new substances increase.

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.

**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?

# LESSON 6

**What happens to the different substances in food as it travels through the digestive system?**

**Investigation**

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.

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.

**Navigation to Next Lesson:** 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.
<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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</thead>
<tbody>
<tr>
<td>LESSON 7</td>
<td>2 days</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| What is the function of the digestive system, and how is M’Kenna’s digestive system different? | Putting Pieces Together | 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. |                     |
| LESSON 8        | 2 days                      |                           |                     |
| What does the surface of M’Kenna’s small intestine look like up close compared with a healthy one? | Investigation | 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. |                     |

**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.

**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

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

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Notes</th>
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</thead>
<tbody>
<tr>
<td>Fever</td>
<td>The patient complains that her stomach hurts after she eats and that she feels nauseated. Her parents say she was regular meals but has suddenly started losing a lot of weight. The patient says she also has diarrhea and stomach cramping. She has a hard time breathing when she tries to play basketball and gets out of breath quickly. The patient complains of feeling tired and weak all the time.</td>
</tr>
<tr>
<td>Throat</td>
<td></td>
</tr>
<tr>
<td>Weight loss</td>
<td></td>
</tr>
<tr>
<td>Nausea</td>
<td></td>
</tr>
<tr>
<td>Diarrhea</td>
<td></td>
</tr>
<tr>
<td>Constipation</td>
<td></td>
</tr>
<tr>
<td>Symptoms that started later</td>
<td></td>
</tr>
<tr>
<td>Fever</td>
<td></td>
</tr>
<tr>
<td>Nausea</td>
<td></td>
</tr>
<tr>
<td>Weight loss</td>
<td></td>
</tr>
<tr>
<td>Nausea</td>
<td></td>
</tr>
<tr>
<td>Weight gain</td>
<td></td>
</tr>
<tr>
<td>Back pain</td>
<td></td>
</tr>
<tr>
<td>Leg pain</td>
<td></td>
</tr>
<tr>
<td>Pruritus</td>
<td></td>
</tr>
<tr>
<td>Difficulty walking or moving</td>
<td></td>
</tr>
<tr>
<td>Confusion</td>
<td></td>
</tr>
<tr>
<td>Difficulty breathing with exercise</td>
<td></td>
</tr>
<tr>
<td>Sweaty palms</td>
<td></td>
</tr>
<tr>
<td>Headaches</td>
<td></td>
</tr>
<tr>
<td>Night sweats</td>
<td></td>
</tr>
<tr>
<td>Difficulty breathing at the time</td>
<td></td>
</tr>
<tr>
<td>Chest pain</td>
<td></td>
</tr>
<tr>
<td>Wheezing</td>
<td></td>
</tr>
<tr>
<td>Anemia</td>
<td></td>
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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, these symptoms are connected to what is happening in her digestive system.

Navigation to Next Lesson: In this lesson, we think that problems in M’Kenna’s digestive system are connected to her symptoms in other systems, such as brain fog, fatigue, and not gaining weight. This made us wonder if the fact that she is not able to get food molecules absorbed from her small intestine (digestive system) as quickly as a healthy person might be part of the reason she isn’t gaining weight.

Lesson 10

2 days

Why is M’Kenna losing so much weight?

Investigation

When you burn fat, the matter seems to vanish.

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.

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 Question | Phenomena or Design Problem | What we do and figure out | How we represent it
---|---|---|---
**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 gasses 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 Question

**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 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.
- 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>Lesson Question</th>
<th>Phenomena or Design Problem</th>
<th>What we do and figure out</th>
<th>How we represent it</th>
</tr>
</thead>
<tbody>
<tr>
<td>LESSON 14</td>
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<tr>
<td>Do all animals do chemical reactions to get energy from food like humans?</td>
<td><img src="image" alt="Dog Image" /></td>
<td>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:</td>
<td></td>
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<tr>
<td>Investigation</td>
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<td></td>
<td></td>
<td>Animal, aside from humans, rearrange matter in food through chemical reactions to release energy.</td>
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<td></td>
<td></td>
<td>In animals, besides humans, oxygen reacts with food to produce carbon dioxide and provide energy.</td>
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<td></td>
<td></td>
<td>Other living things, such as anaerobic bacteria, don't need oxygen for chemical reactions to get energy.</td>
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<tr>
<td></td>
<td></td>
<td>Animals might have different structures in their bodies that do the same functions.</td>
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<tr>
<td>LESSON 15</td>
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<tr>
<td>What questions on our Driving Question Board can we now answer?</td>
<td><img src="image" alt="Bear Image" /></td>
<td>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.</td>
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<tr>
<td>Putting Pieces Together</td>
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<tr>
<td>LESSONS 1-15</td>
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<tr>
<td>29 days total</td>
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</tbody>
</table>
TEACHER BACKGROUND KNOWLEDGE

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 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 ≠ 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.
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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</thead>
<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 (DOB). 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>
</tr>
<tr>
<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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<tr>
<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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<tr>
<td>When</td>
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<tr>
<td>Lesson 10 Initial Ideas Discussion</td>
<td><strong>Formative / Pre Assessment</strong></td>
<td>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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<tr>
<td>Lesson 14 Self Assessment Argumentation rubric with Gotta-Have-It Checklist</td>
<td><strong>Formative and Self Assessment</strong></td>
<td>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.</td>
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<tr>
<td>Lesson 15 Student Assessment Modified Student Assessment Teacher Reference Modeling Rubric</td>
<td><strong>Summative</strong></td>
<td>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.</td>
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<tr>
<td>Occurs in most lessons Progress Tracker</td>
<td><strong>Formative and Student Self Assessment</strong></td>
<td>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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<tr>
<td>Anytime after a discussion Student Self Assessment Discussion Rubric</td>
<td><strong>Student Self Assessment</strong></td>
<td>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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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.
<table>
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<th>Lesson-Level Performance Expectation(s)</th>
<th>Assessment Guidance</th>
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<tr>
<td>Lesson 1</td>
<td>Develop models 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). Ask questions 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>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.</td>
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<tr>
<td>Lesson 2</td>
<td>Analyze and interpret data 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>Analyze and Interpreting Data; Structure and Function; Systems and Analyze and Interpreting Data; Patterns 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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<tr>
<td>Lesson 3</td>
<td>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. 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.</td>
<td>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. 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.</td>
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<td>Lesson 4</td>
<td>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.</td>
<td>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?”</td>
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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.</td>
<td>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. 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 causal relationships. 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.l5.tref. After conducting the investigation and recording their results, check student work using Unknown material with identifier: mr.l5.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.** | **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. |
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.

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.

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).

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 they 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. 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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<td>Lesson 8</td>
<td>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.</td>
<td>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 has celiac disease 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.</td>
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Analyze and interpret data to identify the relationship that taller villi (structure) have more cells that work together to impact the rate of absorption (function) of food molecules into the bloodstream. | 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 McKenna’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 McKenna’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 McKenna’s doctor’s note and their mapping of her symptoms, students are problematizing McKenna’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 there 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 McKenna’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 *McKenna’s Doctor’s Note* to see which symptoms and systems are still not explained. |
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<td>Lesson 10</td>
<td>Analyze and interpret data using graphical displays and statistics 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?”</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.</td>
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**Obtaining, Evaluating, and Communicating Information; Energy and Matter**
After the students read the article *Children Need More Fat in Their Diets Compared to Adults* 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?

**Planning and Carrying Out Investigations; Energy and Matter**
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?”
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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 <em>Making Sense of Burning Fat Investigation Results</em> 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 <em>Progress Tracker</em>. 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 <em>Burning Fat in Open and Closed Systems</em>. 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 | 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. | **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 in their Progress Trackers 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>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.</td>
<td>Developing and Using Models; Systems and System Models 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. Constructing Explanations; Cause and Effect 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>
</tr>
<tr>
<td>Lesson</td>
<td>Lesson-Level Performance Expectation(s)</td>
<td>Assessment Guidance</td>
</tr>
<tr>
<td>--------</td>
<td>----------------------------------------</td>
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<tr>
<td>Lesson 14</td>
<td>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.</td>
<td>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.</td>
</tr>
<tr>
<td>Lesson 15</td>
<td>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.</td>
<td>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.</td>
</tr>
</tbody>
</table>
LESSON 7: What is the function of the digestive system, and how is M’Kenna’s digestive system different?

PREVIOUS LESSON
We analyzed more food data, noting 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.

THIS LESSON
PUTTING PIECES TOGETHER
2 days

We review our Progress Trackers and develop a Gotta-Have-It Checklist to highlight the key ideas we figured out in Lessons 1-6. We develop models to describe how food is broken down in the organs of the digestive system. We critique our models and then develop a consensus model to answer the questions: “How does a healthy digestive system work?” and “How is M’Kenna’s digestive system functioning differently than a healthy one?” We are presented with four conditions that could be causing M’Kenna’s symptoms. Based on what we know, we develop an argument, based on evidence, to eliminate two of the possible conditions. We consider what additional data we need on the remaining conditions to determine the cause of M’Kenna’s symptoms.

NEXT LESSON
We will zoom in closer into the small intestine. Then we will use an interactive simulation to learn that taller villi have more cells, so they are able to allow for more absorption. We will use that model to construct an individual explanation for M’Kenna’s digestive symptoms.

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 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.

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.

WHAT STUDENTS WILL 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.
- We can use a model to represent the digestive system and the interactions that occur within it.
- Effective models include inputs, processes, and outputs.
### Lesson 7 • Learning Plan Snapshot

<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>5 min</td>
<td><strong>NAVIGATION</strong>&lt;br&gt;Review M’Kenna’s symptoms and the investigations we have completed, thus far, to figure out how M’Kenna can experience symptoms in so many different parts of her body.</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>13 min</td>
<td><strong>WHAT CAN WE EXPLAIN NOW?</strong>&lt;br&gt;Look back at the initial models we developed to explain M’Kenna’s symptoms. Consider the investigations we have done since then. Compile all of the pieces of our models from our Progress Trackers into one model.</td>
<td>B</td>
<td>colored pencils, Compiled Models from Progress Tracker</td>
</tr>
<tr>
<td>3</td>
<td>12 min</td>
<td><strong>GOTTA-HAVE-IT CHECKLIST</strong>&lt;br&gt;Develop a Gotta-Have-It Checklist to list the important ideas we have figured out so far that we need to include in our new models to answer the question, “How does a healthy digestive system work?”</td>
<td>C</td>
<td>Gotta-Have-It Checklist</td>
</tr>
<tr>
<td>4</td>
<td>15 min</td>
<td><strong>DEVELOP MODELS IN SMALL GROUPS</strong>&lt;br&gt;Work in small groups to develop a model to explain, “How does a healthy digestive system work?” Use your Gotta-Have-It Checklist to help. Check off ideas on the list that you used or did not use to develop the model.</td>
<td>D</td>
<td>Gotta-Have-It Checklist, chart paper, markers</td>
</tr>
<tr>
<td>5</td>
<td>12 min</td>
<td><strong>PREPARING FOR CONSENSUS MODEL</strong>&lt;br&gt;Examine at least two other small-group models. “Take” ideas to use in your own model. “Leave” critique, based in evidence, to improve others’ models. Brainstorm parts of M’Kenna’s digestive system that you think may be functioning differently.</td>
<td>E-F</td>
<td>2 sticky notes, 1 sticky dot</td>
</tr>
<tr>
<td>6</td>
<td>20 min</td>
<td><strong>DEVELOPING OUR CLASSROOM CONSENSUS MODEL</strong>&lt;br&gt;As a class, develop a consensus model to describe how a healthy digestive system works. Then, discuss how you think M’Kenna’s digestive system is functioning differently than a healthy one. Consider the limitations of the classroom consensus model.</td>
<td>G-H</td>
<td>small-group model, chart paper, markers</td>
</tr>
<tr>
<td>7</td>
<td>13 min</td>
<td><strong>ADD TO OUR PROGRESS TRACKERS</strong>&lt;br&gt;Using the classroom consensus model, individually add to your 3-column Progress Tracker.</td>
<td>I</td>
<td>Progress Tracker, colored pencils</td>
</tr>
<tr>
<td>8</td>
<td>2 min</td>
<td><strong>NAVIGATION</strong>&lt;br&gt;Navigate to the student assessment by considering why doctors might eliminate possible conditions rather than selecting the condition that best fits the symptoms.</td>
<td>J</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>40 min</td>
<td><strong>STUDENT ASSESSMENT TASK</strong>&lt;br&gt;As an assessment task, students are presented with five gastrointestinal conditions that might be causing M’Kenna’s symptoms. Construct an argument, based on evidence, to eliminate two of the possible conditions.</td>
<td>K-O</td>
<td>Task Parts 1 and 2: Eliminate Possible Conditions and Identify Missing Evidence</td>
</tr>
<tr>
<td>10</td>
<td>3 min</td>
<td><strong>NAVIGATION</strong>&lt;br&gt;When students are done with the assessment task, return to the Driving Question Board to find a question that we think we have answered. On a sticky note, record the answer, based on evidence, and post the sticky note near the original question.</td>
<td>P</td>
<td>1-2 sticky notes, Driving Question Board</td>
</tr>
</tbody>
</table>

*End of day 1*

*End of day 2*

*End of day 3*
### Lesson 7 • Materials List

<table>
<thead>
<tr>
<th></th>
<th>per student</th>
<th>per group</th>
<th>per class</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lesson materials</strong></td>
<td>• science notebook</td>
<td>• chart paper</td>
<td>• chart paper</td>
</tr>
<tr>
<td></td>
<td>• colored pencils</td>
<td>• markers</td>
<td>• markers</td>
</tr>
<tr>
<td></td>
<td>• Compiled Models from Progress Tracker</td>
<td>• small-group model</td>
<td>• Driving Question Board</td>
</tr>
<tr>
<td></td>
<td>• Gotta-Have-It Checklist</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 2 sticky notes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 1 sticky dot</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Progress Tracker</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Task Parts 1 and 2: Eliminate Possible Conditions and Identify Missing Evidence</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 1-2 sticky notes</td>
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</tbody>
</table>

### Materials preparation (20 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.
Lesson 7 • Where We Are Going and NOT Going

Where We Are Going

This lesson addresses the DCI element 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 (LS1.C). Specifically, students pull together their previously developed ideas into one model to show that large food molecules, which make up food, are broken down into smaller food molecules through a series of chemical reactions that occur in the digestive system.

Students partially develop the key DCI element that the body is a system of multiple interacting subsystems (LS1.A). Specifically, students argue that the digestive system is made up of a series of subsystems (organs), and each plays an important and distinct role in the digestive system.

Where We Are NOT Going

In this lesson, students do not need to identify where a specific breakdown happens (which organ) or what causes the breakdown (specific enzymes). Students do not need to differentiate between carbohydrates, proteins, and fats. Further, students do not differentiate between cells, tissues, and organs as outlined in the second half of LS1.A element; they will do this in Lesson 8.

In the student embedded assessment, students are presented with five different gastrointestinal conditions that may be causing M’Kenna’s symptoms. Students are not “diagnosing” M’Kenna with a condition. Rather, students are eliminating possible causes of M’Kenna’s symptoms based on evidence.
LEARNING PLAN for LESSON 7

1 · NAVIGATION

MATERIALS: science notebook

Take stock of where the class is by reviewing aspects of the phenomenon we’re trying to explain. Present slide A with M’Kenna’s symptoms and have students open their science notebooks to the page on which they have M’Kenna’s Doctor’s Note with her symptoms. Have students turn and talk with a partner about the questions on slide A. Have students share out their ideas with the whole class. Discuss the focus of our investigations over the course of the first six lessons.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>When we decided to investigate what was happening to food as we digest it, which of M’Kenna’s symptoms were we trying to explain?</td>
<td>M’Kenna’s digestive symptoms—why she was having nausea and vomiting, and why she was losing weight.</td>
</tr>
<tr>
<td>What have we noticed so far in our investigations?</td>
<td>We have noticed a lot!</td>
</tr>
<tr>
<td></td>
<td>We know that small food molecules can be absorbed across the lining of the small intestine.</td>
</tr>
<tr>
<td></td>
<td>We also know that large food molecules can be broken down into smaller food molecules through chemical reactions. This happens in several different organs in the digestive system.</td>
</tr>
<tr>
<td></td>
<td>We also know that some food molecules don’t get broken down at all. Instead, they are excreted from the body as poop.</td>
</tr>
</tbody>
</table>

Navigate by saying, It sounds like we have figured out a lot! Last class, we decided we wanted to put some of these ideas together into one cohesive explanation. Let’s work on doing that now.

2 · WHAT CAN WE EXPLAIN NOW?

MATERIALS: science notebook, colored pencils, Compiled Models from Progress Tracker

As a starting point, encourage students to look back at their initial models from Lesson 1. The initial models can be found on Initial model. Present slide B and give students several seconds to flip back to their initial models. Then, prompt students to think about the investigations they have completed since developing their initial models. Students may want to flip through their science notebooks or their Progress Trackers as reminders. Then, prompt students to look through the models in their Progress Trackers.

Say, If we think of the models from our Progress Trackers as smaller pieces of a larger model, our goal now is to compile the pieces into a larger model.

Pass out Compiled Models from Progress Tracker and instruct students to individually compile all of the models from their Progress Trackers into a larger model using colored pencils.

Tell students that, at this point, they should just focus on modeling the breakdown and absorption of large food molecules in the digestive system, but they do not need to focus on depicting any of the organs in the digestive system.
ADDITIONAL GUIDANCE

Individual time gives students an opportunity to individually synthesize evidence and formulate ideas. It is important to prepare students to build on their ideas and evaluate other's ideas when they share their ideas in small groups and with the whole class. While looking back at their initial models, this is also a great opportunity for students to reflect on how much they have learned.

A suggested representation can be found here:

ADDITIONAL GUIDANCE

Lessons 1–6 focus on helping students explain how healthy digestion works. If students are intent on explaining symptoms associated with other systems, such as the circulatory or respiratory systems, encourage them to document their thinking in their science notebooks so that we can revisit their ideas when we try to explain her non-digestive-related symptoms.

Prepare students to develop a model of the digestive system. Students should map the processes that occur to break down and absorb large food molecules to where they occur in the organs of the digestive system. After students have compiled the models from their Progress Trackers, introduce the idea of developing a model that takes into account the various structures in the digestive system.

Say, We have made a lot of progress on making sense of how food is digested in the body. Our models, thus far, have focused on how food is broken down and absorbed. Based on our last investigation, though, we know that the various structures in the digestive system seem to matter with respect to where, how, and why the chemical processes of digestion take place.

Help students generate the idea to mapping their existing models onto a model of the digestive system.
How could we revise our models to show where each of these processes are taking place?

Maybe we could add our models to a model of the digestive system. We could cut out each of the processes and paste it onto the different parts of the digestive system where it occurs.

Why would it be important to map our current models of the breakdown of food onto a model of the digestive system? How could this help us explain what is going on with M'Kenna?

In our last class, we noticed that different parts of the digestive system do different jobs. It is almost like they are smaller parts, or subsystems, of a larger system. If we combine our models with a model of the digestive system, we might be able to better understand how and why structures of the digestive system relate to the functions.

We have these different pieces, but it's hard to visualize where these different processes are occurring. Often times, we've been looking at charts and graphs to see what's happening, but it would be great to put them all together.

If we can map our models onto the model of the digestive system, it might help us show where M'Kenna's digestive system might be functioning differently.

Say, Let's start by creating a model of a healthy digestive system. Then we can examine our models to show what is going on with M'Kenna.

3 · GOTTA-HAVE-IT CHECKLIST

MATERIALS: science notebook, Gotta-Have-It Checklist

Preview the Gotta-Have-It Checklist. Explain that, before we develop our revised models, we will need to think carefully about what to include in the models. To do so, we will create a Gotta-Have-It Checklist. In the Gotta-Have-It Checklist, students will decide which ideas from their Progress Trackers are the most important for explaining how a healthy digestive system works. Remind students that we are starting by modeling how a healthy digestive system works so that we can use our models to help us think about what might be functioning differently in M'Kenna's digestive system.

In order to develop their checklists, students will need to determine which ideas from their Progress Trackers are most necessary for explaining how a healthy digestive system works. Direct students to find their Progress Trackers in their notebooks. Tell students that these are important ideas they have figured out over the past six lessons and that some ideas may be more critical than others for explaining how healthy digestive systems work.

Tell students that they will be responsible for developing individual Gotta-Have-It Checklists. They will then meet in groups to develop their revised models.

Create the Gotta-Have-It Checklist. Pass out a copy of the Gotta-Have-It Checklist to each student. This will be taped or glued in the students' science notebooks. Use slide C to preview how to build a checklist. Students will complete only the left-hand column right now. They should leave the right-hand columns blank for now.

Have students work individually to develop their Gotta-Have-It Checklists. They will begin by noting ideas from their Progress Trackers that may help explain the question, “How does a healthy digestive system work?” Students record the ideas they want to use on the Gotta-Have-It Checklist. They do not need to record all of the model ideas from the Progress Tracker, only the ones they want to include in their new models.

SUPPORTING STUDENTS IN THREE-DIMENSIONAL LEARNING

As students develop their Gotta-Have-It Checklists, ensure that they have identified different relationships among organs of the digestive system and their respective food molecule outputs (SEP2). These items should help students build their understanding in explaining how food moves through a series of chemical reactions where it is broken down (LS1.C). In order to do this, the Gotta-Have-It Checklist should identify components of the system (organs) and their interactions (processes, inputs, and outputs) (CCC4).
As students work, circulate to push their thinking.

### KEY IDEAS

Though the list below is not exhaustive, it is important that students identify the following ideas as key ideas for their models:

- The digestive system is a long tube with different parts to it (Lesson 1).
- In the small intestine, one part of the digestive system small food molecules are absorbed and large food molecules aren't (Lesson 3).
- Absorption (in the small intestine) means that the molecules cross the lining of the small intestine and go into the body (Lesson 3).
- Fiber is not digested at all and is excreted from the body (Lesson 4).
- Large food molecules (most complex carbohydrates, proteins, and fats) can be broken down into smaller food molecules (Lessons 5 and 6).
- In the mouth, another part of the digestive system some types of complex carbohydrates are broken down into smaller pieces through chemical reactions (Lesson 5).
- Other types of food molecules (proteins and fats) are broken down in other parts of the digestive system (stomach and small intestine) (Lesson 6).

### Facilitate a sharing of ideas.

Facilitate a brief sharing of ideas from the groups. Do not let this discussion take too much time, or it will take away from students’ time to develop and share their new models. Ask students to briefly mention an idea from the Progress Tracker that they plan to include and why it’s important. You can also ask which ideas they do not plan to include and why those ideas are less important. The sample student responses below are not a comprehensive list of all the ideas from the Progress Tracker, but they are important ideas that should surface.

### ADDITIONAL GUIDANCE

At this point in the unit, most ideas from the Progress Tracker will be helpful in answering questions about the phenomenon. However, as you move through the unit, not all ideas will be useful for explaining aspects of the phenomenon, so determining ideas that we need and don't need will become important. You can add this question to help students practice this stock-taking routine, and it's fine for them to say that all the ideas are helpful.

Once students have shared their ideas, prompt them to consider how our models will be different from the compiled models that they have already developed.
**Suggested prompt**

*Can someone suggest an idea from Lessons 1 through 6 that will help us explain how a healthy digestive system works?*

<table>
<thead>
<tr>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>The digestive system is a long tube with different parts to it (Lesson 1).</td>
</tr>
<tr>
<td>In one part of the digestive system, the small intestine, small food molecules are absorbed and large food molecules aren’t (Lesson 3).</td>
</tr>
<tr>
<td>Absorption (in the small intestine) means that the molecules cross the lining of the small intestine (Lesson 3).</td>
</tr>
<tr>
<td>Fiber is not digested at all and is excreted from the body (Lesson 4).</td>
</tr>
<tr>
<td>Large food molecules (most complex carbohydrates, proteins, and fats) can be broken down into smaller food molecules (Lessons 5 and 6).</td>
</tr>
<tr>
<td>In another part of the digestive system, the mouth, some types of complex carbohydrates are broken down into smaller pieces through chemical reactions (Lesson 5).</td>
</tr>
<tr>
<td>Other types of food molecules (proteins and fats) are broken down in other parts of the digestive system (stomach and small intestine) (Lesson 6).</td>
</tr>
<tr>
<td>The digestive system is one system inside of our bodies. The digestive system has multiple organs inside it that each do particular functions. These organs, such as the stomach, the mouth, and the small intestine, all work together to help break down and absorb food. All of the organs work together to carry out the functions of the whole system.</td>
</tr>
</tbody>
</table>

**Based on the ideas we just shared, why are the models we just developed insufficient? Why do we need to add the structures of the digestive system to our models?**

---

**4 · DEVELOP MODELS IN SMALL GROUPS**

**MATERIALS:** science notebook, Gotta-Have-It Checklist, chart paper, markers

**Orient students to developing small-group models of a healthy digestive system.** Present slide D and tell students that they are going to work in small groups to build a model to describe what is happening in a healthy digestive system. Remind students that the goal is to map our models of food breakdown onto a model of the digestive system to illustrate where the processes take place. Pass out *Revised Model (optional).* Explain that students can use the outline of the body to create their small-group model, if they wish. Alternatively, students may create their small-group model on chart paper. *

Emphasize the idea that this model is different from the compiled model that we created at the beginning of this lesson because students will focus specifically on where in the digestive system each of the processes is happening.

**Organize students into small groups and begin developing models.** As students work, walk around the room and look at their models. Where needed, use questions to help students fully articulate their thinking and defend their ideas. Prompt students to remember the evidence they have from previous investigations for each of the ideas they have figured out.

Remind students to indicate on their Gotta-Have-It Checklist which ideas they did and did not use in their models.
Prompt students to make sure that their models include their responses to the following questions:

- What are the structures in the digestive system? How do the functions of each structure distinguish it from other structures in the digestive system?
- What happens to food when it enters the digestive system? What kinds of food molecules are broken down? Where are they broken down?
- What kinds of food molecules are absorbed? Where are they absorbed? What kinds of food molecules are excreted?

As students work, circulate to provide support. If students become stuck, it may help to use the prompts below to get them started.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>What happens to large food molecules? How does it happen? What evidence do you have to support this idea?</td>
<td>They break down into smaller molecules through chemical reactions. We saw that in the graphs of food changing in the mouth and stomach and in our investigation with the cracker and saliva. We think this is true for all food molecules, not just complex carbohydrates and sugars.</td>
</tr>
<tr>
<td>Where do you think the small molecules go?</td>
<td>We know that they can pass through the small intestine wall and that they disappear. We think they get absorbed, but we're not sure where.</td>
</tr>
<tr>
<td>What leaves a healthy body as poop?</td>
<td>In a healthy body, fiber, a large molecule that doesn't break down, leaves the system.</td>
</tr>
</tbody>
</table>

Groups typically engage in rich discussion in this sort of synthesis task. However, if you encounter a group in which this is not happening, the following prompts can help jump-start that discussion.

**Prompts for eliciting student proposals for what should go in the model.**

- What is one of the key components of your model that explains what happens to matter in a healthy person during digestion and why?
- What evidence do you have to support your idea?
- 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?

**Prompts for proposing modifications to the proposal or coming to a consensus with conflicting ideas.**

- How are your ideas similar to the small-group model? How are they different?
- Is there more evidence or clarification needed before we can come to an agreement? What is that?
The final consensus model will likely look something like the image below. Small-group models should include many of these components and interactions.

When students have completed their small-group models, have them post the models somewhere in the room.

End of day 1
5 · PREPARING FOR CONSENSUS MODEL

MATERIALS: 2 sticky notes, 1 sticky dot

Have students critique one another’s models through a gallery walk. Present slide E. Tell students that they will be responsible for visiting at least two other small-group models. Hand out copies of the Peer Feedback Guidelines. Review the guidelines and then share that, at the end of this activity, we will get a chance to evaluate ourselves on giving and receiving feedback using Self-Assessments Giving and Receiving Feedback.

**ASSESSMENT OPPORTUNITY** See the OpenSciEd Teacher’s Handbook for more guidance on the self-evaluation of giving and receiving peer feedback.

At each model, students must do three things. First, they should write a “Take It” sticky note. On the “Take It” note, students should write down an idea from the model that they could use to improve their own model. Students should take this sticky note back to their own models.

Second, students should write a “Leave It” sticky note. On the “Leave It” note, students should write one sentence to respectfully critique one input, process, or output in the model. Students should write a second sentence to cite the evidence from our investigations to support their critique. Students should leave this sticky note on the small-group poster.

Third, students should place one sticky dot on a location in the small-group model to show where they think M’Kenna’s digestive system is different.

Review gallery walk critiques to prepare to build a classroom consensus model. After visiting other small-group models, students should return to their own model, place their “Take It” sticky notes on their model, and then read through all of the notes on their model. Share the instructions for this task by presenting slide F. Prompt students to jot down notes about the things in their models that they want to keep or change as we develop a classroom consensus model.

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

By leaving critique, based on evidence, for other groups, students are engaging in one of the elements of the practice of Engaging in Argument from Evidence. Specifically, students are providing and receiving critique, and the critique must cite evidence from our investigations.
DEVELOPING OUR CLASSROOM CONSENSUS MODEL

MATERIALS: science notebook, small-group model, chart paper, markers

Form a Scientists Circle for a Consensus Discussion. Have students bring their small-group models to the circle and place them in the middle of the circle. Also, have students bring their science notebooks to the circle.

Present slide G and introduce the Consensus Discussion.

Say, We are going to take stock of the ideas in everyone’s models and try to build a classroom consensus model that everyone agrees on to explain how a healthy digestive system works. After we develop a model for a healthy digestive system, we are going to see if we can figure out what might be functioning differently in M’Kenna’s digestive system.

Remind students of discussion norms. 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 someone else or another group’s idea.

Facilitate a Consensus Discussion. Students should offer proposals for what should go in the model, support or challenge these proposals based on evidence, and suggest modifications. During the discussion, ask students how to represent their ideas visually. On a whiteboard or chart paper, create a public representation of agreed-upon ideas as the class puts them together.

KEY IDEAS
Purpose of this discussion: To build a common, class-level model to explain how a healthy digestive system works, while drawing from all of the ideas learned in Lessons 1-6.

Listen for these 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.
- M’Kenna’s body is breaking down large food molecules, but not as many of them are broken down and not as many of the small molecules are absorbed. These are leaving her body as poop.
- All ideas represented on the Gotta-Have-It Checklist:
  - The digestive system is a long tube with different parts to it (Lesson 1).
  - In one part of the digestive system, the small intestine, small food molecules are absorbed and large food molecules aren’t (Lesson 3).
  - Absorption (in the small intestine) means that the molecules cross the lining of the small intestine (Lesson 3).
  - Fiber is not digested at all and is excreted from the body (Lesson 4).
  - Large food molecules (most complex carbohydrates, proteins, and fats) can be broken down into smaller food molecules (Lessons 5 and 6).
  - In another part of the digestive system, the mouth, some types of complex carbohydrates are broken down into smaller pieces through chemical reactions (Lesson 5).
  - Other types of food molecules (proteins and fats) are broken down in other parts of the digestive system (stomach and small intestine) (Lesson 6).

ATTENDING TO EQUITY
The key ideas shared in the teacher guide are suggestions for important ideas that the model could include. It is important, however, to appropriate the words and ideas that your students use and agree upon during this discussion. Your class list of key ideas could be articulated differently and may include other ideas not listed here. Actively look for different ways that students share and represent their ideas as an opportunity to communicate to your students that different ways of representing our thinking are valuable.
The teacher’s role is to prompt students to share what needs to be in the model, what evidence they have to support their ideas, and how to represent their ideas. The students’ role is to offer a proposal for ideas to include in the model and how to represent those ideas, to support or challenge proposed ideas from peers, and to come to a consensus about what should be included in the model. Suggested prompts are provided to help elicit, probe, and challenge student ideas to help them come to a consensus during this discussion.

**During stock-taking:**
- Could someone restate our question (or our charge)? What are we building consensus about?
- What are some things we think we can say at this point about our question?
- What is our evidence for those ideas (those explanations)?

**When soliciting ideas to develop or modify the model or explanation:**
- How should we represent it? Are we OK with that?
- Do we all agree with that?
- How are these explanations similar? How are they different?
- Both groups seem to be using the same term but in a different way. Could someone explain the difference?
- How could we modify what we have to account for the evidence we agree is important to consider?
- What modifications might you make to clarify confusion or address the discontent that this group feels?
- Is there more evidence or clarification needed before we can come to an agreement? What is that?

**When inviting support or critique:**
- Who feels like their idea is not quite represented here?
- Would anyone have put this point a different way?
- What ideas are we in agreement about?
- I’m hearing (Idea X) and (Idea Y). Why (Idea X)? Why (Idea Y)?
- Are there still areas of confusion or discontent?
- Are there still places where we disagree? Can we clarify these?

See the image in activity section 4 for a suggested representation for the classroom consensus model.

After coming to a consensus on our model for a healthy digestive system, identify the portion of M’Kenna’s digestive system that is functioning differently. Summarize the classroom consensus model for a healthy digestive system. Then, look back to the dots on the small-group models marking where students think M’Kenna’s digestive system is functioning differently. Add a dot to the consensus model in the location that most groups identified as the problematic location (likely the small intestine). Before adding the dot, be sure that students agree upon where the dot should be added. Prompt students to provide evidence for their claims.
What is our evidence that M’Kenna’s digestive system is different in the location we have identified?

We know that M’Kenna’s digestive system is still capable of breaking down large food molecules into small food molecules, but it doesn’t break down as many. Since proteins and fats are broken down in the stomach or the small intestine, we think that there might be something going on with her stomach or small intestine. M’Kenna is having trouble absorbing the small food molecules. The small intestine is responsible for absorbing small food molecules, so we think there must be something wrong with M’Kenna’s small intestine.

Lead a discussion about the limitations of the consensus model. Present slide H and have students discuss with a partner whether our model can fully help us explain what’s going on with M’Kenna’s digestion. Then, in a whole-class discussion, draw out the idea that, even though the models we have been developing help explain what is causing changes in the amount of different substances as they travel through the digestive system of a healthy person, they don’t fully explain why M’Kenna isn’t absorbing all the small food molecules that her body has broken down. Press students to recognize this limitation of the current models and have them generate some initial ideas about what is different that could be causing some small food molecules in M’Kenna’s body to not get absorbed.

Does our model fully explain all the parts of M’Kenna’s digestion that might be different?

Our model can’t explain why M’Kenna’s body is not absorbing all the small food molecules that are broken down.

Does our model fully explain all of Mckenna’s symptoms?

No, we haven’t even addressed her non-digestive symptoms!

What do we still need to figure out?

We need to figure out why M’Kenna’s small intestine isn’t absorbing as many small food molecules.

What kinds of evidence do we need?

Maybe we can look at her small intestine up close to see if there are differences between M’Kenna’s digestive system and a healthy one.

**7 · ADD TO OUR PROGRESS TRACKERS**

**MATERIALS:** science notebook, Progress Tracker, colored pencils

Update the 3-column Progress Tracker. Present slide I and pass out the Progress Tracker. Tell students that, just as before, 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 using colored pencils based on the classroom consensus model.

Students may also wish to take this time to update their table of contents.

Below is one suggested representation for the Progress Tracker.
<table>
<thead>
<tr>
<th>Question</th>
<th>Source of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the function of the digestive system and how is M’Kenna’s digestive system different?</td>
<td>Evidence from all investigations in Lessons 1-6.</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 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.
- M’Kenna’s body is breaking down large food molecules, but not as many of them are broken down and not as many of the small molecules are absorbed. These are leaving her body as poop.
- We think something is wrong with M’Kenna’s small intestine.
- All ideas represented on the Gotta-Have-It Checklist:
  - The digestive system is a long tube with different parts to it (Lesson 1).
  - In one part of the digestive system, the small intestine, small food molecules are absorbed, and large food molecules aren’t (Lesson 3).
  - Absorption (in the small intestine) means that the molecules cross the lining of the small intestine (Lesson 3).
  - Fiber is not digested at all and is excreted from the body (Lesson 4).
  - Large food molecules (most complex carbohydrates, proteins, and fats) can be broken down into smaller food molecules (Lessons 5 and 6).
  - In another part of the digestive system, the mouth, some types of complex carbohydrates are broken down into smaller pieces through chemical reactions (Lesson 5).
  - Other types of food molecules (proteins and fats) are broken down in other parts of the digestive system (stomach and small intestine) (Lesson 6).
If you can plan to have time between the Progress Tracker update and the student assessment in the next portion of the lesson, you may wish to provide individual feedback on students' Progress Tracker updates. Specifically, focus on providing feedback on LS1.A, LS1.C, SEP2, and CCC4.

Focus on providing students with feedback by targeting:
- LS1.A - Students should identify that the digestive system is made up of a group of organs, or subsystems, which work together to process food.
- LS1.C - Students should identify that food is broken down through a series of chemical reactions as it travels through the organs of the digestive system.
- SEP2 (2.4) - Students should identify that specific organs break down food particles and that other organs do not.
- CCC4 (4.2) - Students should identify which processes occur in organs that break down food and the associated inputs and outputs of those organs; for example, the mouth begins to break down complex carbohydrates into glucose.

8 · NAVIGATION

MATERIALS: None

Navigate to the student assessment. Present slide J and tell students that, in the next portion of the lesson, they will be presented with different gastrointestinal conditions that could be causing M'Kenna's symptoms. Students will be asked to argue from evidence to eliminate two of the possible conditions as the likely cause. Tell students that, when doctors make diagnoses, they use the same process of eliminating possible conditions.

Have students turn and talk with a neighbor about why they think doctors eliminate possible conditions rather than selecting the condition that best fits the symptoms. Have students share their ideas with the whole class. Make sure to emphasize the idea that eliminating possible conditions can reduce errors or mistakes.

9 · STUDENT ASSESSMENT TASK

MATERIALS: science notebook, Task Parts 1 and 2: Eliminate Possible Conditions and Identify Missing Evidence

Introduce the student assessment. Present slide K and tell students that the assessment will serve two purposes. First, the assessment will serve as evidence of our understanding of the ideas we have developed so far. Second, it will help us make progress on M'Kenna's case as we work to figure out what might be causing her symptoms.

Hand out Task Parts 1 and 2: Eliminate Possible Conditions and Identify Missing Evidence and walk students through the four parts of the assessment. You may wish to present slides L-O as you do so.

Provide time for students to work individually on the assessment. A teacher reference guide for the assessment is provided as the Task Parts 1 and 2: Eliminate Possible Conditions and Identify Missing Evidence Key.

ADDITIONAL GUIDANCE

If your students need to divide their work time into smaller chunks, consider breaking the assessment time into 8-10 minute intervals. Start by presenting slide L. Then provide 8-10 minutes for students to work on part 1 of the assessment task. After 10 minutes, move on to part 2 and slide M.
**ASSESSMENT OPPORTUNITY**

It is important that you do not skip this section! In addition to being an opportunity for assessment, students also make significant progress on figuring out M'Kenna’s case. Students build upon the ideas developed in this student assessment in subsequent lessons. You could have students do this embedded assessment individually or in small groups. There is a part 3 of this assessment that comes after Lesson 8, so students will have another opportunity to demonstrate their understanding.

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**10 · NAVIGATION**

**MATERIALS: 1-2 sticky notes, Driving Question Board**

**Answer questions on the Driving Question Board.** When students have finished the assessment, prompt them to visit the Driving Question Board and read all of the questions. Following the instructions on slide P, students should select one question that they think we have answered. Prompt students to record the question at the top of a new sticky note and then answer the question on the same sticky note. Students should then post the sticky note under the original question on the Driving Question Board.

**SUPPORTING STUDENTS IN MAKING CONNECTIONS IN ELA**

Students write and argument from evidence to explain why the evidence they selected serves as strong evidence that the condition is NOT causing M’Kenna’s symptoms. 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.

Students will be reflecting and adding onto their arguments over the course of several days throughout Lessons 7 and 8. This connects to the Common Core standard: CCSS.ELA-LITERACY.W.6.10: Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.
Lesson-Specific Teacher Materials
### Rubric for 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>Shared a <strong>suggestion</strong> to help improve my peer’s work.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Used evidence from <strong>investigations, observations, activities, or readings</strong> to support the feedback or suggestions I gave.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**One thing that I can do better the next time 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>Read the feedback I received carefully.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asked follow-up questions to better understand the feedback I received.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Said or wrote why I agreed or disagreed with the feedback.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revised my work based on the feedback.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**What is one piece of feedback that you received?**

---

**What did you add or change to address this feedback?**

---

**Giving Feedback**

---

**Receiving Feedback**

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**Lesson 7: Rubric**

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**Unit 7.3 • Lesson 7 • 8/16/19**
Lesson 7: Answer Key 1

Key for Task Parts 1 and 2: Eliminate Possible Conditions and Identify Missing Evidence

The bullet points in red below indicate the important ideas to look for in student responses. They do not indicate a preferred scoring scheme. You can choose how to score or grade the assessment.

Student Assessment

M’Kenna’s doctors brainstormed 5 possible conditions that might account for M’Kenna’s symptoms. Together with a partner, you will work to eliminate 1-2 of these conditions based on all of the evidence you have gathered so far in this unit.

1) Read the information in the chart below, which outlines four different conditions that doctors felt could explain M’Kenna’s symptoms. Write your initial thoughts and ideas in the space below the table.

<table>
<thead>
<tr>
<th>Gastrointestinal Condition</th>
<th>Image of Intestinal Lining</th>
<th>Symptoms</th>
<th>Cause(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diverticular disease</strong></td>
<td><img src="image" alt="" /></td>
<td>Painful abdominal cramps</td>
<td>Diverticula, which can range from pea-sized to much larger, are formed by increased pressure on weakened spots of the intestinal walls by gas, waste, or liquid. Diverticula can form while straining during a bowel movement, such as with constipation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nausea and vomiting</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fever</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chills</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Abdominal tenderness</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Constipation</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diarrhea</td>
<td></td>
</tr>
</tbody>
</table>

Diverticula, which can range from pea-sized to much larger, are formed by increased pressure on weakened spots of the intestinal walls by gas, waste, or liquid. Diverticula can form while straining during a bowel movement, such as with constipation.
If a person has **celiac disease** and eats foods with gluten, the immune system responds by damaging the small intestine. Gluten is a protein found in wheat, rye, and barley.

**Small Intestine**

- Diarrhea
- Bloating
- Gas
- Fatigue
- Weight loss
- Iron-deficiency anemia
- Constipation
- Depression

**Celiac disease** is an immune disease in which people can't eat gluten because it will damage their small intestine. People with this condition have flattened "villi," which are tiny finger-like structures on their small intestine. Villi can only be seen with a high magnification microscope.

**Irritable bowel syndrome (IBS)** is a common disorder that affects the large intestine. Signs and symptoms include cramping, abdominal pain, bloating, gas, and diarrhea or constipation, or both. **IBS** is a chronic condition that needs long-term management.

**Large Intestine**

- Abdominal pain and cramping
- Diarrhea
- Constipation
- Alternating constipation and diarrhea
- Gas and bloating
- Food intolerance
- Fatigue

**IBS** is thought to result from a combination of abnormal gastrointestinal tract movements, increased awareness of bodily functions, and a disruption in the communication between the brain and the gastrointestinal tract. More research is still being done to better understand the causes of IBS.
**Colitis** is a chronic digestive disease characterized by inflammation of the inner lining of the colon. Infection and loss of blood supply in the colon can occur. Colitis affects only the large intestine and only the inside lining.

<table>
<thead>
<tr>
<th>Large Intestine</th>
<th>Not feeling hungry</th>
<th>Weight loss</th>
<th>Fatigue</th>
<th>Dehydration</th>
<th>Joint pain</th>
<th>Canker sores</th>
<th>Eye pain</th>
<th>Anemia</th>
<th>Skin sores</th>
<th>Diarrhea</th>
<th>Rectal bleeding</th>
<th>Abdominal cramping</th>
<th>Frequent and immediate need to empty the bowels</th>
</tr>
</thead>
</table>

**Crohn's disease** is a chronic inflammation of the digestive tract, primarily the small intestine. The chronic disease means sometimes people feel well and sometimes people do not notice symptoms at all.

<table>
<thead>
<tr>
<th>Small Intestine</th>
<th>Persistent diarrhea</th>
<th>Rectal bleeding</th>
<th>Urgent need to move bowels</th>
<th>Abdominal cramps and pain</th>
<th>Fever</th>
<th>Loss of appetite</th>
<th>Weight loss</th>
<th>Fatigue</th>
<th>Night sweats</th>
</tr>
</thead>
</table>

**Colitis** is an inflammatory bowel disease that causes long-lasting inflammation and ulcers or sores in the digestive tract. One type of colitis affects the innermost lining of the large intestine and rectum. Symptoms usually develop over time, rather than suddenly.

**Crohn's disease** is an inflammatory bowel disease. No one knows exactly what causes Crohn's. It may be caused by a malfunctioning immune system, genetics, or environmental factors.
Write your initial ideas about the information in the table here.

- Any initial ideas from students should be accepted here.
- Look for connections between evidence the class has worked with in the unit so far and information in the table.
- You may see students thinking about some possible diseases to eliminate.

2) Gather all of the evidence sources you’ve used so far in this unit and use them to help you eliminate 2 conditions from the table above. Consider gathering the following sources of evidence to complete this task:
   - M’Kenna’s Doctor’s Note, which includes her symptoms
   - M’Kenna’s Endoscopy Images
   - Progress Tracker
   - List additional evidence sources here:
     - Graphs of M’Kenna’s food breakdown versus a healthy person’s food breakdown
     - Information about the small molecules in M’Kenna’s poop

Using the evidence you’ve collected, work with a partner to determine 2 of the conditions in the table that do not match what you believe is causing M’Kenna’s symptoms. Write the condition(s) you identify in the first column of the table below. Then, add any evidence that supports your choice in the second column of the table.

- Students could list any of the conditions here and find possible connections to why that disease might not be causing M’Kenna’s symptoms.
- As long as students are making viable cause-and-effect connections between the evidence and the disease, any answers are fine here.
- One row is completed below to provide an example of what you might be looking for from the students.
<table>
<thead>
<tr>
<th>Condition</th>
<th>Reasons/Evidence this condition <em>could not</em> be what is causing M’Kenna’s symptoms</th>
<th>Why is this evidence that the disease is not causing her symptoms?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colitis</td>
<td>M’Kenna’s Endoscopy Images did not show damage to her large intestine.</td>
<td>Colitis only affects the large intestine, and in an endoscopy image of a colitis patient, you can see the damage. M’Kenna’s large intestine was mostly normal.</td>
</tr>
<tr>
<td></td>
<td>M’Kenna’s Doctor’s Note does not mention joint pain.</td>
<td>Joint pain is a common symptom of colitis. M’Kenna might not have colitis because she does not have this symptom.</td>
</tr>
</tbody>
</table>

**Assessment Task Part 2: Identify Missing Evidence**

3) Now that you have narrowed down the possibilities for what condition(s) could be the cause of M’Kenna’s symptoms, revisit the “Causes” column of the Gastrointestinal Conditions chart above. On your own, brainstorm ideas for what additional evidence you would need to determine which condition is most likely to be the cause of M’Kenna’s symptoms. Write your ideas in the space below. Be ready to share your ideas with the class.

- Any student ideas could be valuable, look for ideas that:
  - connect to the “Causes” section of the chart above,
  - provide information or evidence that the class hasn’t encountered yet, and
  - help to distinguish between the diseases that students have not been able to rule out yet.
1. When we decided to investigate what was happening to food as we digest it, which of M’Kenna’s symptoms were we trying to explain?

1. What have we noticed so far in our investigations?

**INDIVIDUAL** ↔ **WHOLE GROUP**

---

Look at the initial model that you developed to explain M’Kenna’s symptoms. Then think about the investigations that we have done and what we have figured out.

Review all of the models that you developed in your Progress Tracker. If we think of the models from our Progress Trackers as smaller pieces of a larger model, our goal now is to compile the pieces into a larger model to answer: What have we figured out so far?

- Individually, compile all of the models from your Progress Tracker into one model.
- Don’t worry about depicting anything about the organs in the digestive system at this point. Just focus on the breakdown and absorption of large food molecules.

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Develop a Gotta-Have-It Checklist. It lists the important ideas you need to include in your new model to answer the question: How does a healthy digestive system work?

Use pictures, symbols, and words in your model to help represent and further explain the following:

1. What are the different structures in the digestive system? How do the functions of each structure distinguish it from other structures in the digestive system?
2. What happens to food when it enters the digestive system? What kinds of food molecules are broken down? Where are they broken down?
3. What kinds of food molecules are absorbed? Where are they absorbed? What kinds of food molecules are excreted?
Preparing for Consensus Model: Gallery Walk

Examine at least two other small-group models. At each model, do the following:

**TAKE IT**
Write down an idea from the model that you could use to improve your own model.

**LEAVE IT**
Write one sentence to respectfully criticize or suggest an idea in the model.

Take this sticky note back to your model. Leave this sticky note on the small-group model.

- Place a dot on the small-group model to show where you think M’Kenna’s digestive system is different.

Preparing for Our Classroom Consensus Model

Return to your own small-group model.
- Attach your “Take It” sticky notes to your own model.
- Read all of the sticky notes on your model.
- With your group, jot down notes about things in your model that you want to keep or change when we develop a classroom consensus model.

Developing Our Classroom Consensus Model

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

- How does a healthy digestive system work?
- How is M’Kenna’s digestive system functioning differently than a healthy one?

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

Developing Our Consensus Model: Model Limitations

What are the limitations of our model?

As a class, discuss the following questions:

- Does our model fully explain all the parts of M’Kenna’s digestive system that are functioning differently?
- Does our model fully explain all of M’Kenna’s symptoms?
- What do we still need to figure out?
- What kinds of evidence do we need? (Add these ideas to the “Ideas for Investigations” board.)
Adding to Our Progress Trackers

After your class comes to a consensus, work individually to update your Progress Tracker. Our questions were:
- How does a healthy digestive system work?
- How is M’Kenna’s digestive system functioning differently than a healthy one?

You should list all of the sources of evidence you used to develop your updated model.

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

Navigation

Based on what we know now, what could be causing M’Kenna’s symptoms? In the student assessment, you will be presented with different conditions that could be causing M’Kenna’s symptoms. Your task will be to argue from evidence to eliminate two of the possible conditions as the likely cause.

Turn and Talk

When making a diagnosis, doctors often eliminate possible conditions rather than selecting the condition that best fits the symptoms.

Why do you think doctors eliminate possible conditions rather than selecting the condition that best fits the symptoms?

Student Assessment

Now that you have put together some really important ideas, let’s pause to assess our understanding of the ideas that we have developed thus far.

This assessment will serve two purposes:
1) It will serve as evidence of our understanding of the ideas we have developed thus far.
2) It will help us make progress on M’Kenna’s case as we work to figure out what might be causing her symptoms.

Assessment Task Part 1: Examine Possible Conditions

Read the information in the chart your teacher shared with you. Write your initial ideas about which conditions best explain what is causing M’Kenna’s symptoms.

- Diverticular Disease
- Colitis Disease
- Irritable Bowel Syndrome (IBS)
Assessment Task: Gather Evidence

Look back at
- M’Kenna’s Doctor’s Note
- M’Kenna’s Symptoms List
- M’Kenna’s Endoscopy Images
- Progress Tracker

Use these sources of evidence to help you determine which Gastrointestinal Conditions you can eliminate.

Write your ideas on your handout.
Be sure you can support your ideas with evidence.
Be ready to share your ideas with the class.

Assessment Task: Eliminate Conditions

Using the evidence you’ve collected, determine 2 of the conditions in the table that do not match what you believe is causing M’Kenna’s symptoms.

- Write the condition(s) you identify in the first column of the table.
- Add any evidence that supports your choice in the second column of the table.
- Construct an argument to explain why the evidence you selected serves as strong evidence that the condition is NOT causing M’Kenna’s symptoms.

Assessment Task Part 2: Identify Missing Evidence

- Revisit the “Causes” column of the Gastrointestinal Conditions chart. What additional evidence will you need to decide which of the remaining conditions is likely the cause of M’Kenna’s symptoms?
- Write your ideas for the evidence you still need.

Navigation

When you finish your assessment, visit the Driving Question Board and read all of the questions.

- Select one question that you think we have answered.
- Record the question at the top of a new sticky note.
- Record your answer, based on evidence, on the same sticky note.
- Post your sticky note under the original question on the DQB.
Lesson 7: What is the function of the digestive system, and how is M’Kenna’s digestive system different?

Navigation

Review M’Kenna’s symptoms and the investigations we have completed thus far to figure out how M’Kenna can experience symptoms in so many different parts of her body.

Turn and talk

1. Open your science notebook to the page where you have M’Kenna’s Doctor’s Note with her symptoms.
2. Turn and talk with a partner about the following questions:
   - When we decided to investigate what was happening to food as we digest it, which of M’Kenna’s symptoms were we trying to explain?
   - What have we noticed so far in our investigations?

What Can We Explain Now?

In your notebook

3. Obtain a copy of Compiled Models from Progress Tracker.
4. Compile all of the models from your Progress Tracker into a larger model.
   - Focus on the breakdown and absorption of large food molecules.
5. Record questions that come to mind as you are reviewing your model.

Gotta-Have-It Checklist

Think carefully about what to include in your model. To do so, create a Gotta-Have-It Checklist. For the Gotta-Have-It Checklist, decide which ideas from the Progress Trackers are the most important for explaining how a healthy digestive system works.

In your notebook

6. Obtain Gotta-Have-It Checklist and attach it to your science notebook.
7. Work on your own to develop a Gotta-Have-It Checklist.
   - Locate your Progress Trackers in your science notebook.
   - Decide which ideas from your Progress Trackers are the most important for explaining how a healthy digestive system works.
8. Answer the question, “How does a healthy digestive system work?”
Develop Models in Small Groups

With a partner

9. Turn and talk to a partner about the following questions:
   - What are the different structures in the digestive system? How do the functions of each structure distinguish it from other structures in the digestive system?
   - What happens to food when it enters the digestive system? What kinds of food molecules are broken down? Where are they broken down?
   - What kinds of food molecules are absorbed? Where are they absorbed? What kinds of food molecules are excreted?

10. Use pictures, symbols, and words in your model.

11. Record questions that come to mind as you are constructing your model.

Preparing for Consensus Model: Gallery Walk

With a partner

12. Examine at least two other small-group models.

13. At each model, do the following:
   - Write down an idea from the model that you could use to improve your own model.
   - Write one sentence to respectfully critique one input, process, or output in the model.
   - Write a second sentence to cite the evidence from our investigations to support your critique.

14. Brainstorm parts of M’Kenna’s digestive system that you think may be functioning abnormally.

Preparing for our Classroom Consensus Model

With a partner

15. Return to your own model.
   - Place your “Take It” sticky notes on your model.
   - Read through all of the notes on your model.
   - With your group, jot down notes about things in your model that you want to keep or change when we develop a class consensus model.

16. Record questions that come to mind as you are reviewing your model.

Developing our Classroom Consensus Model

With your class

17. Gather in a Scientists Circle and place your small-group posters in the middle of the circle.
   - Develop a consensus model to answer the questions:
     - How does a healthy digestive system work?
     - How is M’Kenna’s digestive system functioning differently than a healthy one?

18. As you develop the consensus model, consider the following questions:
   - What ideas should we include?
   - How should we represent them?
   - Do we have evidence to support them?
Developing Our Consensus Model: Model Limitations

With your class 19. Work with your class to answer the questions:

- Does our model fully explain all the parts of M'Kenna's digestive system that are functioning differently?
- Does our model fully explain all of M'Kenna's symptoms?
- What do we still need to figure out?
- What kinds of evidence do we need?
- Add these ideas to the “Ideas for Investigations” board.

Adding to Our Progress Trackers

In your notebook 20. Obtain a copy of Progress Tracker.

21. Think about the following questions as you individually update your Progress Tracker.

- How does a healthy digestive system work?
- How is M'Kenna’s digestive system functioning differently than a healthy one?

22. List all of the sources of evidence you used to develop your updated model.

Navigation

In the student assessment, you will be presented with different conditions that could be causing M'Kenna's symptoms. Your task will be to argue from evidence to eliminate two of the possible conditions as the likely cause.

With a partner 23. Turn and talk to a partner about the following question:

- Why do you think doctors eliminate possible conditions rather than selecting the condition that best fits the symptoms?

24. Be prepared to share your thoughts with the whole class.

Student Assessment

Now that you have put together some really important ideas, let's pause to assess our understanding of the ideas that we have developed thus far.

Check your learning 25. Think about the purposes for this assessment.

- It will serve as evidence of our understanding of the ideas we develop thus far.
- It will help us make progress on M’Kenna’s case as we work to figure out what might be causing her symptoms.

Assessment Task Part 1: Eliminate Possible Conditions

Check your learning 26. Obtain a copy of Task Parts 1 and 2: Eliminate Possible Conditions and Identify Missing Evidence.

27. Work on the assessment following the directions of your teacher.
Assessment Task Part 2: Identify Missing Evidence

Check your learning

28. Revisit the “Causes” column of the Gastrointestinal Conditions chart.
   - What additional evidence will you need to decide which of the remaining conditions is likely the cause of M’Kenna’s symptoms?

29. Write your ideas for the evidence you still need.

30. Be ready to share your ideas with the class.

Navigation

On your own

31. When you finish your assessment, visit the Driving Question Board and read all of the questions.
   - Select one question that you think we have answered.
   - Record the question at the top of a new sticky note.
   - Record your answer, based on evidence, on the same sticky note.
   - Post your sticky note under the original question on the DQB.
Compiled Models from Progress Tracker

Review your Progress Tracker. Compile all of the models that you have developed so far in your Progress Tracker into one model to answer: What have you figured out so far?

Use pictures, symbols, and words to try to explain the key ideas in your models.

- Record questions that you have if you become stuck.
Revised Model (optional)

Build a revised model to explain the following question:
How does a healthy digestive system work?

- Use pictures, symbols, and words to explain how a healthy digestive system works.
- Record questions that you have if you become stuck.
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:

- How does a healthy digestive system work?

<table>
<thead>
<tr>
<th>What our model needs to have to answer the question, “How does a healthy digestive system work?”</th>
<th>Check off pieces of the model as you use them.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Used</td>
</tr>
<tr>
<td>2.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td></td>
</tr>
</tbody>
</table>
Use your checklist to make a new model for answering the question, “How does a healthy digestive system work?” 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 “Did not use” column.
<table>
<thead>
<tr>
<th>Question</th>
<th>Source of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>What we figured out in words/pictures</th>
<th>What we figured out in words/pictures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Task Parts 1 and 2: Eliminate Possible Conditions and Identify Missing Evidence

M’Kenna’s doctors brainstormed 5 possible conditions that might account for M’Kenna’s symptoms. You will work to eliminate 1-2 of these conditions based on all of the evidence you have gathered so far in this unit.

1. Read the information in the chart below, which outlines five different conditions that doctors felt could explain M’Kenna’s symptoms. Write your initial thoughts and ideas in the space below the table.

<table>
<thead>
<tr>
<th>Gastrointestinal Condition</th>
<th>Image of Intestinal Lining</th>
<th>Symptoms</th>
<th>Cause(s)</th>
</tr>
</thead>
</table>
**Diverticular disease** is the general name for a common condition that causes small bulges or sacs to form in the wall of the large intestine. Although these sacs can form anywhere in the colon, they are most common in the part of the large intestine closest to the rectum.

<table>
<thead>
<tr>
<th>Large Intestine</th>
<th>Diverticula, which can range from pea-sized to much larger, are formed by increased pressure on weakened spots of the intestinal walls by gas, waste, or liquid. Diverticula can form while straining during a bowel movement, such as with constipation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Painful abdominal cramps</td>
<td>Nausea and vomiting</td>
</tr>
<tr>
<td>Fever</td>
<td>Chills</td>
</tr>
<tr>
<td>Abdominal tenderness</td>
<td>Constipation</td>
</tr>
<tr>
<td>Diarrhea</td>
<td></td>
</tr>
</tbody>
</table>

**MAC 06**
<table>
<thead>
<tr>
<th>If a person has <strong>celiac disease</strong> and eats foods with gluten, the immune system responds by damaging the small intestine. Gluten is a protein found in wheat, rye, and barley.</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Digestive System" /></td>
</tr>
<tr>
<td><strong>Small Intestine</strong></td>
</tr>
</tbody>
</table>
| *Diarrhea*  
*Bloating*  
*Gas*  
*Fatigue*  
*Weight loss*  
*Iron-deficiency anemia*  
*Constipation*  
*Depression* |
| **Celiac disease** is an immune disease in which people can’t eat gluten because it will damage their small intestine. It affects both males and females. People with this condition have flattened “villi,” which are tiny finger-like structures on their small intestine. Villi can only be seen with a high magnification microscope. |

<table>
<thead>
<tr>
<th>Irritable bowel syndrome (IBS) is a common disorder that affects the large intestine. Signs and symptoms include cramping, abdominal pain, bloating, gas, and diarrhea or constipation, or both. IBS is a chronic condition that needs long-term management.</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image2.png" alt="Digestive System" /></td>
</tr>
<tr>
<td><strong>Large Intestine</strong></td>
</tr>
</tbody>
</table>
| *Abdominal pain and cramping*  
*Diarrhea*  
*Constipation*  
*Alternating constipation and diarrhea*  
*Gas and bloating*  
*Food intolerance*  
*Fatigue* |
| **IBS** is thought to result from a combination of abnormal gastrointestinal tract movements, increased awareness of bodily functions, and a disruption in the communication between the brain and the gastrointestinal tract. More research is still being done to better understand the cause of IBS. |
**Colitis** is a chronic digestive disease characterized by inflammation of the inner lining of the colon. Infection and loss of blood supply in the colon can occur. Colitis affects only the large intestine and only the inside lining.

<table>
<thead>
<tr>
<th>Large Intestine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not feeling hungry</td>
</tr>
<tr>
<td>Weight loss</td>
</tr>
<tr>
<td>Fatigue</td>
</tr>
<tr>
<td>Dehydration</td>
</tr>
<tr>
<td>Joint pain</td>
</tr>
<tr>
<td>Canker sores</td>
</tr>
<tr>
<td>Eye pain</td>
</tr>
<tr>
<td>Anemia</td>
</tr>
<tr>
<td>Skin sores</td>
</tr>
<tr>
<td>Diarrhea</td>
</tr>
<tr>
<td>Rectal bleeding</td>
</tr>
<tr>
<td>Abdominal cramping</td>
</tr>
<tr>
<td>Frequent and immediate need to empty the bowels</td>
</tr>
</tbody>
</table>

**Colitis** is an inflammatory bowel disease that causes long-lasting inflammation and ulcers or sores in the digestive tract. One type of colitis affects the innermost lining of the large intestine and rectum. Symptoms usually develop over time, rather than suddenly.

**Crohn's disease** is a chronic inflammation of the digestive tract, primarily the small intestine. The chronic disease means that sometimes people feel well and sometimes people do not notice symptoms at all.

<table>
<thead>
<tr>
<th>Small Intestine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persistent diarrhea</td>
</tr>
<tr>
<td>Rectal bleeding</td>
</tr>
<tr>
<td>Urgent need to move bowels</td>
</tr>
<tr>
<td>Abdominal cramps and pain</td>
</tr>
<tr>
<td>Fever</td>
</tr>
<tr>
<td>Loss of appetite</td>
</tr>
<tr>
<td>Weight loss</td>
</tr>
<tr>
<td>Fatigue</td>
</tr>
<tr>
<td>Night sweats</td>
</tr>
</tbody>
</table>

**Crohn's disease** is an inflammatory bowel disease. No one knows exactly what causes Crohn's. It may be caused by a malfunctioning immune system, genetics, or environmental factors.
Write your initial ideas about the information in the table here.

2) Gather all of the evidence sources you've used so far in this unit and use them to help you eliminate 2 conditions from the table above. Consider gathering the following sources of evidence to complete this task:

- M’Kenna’s Doctor’s Note, which includes her symptoms
- M’Kenna’s Endoscopy Images
- Progress Tracker
- Updated Model
- List additional evidence sources here:
3) Using the evidence you’ve collected, determine 2 of the conditions in the table that do not match what you believe is causing M’Kenna’s symptoms. Write the condition(s) you identify in the first column of the table below. Then, add any evidence that supports your choice in the second column of the table. Finally, construct an argument to explain why the evidence you have selected serves as strong evidence that the condition is not causing M’Kenna’s symptoms.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Reasons/Evidence this condition <strong>could not</strong> be what is causing M’Kenna’s symptoms</th>
<th>Why is this evidence that the disease is not causing her symptoms?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
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<td></td>
</tr>
</tbody>
</table>

**Assessment Task Part 2: Identify Missing Evidence**

4) Now that you have narrowed down the possibilities for what condition(s) could be the cause of M’Kenna’s symptoms, revisit the “Causes” column of the Gastrointestinal Conditions chart above. Brainstorm ideas for what additional evidence you would need to determine which condition is most likely to be the cause of M’Kenna’s symptoms. Write your ideas in the space below or on the back of this page. Be ready to share your ideas with the class.
**LESSON 8: What does the surface of M'Kenna's small intestine look like up close compared with a healthy one?**

**PREVIOUS LESSON**
We developed models to answer the questions, “How does a healthy digestive system work?” and “How is M'Kenna's digestive system functioning differently than a healthy one?” We were presented with four conditions that could be causing M'Kenna's symptoms. Then, we developed arguments, based on evidence, to eliminate two of the possible conditions. We considered what types of additional data we would need to determine the cause of M'Kenna's symptoms.

**THIS LESSON INVESTIGATION**
We decide to zoom in on the small intestine to better understand its structures and functions. First, we take stock of where we are in the body by mapping M'Kenna's systems to the general organization of the human body systems. We identify a structure called villi that line the small intestine, complete an interactive simulation to gather data, and analyze the results to learn that taller villi have more cells, so they are able to allow for a higher rate of absorption. M'Kenna's villi are flat, so they don't allow for the same amount of absorption as in a healthy system, which explains why she has food molecules in her large intestine that are different from a healthy person.

**NEXT LESSON**
We will revisit the Driving Question Board (DQB) to see our progress and reorganize questions into clusters related to body systems. We will look at M'Kenna's symptoms in other systems, and add these questions to our DQB: “How can a problem in one body system cause problems in other systems?” and “How are these different systems connected?”

**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 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.
- Analyze and interpret data to identify the relationship that taller villi (structure) have more cells that work together to impact the rate of absorption (function) of food molecules into the bloodstream.

**WHAT STUDENTS WILL 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.
<table>
<thead>
<tr>
<th>Part</th>
<th>Duration</th>
<th>Summary</th>
<th>Slide</th>
<th>Materials</th>
</tr>
</thead>
</table>
| 1    | 3 min    | **NAVIGATION**  
Remind students of their conclusion from Lesson 7 that they needed to collect more evidence about M'Kenna's symptoms to determine which of the possible diagnoses might be causing her symptoms. | A     |                                                                                               |
| 2    | 8 min    | **MAP M'KENNA'S SYSTEM TO THE ORGANIZATION OF THE HUMAN BODY SYSTEM**  
As a class, create a visual map that connects M'Kenna's specific example to the general organization of the human body system. | B     | Zoomed-In Images of the Small Intestine, chart paper, markers                                |
| 3    | 8 min    | **EXAMINE THE LINING OF THE SMALL INTESTINE**  
As a class, zoom into the lining of a healthy small intestine and discover that the finger-like structures, or villi, that line the small intestine are actually made up of cells. | C-D   | Zoomed-In Images of the Small Intestine, chart paper from previous step, markers               |
| 4    | 20 min   | **EXAMINE THE FUNCTION OF THE VILLI**  
| 5    | 12 min   | **CONSENSUS BUILDING DISCUSSION ABOUT THE STRUCTURE AND FUNCTION OF THE SMALL INTESTINE**  
As a class, have a Consensus Building Discussion about what we've figured out so far about the structures of the small intestine and their functions. | G     | Connecting the Structure of Villi to Their Function                                           |
| 6    | 5 min    | **UPDATE THE 3-COLUMN PROGRESS TRACKER**  
Students independently use what they have figured out so far in this lesson to update their 3-column Progress Trackers. | H     | Progress Tracker, Progress Tracker                                                           |
| 7    | 15 min   | **ARGUE FROM EVIDENCE: DIAGNOSTIC TASK**  
Complete Part 3: Argue from Evidence What's Causing M'Kenna's Symptoms, which was started in Lesson 7. Argue from evidence which diagnosis (Celiac) best explains why M'Kenna is experiencing her symptoms. | I     | Part 3: Argue from Evidence What's Causing M'Kenna's Symptoms, Peer Feedback Guidelines, Self-Assessment: Giving and Receiving Feedback |
| 8    | 5 min    | **REVISIT THE DRIVING QUESTION BOARD**  
Revisit the Driving Question Board in partners, noting questions on which we've made progress and providing evidence to support those answers. Identify questions that have not yet been answered as possible next steps. | J     | Let's Answer Questions from Our DQB!                                                        |

End of day 1

End of day 2
<table>
<thead>
<tr>
<th>Lesson materials</th>
<th>per student</th>
<th>per group</th>
<th>per class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zoomed-In Images of the Small Intestine</td>
<td>• science notebook</td>
<td>• access to internet-enabled computer devices to run the NetLogo simulation</td>
<td>• chart paper</td>
</tr>
<tr>
<td>science notebook</td>
<td>• <a href="http://bit.ly/tour-digestive-system">http://bit.ly/tour-digestive-system</a></td>
<td></td>
<td>• markers</td>
</tr>
<tr>
<td><a href="https://openscied.org/villi-absorption/">https://openscied.org/villi-absorption/</a></td>
<td>• Connecting the Structure of Villi to Their Function</td>
<td></td>
<td>• chart paper from previous step</td>
</tr>
<tr>
<td>Progress Tracker</td>
<td>• Part 3: Argue from Evidence What's Causing M'Kenna's Symptoms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Progress Tracker</td>
<td>• Peer Feedback Guidelines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-Assessment: Giving and Receiving Feedback</td>
<td>• Let's Answer Questions from Our DQB!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Materials preparation (20 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.

Fill in the handout Let's Answer Questions from Our DQB! with questions from your class' Driving Question Board.

Test to make sure the simulation students will be using is working, following the directions in the student handout: Connecting the Structure of Villi to Their Function.
Lesson 8 • Where We Are Going and NOT Going

Where We Are Going

This lesson provides a key link in the storyline that connects back to Lessons 2-6 as students see that the structure of M’Kenna’s small intestine is the underlying cause for pieces of evidence that the class has collected, such as small food molecules in her stool, and lack of absorption in her small intestine. M’Kenna’s small intestine has a major structural difference: It is smooth, but an intestine with proper function has many finger-like folds called “villi” that can only be seen at a microscopic level. In this lesson, students figure out that the folds create more surface area through which small, broken-down food molecules can pass. M’Kenna is absorbing some of those micronutrients but not all of them because her villi are damaged, and she has less surface area in her small intestine than a healthy person.

When students complete the NetLogo interactive simulation, they may explain that the relationship between greater villi height and increased absorption is due to:

- Increased number of food molecule collisions with the small intestine surface.
- Increased amount of time it takes for food molecules to exit the digestive system.
- Increased number of opportunities for food molecules crossing through a pore/hole in the small intestine’s surface.
- Increased surface area in contact with the food molecules.

Any/all of these ideas are useful in helping establish a mechanism related to structural differences in the organ that affect the flow of matter into the circulatory system.

Where We Are NOT Going

A distinction between villi and microvilli is not made in this lesson, though microvilli can be seen in some of the photographs on the slides. This unit does not have a focus on cells, and instruction about the cellular membrane is not addressed. Therefore, stopping with “villi” is sufficient here. It is assumed that students come in with background knowledge of cells and cell membranes.

This lesson builds on DCI elements from LS1.A that students should have previously developed:

- All living things are made up of cells.
- Cell membranes are a boundary that controls what enters and leaves the cell.

These DCI elements would have been built by working on the following NGSS performance expectations in sixth grade (PEs)—MS-LS1-1, MS-LS1-2—and will not be developed here.
LEARNING PLAN for LESSON 8

1 · NAVIGATION

MATERIALS: None

Revisit what we figured out from the Task Parts 1 and 2: Eliminate Possible Conditions and Identify Missing Evidence in L7. Remind students that, in the last lesson, they were presented with four possible diagnoses that could potentially explain why M’Kenna was experiencing digestive symptoms. Show slide A.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>What evidence were we missing that would help us determine which of these diagnoses was most likely causing M’Kenna’s symptoms?</td>
<td>We needed more information about M’Kenna’s symptoms. Last class, we came up with several new pieces of evidence we could collect. Our teacher has more information about M’Kenna’s small intestine, so we can look more into that. If her small intestine shows inflammation, that would be an indication of Crohn’s disease. If her small intestine shows that her “villi” are flat (whatever those are...), that would be an indication that she has Celiac disease. We aren’t sure what “villi” are.</td>
</tr>
</tbody>
</table>

2 · MAP M’KENNA’S SYSTEM TO THE ORGANIZATION OF THE HUMAN BODY SYSTEM

MATERIALS: Zoomed-In Images of the Small Intestine, science notebook, chart paper, markers

Pause to consider how the small intestine fits into the larger digestive system. Post a blank piece of chart paper.

Say, If we are going to zoom in on the small intestine, maybe we should pause to orient ourselves as to where we are in M’Kenna’s body.

On the top of the chart paper, write “M’Kenna’s Body” and “System” next to it. Say, We know that we started with M’Kenna’s whole body. According to our definition of “system” on our word wall, we know that the body itself is a system.

Below that, on the next line, write “Digestive System,” saying, Then, we connected some of her symptoms to another system, the digestive system. Because this is a system within a system, we call it a subsystem.

Below that, on the next line, write, “Small Intestine.” Remind students of what they previously discussed about wanting to zoom in on the small intestine to better understand what might be happening with those villi that they read about. Referring to the definition for the word “organ” on the word wall, write “Organ” next to “Small Intestine.”

Zoom in on the small intestine and jot noticings and wonderings. Hand out page one of Zoomed-In Images of the Small Intestine or use the images on slide B. Now, say, So, as a class, we decided that we wanted to zoom into the small intestine of a healthy person and M’Kenna to see if we can figure anything out about these villi structures we read about. Let’s examine the first two images. We first looked at the interior of a healthy small intestine and M’Kenna’s small intestine when we examined her endoscopy results in Lesson 2. Now we want to zoom in even closer to see what’s happening on the surface of the small intestine.

Zoom in on the small intestine and jot noticings and wonderings. Hand out page one of Zoomed-In Images of the Small Intestine or use the images on slide B. Now, say, So, as a class, we decided that we wanted to zoom into the small intestine of a healthy person and M’Kenna to see if we can figure anything out about these villi structures we read about. Let’s examine the first two images. We first looked at the interior of a healthy small intestine and M’Kenna’s small intestine when we examined her endoscopy results in Lesson 2. Now we want to zoom in even closer to see what’s happening on the surface of the small intestine.

Instruct students to work with a partner to examine the images on page one of Zoomed-In Images of the Small Intestine. As they look closely at the images, have students create a Notice and Wonder Chart in their science notebooks. Students should make a note of anything they notice in the images that catch their attention and any questions they have about what they see. Students can refer back to Analyzing Endoscopy Images in their science notebooks as a comparison to what they first observed about the differences between a healthy small intestine and M’Kenna’s.

ATTENDING TO EQUITY

The term “organ” should have been added to the word wall at the end of Lesson 2 with a definition of “structure inside the body.” In Lesson 4, students built upon their understanding of this term when they learn that an organ is a subsystem of a body system. In this case, the small intestine is a subsystem of the digestive system.

SUPPORTING STUDENTS IN DEVELOPING AND USING STRUCTURE AND FUNCTION

As students make observations about the photos, draw their attention to the structures they notice that make up parts of the lining of the small intestine. Encourage students to make their observations through the lens of structure/function relationships. To deepen students’ connection of the structures they’re observing with the functions that they might serve, pose the following question.

openscied.org
Reconvene students and use the prompts on slide B to guide them to zoom into the next level of subsystems.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>These images show one view of the lining of the small intestine. What structures did you notice in the images?</td>
<td>There are these finger-like structures growing out of the lining of the small intestine.</td>
</tr>
<tr>
<td>What information are you able to gather about the function of these structures?</td>
<td>We don’t know. We don’t have evidence that tells us about the function.</td>
</tr>
<tr>
<td>What would you need in order to be able to understand the function of these finger-like structures? Were you able to get a good view of the villi?</td>
<td>We couldn’t totally see all the structures, but we could if we were able to zoom in closer! We want to zoom into the lining of the small intestine, so we can examine the finger-like structures up close.</td>
</tr>
</tbody>
</table>

3 · EXAMINE THE LINING OF THE SMALL INTESTINE

MATERIALS: Zoomed-In Images of the Small Intestine, science notebook, chart paper from previous step, markers

Examine the images of the lining of the healthy small intestine and write down noticings and wonderings. Have students examine the micrograph of the small intestine on page two of Zoomed-In Images of the Small Intestine with a partner, recording what they notice and wonder in their science notebooks. Then, ask students to share out their noticings about the structures they see and highlight responses that indicate that students can see finger-like structures.

Show slide C.

Say to students, We can call these finger-like structures “villi.” Let’s add this to our word wall.

Add “Villi” to the systems mapping chart. Add the word “Villi” to the next line of the systems chart you started earlier, leaving the systems label blank for now. Return to sharing out what students notice and wonder about the villi. Listen for students who share that they can see smaller structures on the villi. Prompt students to ask to zoom in even closer on the villi, saying, Oh that’s interesting. What do you think we should do next?

Zoom in and examine the micrograph of the lining of a healthy small intestine. Once students have indicated that they would like to zoom in to see a close-up view of the surface of the villi, have them turn to page three of Zoomed-In Images of the Small Intestine. Explain that this image zooms in on the micrograph, or a photograph from a microscope, that shows a thin slice of the surface of a healthy small intestine that they examined earlier. Again, give partners two minutes to jot what they notice and wonder, then ask the class to share out their noticings. Listen for students who notice that there are smaller structures that make up the villi. When you hear this, pause the sharing to add to your systems mapping chart.

Show slide D.

Say, Let’s pause for a second to think about what we just saw. We agreed at the beginning of this lesson that we wanted to zoom in on the small intestine, an organ of the digestive system, to figure out what might be going on that could help us figure out which diagnosis best explains M’Kenna’s symptoms. We found that there appeared to be smaller structures in the lining of the small intestine, so we zoomed in on that and found even smaller structures.

✱ ATTENDING TO EQUITY

When new scientific words, like “villi,” are introduced, it can be helpful for Emergent Multilingual students to see a reference to those words added to a word wall. Add these words to the word wall as they emerge in the discussion, rather than before.

[Image of a hand-drawn diagram showing villi and small intestine lining]
**Suggested prompt**

<table>
<thead>
<tr>
<th>Question</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you notice about the structure of the micrograph of the small intestine?</td>
<td>It has smaller structures on it that are all lined up one next to the other.</td>
</tr>
<tr>
<td>Have we seen similar structures before?</td>
<td>Yes - we saw similar structures in a previous unit.</td>
</tr>
<tr>
<td>What do you think we could call those smaller structures lining the small intestine?</td>
<td>They look like the cells we've seen in the past, so we think we could call these cells, too!</td>
</tr>
</tbody>
</table>

**Add to the systems mapping chart.** Write “Cells of the Small Intestine” under “Villi” on your systems mapping chart, leaving the systems label blank.

Say, You mentioned that the cells look like they’re lined up next to one another. When scientists see cells that form particular structures like this, they call those structures “tissues.”

Add the word “Cells” and “Tissues” to the systems mapping chart.

Say, We just organized some really important information. Now we can see how the digestive system is made up of other, smaller parts, and those parts are made of other parts! The digestive system is a subsystem of the human body, but the parts of the digestive system are also subsystems. Each part of the digestive system has components that work together to complete a task, making each part a subsystem.

We had other body systems that we looked at in Lesson 1. What were some of those systems? As we figure out more about M’Kenna’s other symptoms, let’s look for the same organization of those other body systems.

We know that our body systems are organized into parts, each of which is a subsystem. Let’s zoom into one of those subsystems to see if we can better understand what’s happening in M’Kenna’s digestive system.

*ATTENDING TO EQUITY*

When new scientific words, like “cells” or “tissues,” are introduced, it can be helpful for Emergent Multilingual students to see a reference to those words added to a word wall. Add these words to the word wall as they emerge in the discussion, rather than before.
4 · EXAMINE THE FUNCTION OF THE VILLI


Review what we know about M’Kenna’s small intestine. Use the following prompts to help students recall what they know about M’Kenna’s small intestine from looking at her endoscopy images compared with the images from a healthy small intestine. Students can go back to the computer simulation http://bit.ly/tour-digestive-system to view the images. Give students five minutes to examine the images independently, so they can jot what they notice and wonder in their science notebooks if they wish. Use the following prompts to motivate the use of https://openscied.org/villi-absorption/ to understand how the height of the villi affects absorption of food molecules in the small intestine.

Show slide E.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>What did you notice about the images of M’Kenna’s small intestine as compared with the images of a healthy small intestine from Lesson 2? How do you think this relates to what we just saw?</td>
<td>M’Kenna’s small intestine lining is smoother, with fewer ridges than the healthy small intestine. We think those ridges might be the villi we were looking at before.</td>
</tr>
<tr>
<td>We’ve done a thorough examination of the structures inside a healthy small intestine. In Lesson 3 we worked with dialysis tubing and figured out something about what the small intestine is supposed to do. What did we figure out?</td>
<td>So we learned that the walls of the small intestine let some small food molecules through, but big ones don’t go through.</td>
</tr>
<tr>
<td>So, do you think the villi could have anything to do with that?</td>
<td>I’m not sure, maybe?</td>
</tr>
<tr>
<td>Think about the images of a healthy small intestine lining and the villi that we examined. If we were to look at a micrograph of M’Kenna’s tissue, what do you predict we would observe?</td>
<td>In the healthy small intestine, we saw finger-like structures that we called villi. Then we zoomed in and saw that those villi were made up of individual cells smooshed together. We think M’Kenna’s small intestine will have villi that are more flat or smooth. Maybe it would have fewer villi or none at all.</td>
</tr>
<tr>
<td>What else would we need to know about the villi? What would you like to see the villi doing to help us understand how not having them impacts M’Kenna?</td>
<td>We need to know how the villi function. Like, if we could see how they interact with food, that could help us. We could compare the function of a healthy small intestine with M’Kenna’s small intestine to see if there are any differences.</td>
</tr>
</tbody>
</table>

Connect what we figured out about the structure of the villi to its function. Help students transition to thinking about the function of the villi and their role in absorbing food molecules into the bloodstream by having them talk to a partner about the following.

Say, I have a simulation that might help us to answer that question about how villi structure affects their function. Show slide F.

Run the NetLogo interactive simulation. Hand out Connecting the Structure of Villi to Their Function. Guide students through the instructions for loading the simulation and adjusting the settings of it. Before they begin their trials, instruct students to create a data table in the space provided in the handout where they should keep track of the following data points for each simulation:

- Villi Height
- Number of Cells present (students should count these on their screens)
- Percentage of food absorbed into the blood

Students are not given templates for the creation of data tables or graphs in Connecting the Structure of Villi to Their Function, so they will have to draw upon prior knowledge of how to construct these to complete the task. Some students may struggle to initiate this task because they cannot recall a visual of what their data table might look like. For those students who are struggling to construct an organized data table, gather them in a small group and work together to co-construct a template for collecting data.

Talk through each data point that students must collect as they run trials in the NetLogo interactive simulation so that you are sure students understand how and what to collect. As a group, determine the number of columns that will be needed and what labels are appropriate.

Once students have completed their trials and collected their data, look for students who are struggling to convert their data tables into graphs. In a similar fashion, invite struggling students into a small group. Discuss as a group what labels are appropriate for the x- and y-axes, then discuss a scale that makes sense. You can use a sample data point to model how to plot a point on the graph, then have students complete the graphing independently at the table. Observe and support as needed.

SUPPORTING STUDENTS IN ENGAGING IN ANALYZING AND INTERPRETING DATA

Students organize and use data collected in the NetLogo simulation to develop a graph showing the relationship between villi height and the rate of food absorption.
Instruct students to run a minimum of three trials, collecting data in their data tables. Then, have students complete the “Graphing Data” portion of Connecting the Structure of Villi to Their Function and answer the questions in the “Making Sense” portion.

End of day 1

5 · CONSENSUS BUILDING DISCUSSION ABOUT THE STRUCTURE AND FUNCTION OF THE SMALL INTESTINE

MATERIALS: science notebook, Connecting the Structure of Villi to Their Function

Come together in a Scientists Circle for a Consensus Building Discussion. Gather the class in a Scientists Circle to help students recall what they’ve figured out so far about the structures of the small intestine and their functions. Students will later use these key ideas when revising their 3-column Progress Trackers.

Instruct students to bring their science notebooks and the results of their data collection and analysis on Connecting the Structure of Villi to Their Function.

Show slide G. As students share, keep track of ideas in a common space on the board or on chart paper.

KEY IDEAS

Purpose of this discussion: In this discussion, students will come to a consensus on what they’ve figured out about the role of the villi in absorption of food molecules into the bloodstream. Together they’ll sort out how they want to revise the models they’ve been working on in their 3-column Progress Trackers.

Listen for these ideas:

- The height of the villi in the small intestine is directly related to the number of cells that allow food molecules to be absorbed into the bloodstream.
- Taller villi mean more cells, which means that there are more doors for food molecules to pass through.
- Absorption is happening in one direction, from inside the small intestine out into the bloodstream, so the dashed line in our consensus model, which implies multi-directional flow, needs to be revised to look more like one-way doors.
- We can assume that M’Kenna’s villi are flat based on evidence from the simulation and the endoscopy images, and, therefore, have fewer cells, or doors, to allow food molecules into the bloodstream. The structure of M’Kenna’s small intestine has a direct impact on her small intestine’s ability to function as a healthy system would.
- M’Kerina likely has food molecules other than fiber and water in her poop because her villi are flat and not allowing for proper absorption of food molecules out of the small intestine and into the bloodstream.

See some example discussion prompts below:

- What are some of the key things we figured out about the structures of the small intestine?
- What are some of the key things we figured out about the functions of those structures?
- How does M’Kenna’s small intestine compare with a healthy system?
- What is the role of the villi? What do the villi have to do with M’Kenna’s symptoms?
Use what we’ve figured out to update the 3-column Progress Tracker. Guide students to use the ideas that were shared during the Consensus Building Discussion to fill in their 3-column Progress Trackers. Show slide H.

Here is one suggested representation.

<table>
<thead>
<tr>
<th>Question</th>
<th>Source of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. What does the surface of M'Kenna’s small intestine look like up close compared with a healthy one?</td>
<td>• NetLogo interactive simulation</td>
</tr>
<tr>
<td></td>
<td>• Close-up images of the healthy villi</td>
</tr>
</tbody>
</table>

What I figured out in words/pictures

- The body is organized into systems and subsystems. So, body system > digestive system > small intestine > villi > cells of the small intestine.
- Absorption is happening in one direction, from inside the small intestine out into the bloodstream, so the dashed line in our Consensus Model, which implies multi-directional flow, needs to be revised to look more like one-way doors.
- Villi height is directly related to the number of cells there are to absorb food molecules into the bloodstream. So, taller villi equal more cells, which increases the rate of absorption.
- M'Kenna’s villi are flat, and, therefore, have fewer cells, or doors, to allow food molecules into the bloodstream.
- Healthy villi are finger-like and have more cells to allow more food molecules into the bloodstream.
- M'Kenna likely has food molecules other than fiber and water in her poop because her villi are flat and do not allow for proper absorption of food molecules out of the small intestine and into the bloodstream.
Use science notebooks to argue from evidence for the diagnosis that is most likely causing M’Kenna’s symptoms. Part 3: Argue from Evidence What’s Causing M’Kenna’s Symptoms can be completed independently in class or as home learning.

HOME LEARNING OPPORTUNITY

Students will need to argue from evidence which of the remaining diagnoses best explain why M’Kenna is experiencing her symptoms. Encourage students to use all of the evidence they have collected so far in this unit and their notes from their science notebook to construct their argument. You can choose to have students do this in class or as home learning.

Remind students that a scientific argument presents a claim and supports that claim with multiple points of evidence.

Show slide 1.

Explain to students that, now that they have examined a healthy small intestine and compared it with M’Kenna’s, they should have sufficient evidence to construct an argument for which diagnosis best explains why M’Kenna is experiencing symptoms. Hand out Part 3: Argue from Evidence What’s Causing M’Kenna’s Symptoms.

Say, We have confirmed that there is a structural change in M’Kenna’s digestive system compared with a healthy system. Now that we have sufficient evidence, let’s revisit the Diagnosis Task. You will argue from evidence which diagnosis you think best explains why M’Kenna is experiencing these symptoms. Be sure to include an argument for how you know it is not one of the diagnoses that you did not choose.

It is likely that students will select celiac disease as the disease that best explains M’Kenna’s symptoms due to the reference to villi in the causes column of the Gastrointestinal Conditions table. Students may be tempted to focus solely on this piece of evidence to connect M’Kenna to the diagnosis. Encourage students to also address one or more symptoms that connect M’Kenna to celiac disease to provide stronger evidence to support this claim.

ASSESSMENT OPPORTUNITY

Students are revisiting the assessment they began in Lesson 7 to further narrow the possibilities of which diagnosis most aligns with the evidence that students have collected about M’Kenna’s digestive system so far in this unit. Guide students to use their science notebooks and any class charts as sources of evidence to complete this assessment.

There are scaffolds built into Part 3: Argue from Evidence What’s Causing M’Kenna’s Symptoms, which will help students construct an organized argument that is supported with evidence and reasoning. If you prefer or you feel students are ready, you can remove these scaffolds and ask students to write an argument in a more open-ended fashion.

**SUPPORTING STUDENTS IN THREE-DIMENSIONAL LEARNING**

Students were initially given four diagnoses to choose from that could explain why M’Kenna is having specific symptoms. After narrowing down the diagnoses in Parts 1 and 2 of the Assessment Diagnosis Task, students must now compare the remaining diagnoses to determine which one best explains why M’Kenna is experiencing her symptoms. Students are using the SEP engaging in argument from evidence by using the CCC structure/function to build towards the DCI LS1.A.

After students create an argument for which diagnosis best explains M’Kenna’s symptoms, they compare each other’s arguments and provide feedback that is used to revise their arguments.
To support writing in science, some students may benefit from assistance as they prepare to organize their argument in writing. For those students who struggle with written organization, provide them with a structure built around sentence stems so that they can craft an argument that demonstrates their content knowledge without getting tripped up by organizational challenges.

You may provide something like:

M’Kenna’s symptoms are being caused by ______.

One piece of evidence I collected that supports this is ______. This supports my conclusion because...

Another piece of evidence I collected that supports this is ______. This supports my conclusion because...

I know that M’Kenna does not have _____ because...

Identify similarities and differences between arguments. Put students into groups of 3. Ask students to compare and critique their peers’ arguments based on how well their evidence supports their explanation of which diagnosis fits M’Kenna’s symptoms. Use Peer Feedback Guidelines to support students in giving and receiving feedback. You can choose to have students revise their arguments based on peer critique.

Additionally, students can complete the rubric Self-Assessment: Giving and Receiving Feedback to reflect upon the feedback they give to and receive from peers.

8 · REVISIT THE DRIVING QUESTION BOARD

MATERIALS: science notebook, Let’s Answer Questions from Our DQB!

Take out science notebooks. Instruct students to use the evidence they’ve collected in their science notebooks, along with any artifacts they’ve created as a class, to identify questions from the Driving Question Board on which they’ve made progress. Instruct students to use a highlighter to indicate questions from the list that they’ve made progress toward answering. Then, ask students to choose three questions they should elaborate on what they know so far, supporting their ideas with evidence they’ve collected. This activity can be completed in class with a partner, individually, or as home learning.

HOME LEARNING OPPORTUNITY

Students can complete Let’s Answer Questions from Our DQB! as a home learning task. Remind students to take home their science notebooks so that they have access to a record of the evidence they’ve collected throughout the unit. They will need this to argue from evidence when they select three DQB questions to answer based on what they’ve figured out so far in this unit.

Show slide J. Hand out Let’s Answer Questions from Our DQB!

Say, We’ve figured out some really important things! We’ve figured out what is most likely causing M’Kenna’s symptoms. We need to check back in on our Driving Question Board to see what other questions we’ve answered so far and what questions still remain. This will help us determine where we should go next.
**Additional Lesson 8 Teacher Guidance**

<table>
<thead>
<tr>
<th>SUPPORTING STUDENTS IN MAKING CONNECTIONS IN MATH</th>
</tr>
</thead>
<tbody>
<tr>
<td>This lesson connects to several Common Core Math Standards, while students are using mathematical thinking during the NetLogo Simulation.</td>
</tr>
<tr>
<td><strong>CCSS.MATH.CONTENT.6.NS.C.8</strong> Solve real-world and mathematical problems by graphing points in all four quadrants of the coordinate plane.</td>
</tr>
<tr>
<td><strong>CCSS.MATH.CONTENT.6.RP.A.2</strong> Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship.</td>
</tr>
<tr>
<td><strong>CCSS.MATH.CONTENT.7.SP.C.6</strong> 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.</td>
</tr>
<tr>
<td><strong>CCSS.MATH.CONTENT.7.SP.C.8.C</strong> Design and use a simulation to generate frequencies for compound events.</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>SUPPORTING STUDENTS IN MAKING CONNECTIONS IN ELA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students write and argument from evidence about which diagnosis most aligns with the evidence that students have collected about M'Kenna's digestive system so far in this unit. This connects to the Common Core standard: <strong>CCSS.ELA-LITERACY.WHST.6-8.1.B</strong> Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.</td>
</tr>
</tbody>
</table>

Students have been reflecting and adding onto their arguments over the course of several days throughout Lessons 7 and 8. This connects to the Common Core standard: **CCSS.ELA-LITERACY.W.6.10** Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.
Lesson-Specific Teacher Materials
**Argument Rubric - Part 3 - M’Kenna’s Disease**

**Claim**
- There is a claim that states that M’Kenna has Celiac Disease.

**Justification**

<table>
<thead>
<tr>
<th>Evidence or empirical data supports the claim includes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- M’Kenna’s endoscopy images of her small intestine look differently than the healthy small intestine images</td>
</tr>
<tr>
<td>- Graphs show that M’Kenna is breaking down all large food molecules except for all “other complex carbohydrates”</td>
</tr>
<tr>
<td>- Graphs show M’Kenna has food molecules left in her large intestine and poop, that are not found in a healthy person</td>
</tr>
<tr>
<td>- M’Kenna has flat villi in her small intestine</td>
</tr>
</tbody>
</table>

**Scientific principles or ideas that explain how each piece of evidence supports the claim (reasoning) includes:**

<table>
<thead>
<tr>
<th>Scientific principles or ideas supports the claim includes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Since there are structural differences in the small intestine images, this indicates there could be a difference of M’Kenna’s function of her small intestine</td>
</tr>
<tr>
<td>- Since small molecules are not being absorbed by the small intestine, they continue moving down her digestive tract and end up in her poop</td>
</tr>
<tr>
<td>- The food molecules are being broken down in M’Kenna and in a healthy person because we see large food molecules in the graphs go down and small food molecules go up, but then in M’Kenna they all are not being absorbed because food molecules are still left in her poop and large intestine</td>
</tr>
<tr>
<td>- Flat villi make it more difficult to absorb food so small molecules are left over in the process as food moves through the body. The villi are the cells of the digestive system in the small intestine where food is absorbed. When functioning properly, villi increasing the surface area in the small intestine where small food molecules can be absorbed (structure/function)</td>
</tr>
<tr>
<td>Rebuttal</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>a critique of the evidence of an alternate claim</td>
</tr>
<tr>
<td>Not other diseases because the damage located in the small intestine</td>
</tr>
<tr>
<td>The other small intestine diseases are not caused by damages to the villi structures</td>
</tr>
<tr>
<td>Any other valid critique that relies on evidence</td>
</tr>
<tr>
<td>a critique of the reasoning of an alternate claim</td>
</tr>
<tr>
<td>The disease M’Kenna has must be related to the small intestine because that is where we knew there was damage from the images we examined</td>
</tr>
<tr>
<td>The disease M’Kenna has must be a result of or related to the damage of villi in the small intestine because we know that the damage villi absorb small molecules less efficiently than normal villi which can explain why we see small molecules in M’Kenna’s poop.</td>
</tr>
<tr>
<td>Any other valid critique of reasoning that students propose</td>
</tr>
</tbody>
</table>
Lesson 8: Answer Key

Connecting the Structure of Villi to Their Function

Procedure

1. Use your Chrome browser to go to this website: https://openscied.org/villi-absorption/
2. Adjust the “end-simulation-at” slider to be any value above 2 and keep it at that value for all simulation runs.
3. Adjust the “end-simulation-at” slider to be any value above 2 and keep it at that value for all simulation runs.
4. You can adjust the “villi-height” slider to be any of the values you want to test for villi heights.
5. Press the SETUP/RESET button to initialize the model. The values you want to test for villi heights.
6. Press the GO/PAUSE button to run the model.
7. When the model stops running, record the percentage of food particles absorbed into the blood.
8. Create a data table on the next page to record each of your results.

Repeat steps 5–7 if you want to do more than one trial for this villi height. When you are ready to test a new villi height, go back to step 4, make your changes, and repeat the remaining steps.

In a data table you make below, record the percentage of food particles absorbed into the blood when the model stops running. Repeat the steps to test a new villi height.
Create a data table in the space below, recording the following information for each trial you run:

<table>
<thead>
<tr>
<th>Villi Height</th>
<th># Cells</th>
<th>% Absorbed</th>
<th>Simulation Height</th>
<th>V vill Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.8</td>
<td>119</td>
<td>10</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>28.2</td>
<td>74</td>
<td>5</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>43.6</td>
<td>35</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Create a graph from the data in your data table that shows the relationship between the height of the villi and the percentage of food that is absorbed into the bloodstream.

Percentage of food absorbed into the blood:
- Number of cells present (students should count those on their screens)
- Villi Height

Create a data table in the space below, recording the following information for each trial you run:
1. How did villi height affect the percentage of food particles absorbed into the blood?

As the villi got taller, the percentage of absorption increased. According to the data I gathered, an increase in the number of cells directly resulted in an increase in the rate of absorption. For example, when there were 35 cells, the absorption was 43.6%. But the rate increased to 58.2% when the number of cells increased to 74.

2. In this model, when small food molecules run into a cell membrane, they have a 50% chance of hitting the membrane at a point where there is a door they can pass through. When the villi are taller, the doors are more cells allowing the villus to absorb food molecules to pass through. When the villi are taller, there are more cells allowing the villus to absorb food molecules to pass through. Why would simply changing the shape of the villi cause a change in the percentage of food particles absorbed in a fixed time period?

As the villi got taller, more cells were added, which increased the number of chances food molecules have of passing through a cell. For example, if you had 50 cells and a 50% chance they would allow food molecules to pass through, you could count on about 25 cells allowing food molecules to pass through. When you increase the number of cells to 100 and maintain the 50% chance, you could count on 50 cells allowing food molecules to pass through a cell. For example, if you had 75 cells, you could count on about 37.5 cells allowing food molecules to pass through.

3. Describe the relationship between the height of the villus and the rate of absorption. Use the word “cells” in your description. Cite evidence from your data to support your ideas.

The villi are lined with cells that allow food molecules to pass through. According to the data I gathered, an increase in the number of cells is directly related to an increase in the rate of absorption. For example, when there were 35 cells, the absorption was 43.6%. But the rate increased to 58.2% when the number of cells increased to 74. According to the data I gathered, an increase in the number of cells is directly related to an increase in the rate of absorption.

Making Sense
Lesson 8: Answer Key 2

Part 3: Sample Student Response of What’s Causing M’Kenna’s Symptoms

This document provides a sample student response to the Lesson 8 individual assessment in an unstructured form. We recommend using the argument rubric to assess your students.

1. Claim. The condition that is most likely causing M’Kenna’s symptoms is: Celiac Disease.

2. Write an argument to support your claim. Use your work from Parts 1 and 2 in Lesson 7 and use at least 4 pieces of evidence from the unit so far that support your claim that M’Kenna has the disease you chose and not the other diseases you examined. List each piece of evidence and cite any sources used.

Evidence #1:

How is Evidence #1 connected to M’Kenna and her disease?

How does Evidence #1 help you rule out other diseases in the table?

Evidence #1: This evidence is connected to M’Kenna’s symptoms because... It helps rule out other diseases by showing... 

Sample Student Response

It’s difficult to eliminate diseases based on M’Kenna’s symptoms alone from her doctor’s note. Her symptoms such as diarrhea, fatigue, and weight loss could be caused by several of these diseases. She also has these symptoms such as diarrhea, fatigue, and weight loss could be caused by several of these diseases. Second, we also analyzed several graphs and came to the condition that the small intestine was not absorbing food molecules as a healthy digestive system should. One of the graphs shows that her small intestine looked very different from the graphs of the other diseases we examined. We looked at M’Kenna’s endoscopy images and saw a difference between her small intestine and the others. First, we looked at the endoscopy images of the other diseases we examined. We saw a difference between her small intestine and the other diseases we examined. Second, we looked at the endoscopy images of the other diseases we examined. We saw a difference between her small intestine and the other diseases we examined. 

We also looked at microscopic images of what the small intestine should look like and there are also differences in the image. We compared the microscopic images of M’Kenna’s small intestine and the other diseases we examined. We saw a difference between her small intestine and the other diseases we examined. 

We recommend providing a sample student response to the Lesson 8 individual assessment in an unstructured form.
Discuss as a class:
What evidence were we missing that would help us determine which of these diagnoses was most likely causing M’Kenna’s symptoms?

Map the digestive system using systems thinking

Discuss as a class:
These images show the lining of the small intestine.

1. What structures did you notice in the images?
2. What are you able to tell about the function of these structures?
3. What would you need in order to be able to understand the function of these finger-like structures? Were you able to get a really good view of the structures?

Examine the Lining of the Small Intestine

Micrograph of vili lining the small intestine. By David Litman.

Zoomed-in view of micrograph of vili. Rice University.
Examine the Function of the Villi

Discuss as a class:
What do you notice about the images of M'Kenna’s small intestine as compared to the images of a healthy small intestine?

What have we figured out so far about the way food molecules are absorbed in the small intestine in both a healthy system and in M'Kenna’s?

Think about the images of a healthy small intestine lining and the villi that we examined. If we were to look at a micrograph of M'Kenna’s tissue, what do you predict we would observe?

Consensus Building Discussion

Bring your science notebooks and the results of your data collection and analysis to the Scientists Circle.

◉ What are some of the key things we figured out about the structures of the small intestine?
◉ What are some of the key things we figured out about the functions of those structures?
◉ How does M'Kenna’s small intestine compare to a healthy system?
◉ What is the role of the villi? What do the villi have to do with M'Kenna’s symptoms?

Use a Simulation to Examine the Function of the Villi

1. Use your Chrome browser to go to this website: https://openscied.org/villi-absorption/
2. Adjust the “end-simulation-at” slider to be any value above 12, and keep it at that value for all simulation runs.
3. Adjust the “initial-number-small-food-particles” slider to be any value above 100, and keep it at that value for all simulation runs. You can also adjust the “large-particles” slider if you wish.
4. You can adjust the “villi-height” slider to be any of the values you want to test for villi heights.
5. Press the SETUP/RESET button to initialize the model.
6. Then press the GO/PAUSE button to run the model.
7. When the model stops running, record the percentage of food particles absorbed into the blood in a data table you make below.
8. Repeat steps 5–7 if you want to do more than one trial for this villi height. When you are ready to test a new villi height, go back to step 4, make your changes, and repeat the remaining steps.

Update the 3-Column Progress Tracker

Update the 3-column Progress Tracker in your science notebook.
◉ Use the results of the Consensus Building Discussion.
◉ Use the results of the Netlogo Interactive Simulation.
◉ Use the close-up images of the villi.

Use words and pictures to update your Progress Tracker.
Complete Part 3 of the Assessment Diagnosis Task.

Use everything you've figured out so far in this unit to argue from evidence which diagnosis best explains why M’Kenna is experiencing her symptoms.

Optional: Give peer feedback on your arguments from evidence. Then, assess yourself on giving and receiving feedback using the self-assessment rubric.

Look back at
- Science notebooks
- Progress Trackers
- Class charts

Highlight questions we’ve made progress toward answering.
Then, choose three questions to answer using evidence to support your ideas.

What Questions Have We Made Progress On?

What Questions Have We Made Progress On?

What Questions Have We Made Progress On?
Lesson 8: What does the surface of M’Kenna’s small intestine look like up close compared with a healthy one?

Navigation

With a partner

1. Have a discussion with your class about the following question:
   a. What evidence were we missing that would help us determine which of the diagnoses was most likely causing M’Kenna’s symptoms?

Examine the Small Intestine

Your teacher will show you some images on a projector. These images show the lining of the small intestine.

With your class

2. Have a discussion with your class about the following questions:
   a. What are you able to tell about the function of these structures?
   b. What would you need in order to be able to understand the function of these finger-like structures? Were you able to get a really good view of the structures?

Examine the Lining of the Small Intestine

With a partner

3. Examine the micrograph of the small intestine on page 2 of Zoomed-In Images of the Small Intestine with a partner.

Examine the Function of the Villi

With your class

4. Have a discussion with your class about the following questions:
   a. What do you notice about the images of M’Kenna’s small intestine as compared with the images of a healthy small intestine?
   b. What have we figured out so far about the way food molecules are absorbed in the small intestine in both a healthy system and in M’Kenna’s?
   c. Think about the images of a healthy small intestine lining and the villi that we examined. If we were to look at a micrograph of M’Kenna’s tissue, what do you predict we would observe?
Examine the Function of the Villi With a Simulation

5. Use your Chrome browser to go to this website:
https://openscied.org/villi-absorption/
6. Run the NetLogo interactive simulation.
   a. Use Connecting the Structure of Villi to Their Function as a guide.
   b. Run a minimum of three trials.

Consensus Building Discussion

Bring science notebooks and the results of the data collection and analysis on Connecting the Structure of Villi to Their Function to the Scientists Circle.

7. Come to a consensus on what you've figured out about the role of the villi.
   a. What are some of the key things we figured out about the structures of the small intestine?
   b. What are some of the key things we figured out about the functions of those structures?
   c. How does M'Kenna's small intestine compare with a healthy system?
   d. What is the role of the villi? What do the villi have to do with M'Kenna's symptoms?

Update the 3-Column Progress Tracker

Use words and pictures to update your Progress Tracker.

8. Update the 3-column Progress Tracker in your science notebook.
   a. Use the results of the Consensus Building Discussion.
   b. Use the results of the Netlogo Interactive Simulation.
   c. Use the close-up images of the villi.

Argue from Evidence: Diagnostic Task

   a. Use everything you've figured out so far in this unit to argue from evidence which diagnosis best explains why M'Kenna is experiencing her symptoms.
Revisit the Driving Question Board: What questions have we made progress on?

**With a partner**

10. Take a minute to review your science notebook, Progress Tracker, and class charts to find questions that you have made progress toward answering on our Driving Question Board.
Zoomed-In Images of the Small Intestine

Image of the small intestine. Jose Luis Calvo

Intestinal lining. Used with permission.
Connecting the Structure of Villi to Their Function

Procedure

1. Use your Chrome browser to go to this website: https://openscied.org/villi-absorption/ A simulation will load.

2. Adjust the "end-simulation-at" slider to be any value above 12, and keep it at that value for all simulation runs.

3. Adjust the "initial-#-small-food-particles" slider to be any value above 100, and keep it at that value for all simulation runs. You can also adjust the "large particles" slider if you wish.

4. You can adjust the "villi-height" slider to be any of the values you want to test for villi heights.

5. Press the SETUP/RESET button to initialize the model.

6. Then press the GO/PAUSE button to run the model.

7. When the model stops running, record the percentage of food particles absorbed into the blood in a data table you make below.

Repeat steps 5–7 if you want to do more than one trial for this villi height. When you are ready to test a new villi height, go back to step 4, make your changes, and repeat the remaining steps.

Create a data table on the next page record each of your results.
Data Table  Create a data table in the space below, recording the following information for each trial you run:

- Villi Height
- Number of Cells present (students should count these on their screens)
- Percentage of food absorbed into the blood
**Graphing Data**  Graph your data to show the relationship between the height of the villi and the percentage of food that is absorbed into the bloodstream.

![Graph](image-url)
Making Sense

1. How did villi height affect the percentage of food particles absorbed into the blood?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

2. In this model, when small food molecules run into a cell membrane, they have a 50% chance of hitting the membrane at a spot where there is a door they can pass through. If this is always constant in every simulation run, then why would simply changing the shape of the villi cause a change in the percentage of food particles absorbed in a fixed time period?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

3. Describe the relationship between the height of the villi and the rate of absorption. Use the word “cells” in your description. Cite evidence from your data to support your ideas.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
## Progress Tracker

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

**What we figured out in words/pictures**

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

**What we figured out in words/pictures**
Part 3: Argue from Evidence What’s Causing M’Kenna’s Symptoms

Now that you have gathered more evidence about the structures of the digestive system and their functions, revisit the Gastrointestinal Conditions table below and determine which of the conditions best explains what is causing M’Kenna’s symptoms. Using all of what you’ve figured out in this unit, construct an argument from evidence that you’ve collected that shares a conclusion about which condition you believe is causing M’Kenna’s symptoms and the evidence you have that supports that conclusion.

<table>
<thead>
<tr>
<th>Gastrointestinal Condition</th>
<th>Image of Intestinal Lining</th>
<th>Symptoms</th>
<th>Cause(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diverticular disease</td>
<td><img src="image" alt="Large Intestine" /></td>
<td>Painful abdominal cramps, Nausea and vomiting, Fever, Chills, Abdominal tenderness, Constipation, Diarrhea</td>
<td>Diverticula, which can range from pea-sized to much larger, are formed by increased pressure on weakened spots of the intestinal walls by gas, waste, or liquid. Diverticula can form while straining during a bowel movement, such as with constipation.</td>
</tr>
</tbody>
</table>
If a person has **celiac disease** and eats foods with gluten, their immune system responds by damaging the small intestine. Gluten is a protein found in wheat, rye, and barley.

<table>
<thead>
<tr>
<th>Small Intestine</th>
</tr>
</thead>
</table>

- Diarrhea
- Bloating
- Gas
- Fatigue
- Weight loss
- Iron-Deficiency Anemia
- Constipation
- Depression

**Celiac disease** is an immune disease in which people can’t eat gluten because it will damage their small intestine. It affects both males and females. People with this condition have flattened “villi,” which are tiny finger-like structures, on their small intestine. Villi can only be seen with a high magnification microscope.

<table>
<thead>
<tr>
<th>Large Intestine</th>
</tr>
</thead>
</table>

**Irritable bowel syndrome (IBS)** is a common disorder that affects the large intestine. Signs and symptoms include cramping, abdominal pain, bloating, gas, and diarrhea or constipation, or both. IBS is a chronic condition that needs to be managed long term.

| DrAlexander Mantas & mantasmd.com |

- Abdominal pain and cramping
- Diarrhea
- Constipation
- Alternating constipation and diarrhea
- Gas and bloating
- Food intolerance
- Fatigue

**IBS** is thought to result from a combination of **abnormal gastrointestinal tract movements**, increased awareness of bodily functions, and a disruption in the communication between the brain and the gastrointestinal tract. More research is still being done to better understand the causes of IBS.
**Colitis** is a chronic digestive disease characterized by inflammation of the inner lining of the colon. Infection and loss of blood supply in the colon can occur. Colitis affects only the large intestine and only the inside lining.

<table>
<thead>
<tr>
<th>Not feeling hungry</th>
<th>Weight loss</th>
<th>Fatigue</th>
<th>Dehydration</th>
<th>Joint pain</th>
<th>Canker sores</th>
<th>Eye pain</th>
<th>Anemia</th>
<th>Skin sores</th>
<th>Diarrhea</th>
<th>Rectal bleeding</th>
<th>Abdominal cramps</th>
<th>Frequent and immediate need to empty the bowels</th>
</tr>
</thead>
</table>

Colitis is an inflammatory bowel disease that causes long-lasting inflammation and ulcers or sores in the digestive tract. One type of colitis affects the innermost lining of the large intestine and rectum. Symptoms usually develop over time, rather than suddenly.

**Crohn’s disease** is a chronic inflammation of the digestive tract, primarily the small intestine. This chronic disease means sometimes people feel well and sometimes people do not notice symptoms at all.

<table>
<thead>
<tr>
<th>Persistent diarrhea</th>
<th>Rectal bleeding</th>
<th>Urgent need to move bowels</th>
<th>Abdominal cramps and pain</th>
<th>Fever</th>
<th>Loss of appetite</th>
<th>Weight loss</th>
<th>Fatigue</th>
<th>Night sweats</th>
</tr>
</thead>
</table>

Crohn’s disease is an inflammatory bowel disease. No one knows exactly what causes Crohn’s. It may be caused by a malfunctioning immune system, genetics, or environmental factors.

<table>
<thead>
<tr>
<th>Diagnosis and Management of Crohn’s Disease, 84, No 12</th>
</tr>
</thead>
</table>

---

1. **Claim.** The condition that is most likely causing M’Kenna’s symptoms is:

   ________________________.

2. **Write an argument to support your claim.** Use your work from Parts 1 and 2 in lesson 7 and use at least 4 pieces of evidence from the unit so far that support your claim that M’Kenna has the disease you chose and not the other diseases you examined. List each piece of evidence and answer the questions below.
Evidence #1:

______________________________________________________________

How is Evidence #1 connected to M’Kenna and her disease?

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

How does Evidence #1 help you rule out other diseases in the table?

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

Evidence #2:

______________________________________________________________

How is Evidence #2 connected to M’Kenna and her disease?

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

How does Evidence #2 help you rule out other diseases in the table?

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________
Evidence #3:

How is Evidence #3 connected to M’Kenna and her disease?

How does Evidence #3 help you rule out other diseases in the table?

Evidence #4:

How is Evidence #4 connected to M’Kenna and her disease?

How does Evidence #4 help you rule out other diseases in the table?
Lesson 7 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**

This tool was inspired by the Sticky Note Feedback resource originally developed by Ambitious Science Teaching at: [https://ambitiousscienceteaching.org/sticky-note-student-feedback/](https://ambitiousscienceteaching.org/sticky-note-student-feedback/)

*Feedback needs to be specific and actionable.* That means it needs to be related to science ideas and that you 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 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 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 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.
## Lesson 8 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 <strong>based on the feedback</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What is one piece of feedback you received?

__________________________________________________________________________

What did you add or change to address this feedback?

__________________________________________________________________________
Revisit Questions from Our DQB!

Look through the list of questions from our DQB, and mark which ones you think we've made progress on. Then pick three of the questions you marked and write what you think that answer would be. Extra boxes are provided in case you want to add to this list later in the unit.

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer and Supporting Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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