Metabolic Reactions

Lesson 1-2

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

Metabolic Reactions: Inside Our Bodies

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

Metabolic Reactions: Inside Our Bodies

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UNIT OVERVIEW

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

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

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

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


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

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

Building Toward NGSS Performance Expectations

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

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

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

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

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

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

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

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<th>Lesson Question</th>
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<td><strong>LESSON 1</strong></td>
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<tr>
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| What is going on inside M’Kenna’s body that is making her feel the way she does? | M’Kenna’s Doctor’s Note describes the symptoms in different parts of her body. | 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:  
- 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.  
- We have some ideas for possible investigations we could pursue. | ![Diagram](image) |
| Anchoring Phenomenon |                             |                          |                     |

**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.

<table>
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<th><strong>LESSON 2</strong></th>
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<tr>
<td>2 days</td>
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| 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:  
- The digestive system is made up of different parts called organs. The different organs have similarities and differences in their structures.  
- M’Kenna’s small intestine doesn’t look the same as a healthy one.  
- In a healthy person, many different substances in a graham cracker decrease as they travel through the small intestine.  
- Some substances in M’Kenna’s small intestine decrease, but others do not decrease as much compared to a healthy person. | ![Diagram](image) |

**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?
<table>
<thead>
<tr>
<th>Lesson Question</th>
<th>Phenomena or Design Problem</th>
<th>What we do and figure out</th>
<th>How we represent it</th>
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<tbody>
<tr>
<td><strong>LESSON 3</strong></td>
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| 2 days         |                             | 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). |

![Dialysis tube system of the small intestine allows small but not large molecules to pass through its walls.](image)

**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**   |                             | 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. |

![Food Molecules](image)

**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 Question

**LESSON 5**

3 days

**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 Question

**LESSON 6**

1 day

**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.

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<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 7</td>
<td></td>
<td>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:</td>
<td>![Digestive System Diagram]</td>
</tr>
</tbody>
</table>
| What is the function of the digestive system, and how is M’Kenna’s digestive system different? | ![All previous phenomena] | - 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. | |
| Putting Pieces Together | | 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. |

| LESSON 8        |                             | 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: | ![Small Intestine Diagram] |
| What does the surface of M’Kenna’s small intestine look like up close compared with a healthy one? | ![When you look closely at the lining of the small intestine, you see long finger-like projections.] | - 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. | |
| Investigation   |                             | 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. |

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Lesson 9
1 day
How can a problem in one body system cause problems in other systems?

### Problematizing

<table>
<thead>
<tr>
<th>Patient's Name: M'Kenna</th>
<th>Age: 13</th>
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</thead>
<tbody>
<tr>
<td>Symptoms that started first:</td>
<td></td>
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<tr>
<td>Fever</td>
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<tr>
<td>Weight loss</td>
<td></td>
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<tr>
<td>Fatigue</td>
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<tr>
<td>Nausea</td>
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<tr>
<td>Cramping</td>
<td></td>
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<tr>
<td>Discomfort</td>
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<tr>
<td>Symptoms that started later:</td>
<td></td>
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<tr>
<td>Headaches</td>
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<tr>
<td>Numbness</td>
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<tr>
<td>Slow heartbeat</td>
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<tr>
<td>Dizziness</td>
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<td>Difficulty breathing with exercise</td>
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<tr>
<td>Difficulty breathing at the time</td>
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<tr>
<td>Chest pain</td>
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<tr>
<td>Nausea</td>
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<tr>
<td>Asthma</td>
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**M'Kenna's Doctor's Note** shows symptoms in other body systems.

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

We figure out:

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

#### 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 11

2 days

What happens to matter when it is burned?

Investigation

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

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

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

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

Lesson 12

2 days

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

Investigation

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

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

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

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

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

#### Putting Pieces Together

<table>
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<th>What we do and figure out</th>
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<tbody>
<tr>
<td>All previous phenomena</td>
<td>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:</td>
<td></td>
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<tr>
<td></td>
<td>- 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.</td>
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<td>- The respiratory and circulatory systems work together to bring food molecules and oxygen to cells in the body and to remove carbon dioxide.</td>
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<td>- Humans need to take in food. Food is a type of fuel, which means that it can react with other substances to release energy.</td>
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<td>- Cells rearrange food and oxygen through a chemical reaction, which creates carbon dioxide and water and releases energy that cells can use.</td>
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<td>- 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).</td>
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<tr>
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<td>- When the body takes in excess food, it can be stored for later in the form of fat molecules in the body.</td>
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<td>- 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.</td>
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<td>- M’Kenna’s body used fat molecules stored in her body when she wasn’t getting enough matter from food.</td>
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<td>- 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.</td>
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</table>

#### Navigation to Next Lesson:

We’ve accomplished our mission to figure out what was causing M’Kenna’s symptoms, and we’ve learned a lot about how our bodies work along the way! We can now explain things like how our bodies can get energy from eating a piece of chicken, and that got us thinking...what if we fed a dog that piece of chicken? Would their bodies do the same thing as our bodies? Would their bodies do chemical reactions to break food down and burn it for energy?
<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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</tbody>
</table>
| Do all animals do chemical reactions to get energy from food like humans? | ![Dog Image] | We investigate an organism of our choice to see if it does metabolic reactions similar to the way humans do. We argue from evidence whether (1) our organism does chemical reactions to break down and burn food molecules the same way as humans and (2) it has the same structures inside its body that work together to do those processes. Then we come together to share our findings with other groups to give and receive feedback. We figure out:  
- Animals, aside from humans, rearrange matter in food through chemical reactions to release energy.  
- In animals, besides humans, oxygen reacts with food to produce carbon dioxide and provide energy.  
- Other living things, such as anaerobic bacteria, don't need oxygen for chemical reactions to get energy.  
- Animals might have different structures in their bodies that do the same functions. |                   |
|                  | ![Book Image]              |                          |                   |
|                 |                             |                          |                   |
|                 |                             |                          |                   |
|                 |                             |                          |                   |
| LESSON 15       |                             |                          |                    |
| What questions on our Driving Question Board can we now answer? | ![Bear Image] | 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. |                   |
|                 | ![Diagram Image]          |                          |                   |
|                 |                             |                          |                   |
| LESSONS 1-15    |                             |                          |                    |
| 29 days total   |                             |                          |                    |
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**

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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 \( \frac{a}{b} \) associated with a ratio \( a:b \) with \( b \neq 0 \), and use rate language in the context of a ratio relationship.
- **CCSS.MATH.CONTENT.7.SP.C.6**: Approximate the probability of a chance event by collecting data on the chance process that produces it and observing its long-run relative frequency, and predict the approximate relative frequency given the probability.
- **CCSS.MATH.CONTENT.7.SP.C.8.C**: Design and use a simulation to generate frequencies for compound events.

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

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

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

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

### Overall Unit Assessment

<table>
<thead>
<tr>
<th>When</th>
<th>Assessment and Scoring Guidance</th>
<th>Purpose of Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesson 1</td>
<td>Initial Model</td>
<td><strong>Pre Assessment</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>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.</td>
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<tr>
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<td>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. Use your judgement on how to press students to form how and why questions. If a student struggles with sharing, choose to celebrate going public with questions over getting to a how or why question. If students do not ask questions about the phenomenon that seek to investigate how different body systems work together, that’s okay at this point. They will have another opportunity to add questions to the DQB in Lesson 9. Also, questions can be added to the DQB at any point throughout the unit. We recommend always having sticky notes or index cards on hand to capture students’ evolving questions.</td>
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<tr>
<td>Lesson 7</td>
<td>Student (group sensemaking)</td>
<td><strong>Formative</strong></td>
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<td>Formative Assessment Teacher Key</td>
<td>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.</td>
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<td>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></td>
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<td>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.</td>
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<td>This midpoint assessment is important formatively to make sure the class is on the same page and ready to move forward in the unit. At this point, students should be comfortable with the evidence and reasoning laid out in the rubric for this assessment.</td>
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<td>When</td>
<td>Assessment and Scoring Guidance</td>
<td>Purpose of Assessment</td>
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</table>
| Lesson 10            | Initial Ideas Discussion       | **Formative / Pre Assessment**  
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. |
| Lesson 14            | Self Assessment Argumentation rubric with Gotta-Have-It Checklist | **Formative and Self Assessment**  
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.  
**Peer Assessment**  
In this lesson, students use a general argumentation rubric paired with their co-constructed Gotta-Have-It Checklist from the previous lesson to provide peer feedback to small groups on their arguments. |
| Lesson 15            | Student Assessment Modified Student Assessment Teacher Reference Modeling Rubric | **Summative**  
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.  
If your students are struggling or you think they will need support in creating the model, there is a modified student assessment that gives students the components and interactions they will need in their model. |
| Occurs in most lessons | Progress Tracker               | **Formative and Student Self Assessment**  
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. |
| Anytime after a discussion | Student Self Assessment Discussion Rubric | **Student Self Assessment**  
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. |
When Assessment and Scoring Guidance Purpose of Assessment

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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>
<thead>
<tr>
<th>Lesson</th>
<th>Lesson-Level Performance Expectation(s)</th>
<th>Assessment Guidance</th>
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<tr>
<td>Lesson 1</td>
<td><strong>Develop models</strong> based on evidence to predict the relationships between components of a system (organs and body systems) to explain what is causing M'Kenna to feel the way she does (effect). <strong>Ask questions</strong> that arise from careful observation of M'Kenna's Doctor's Note to clarify and seek additional information about what is going on inside the body of M'Kenna that is causing her symptoms (effect).</td>
<td><strong>Developing and Using Models; Cause and Effect; Systems and System Models</strong> Teachers can use students' initial models to highlight the range and diversity of ideas the class as a whole has. See more information about how to use initial models in the Overall Unit Assessment table above. Also, use the Consensus Discussion about the initial class model to assess which ideas students are bringing up in their models to explain the cause or underlying mechanism of M'Kenna's symptoms. Look for agreement on key components of the models, such as (1) the digestive system, (2) input of food, and (3) some connections to other body systems. Do not worry if students do not know the function of each body system. There will be other opportunities to build understanding of other body systems. See the teacher guide in this section for some guidance to help students if they are struggling when developing their initial models. <strong>Asking Questions; Cause and Effect</strong> Students have opportunities to pose and build on other students' questions during the construction of the Driving Question Board (DQB). Look for how or why questions about phenomena that seek to investigate interactions inside of the body, either within a system or between different systems. Use your judgement on how to press students to form “how” and “why” questions. If a student struggles with sharing, encourage them to go public with questions rather than focusing specifically on forming a “how” or “why” question. If students do not ask questions at this point about the phenomenon that seek to investigate how different body systems work together, this is okay. They will have another opportunity to add questions to the DQB in Lesson 9. Also, questions can be added to the DQB at any point throughout the unit. We recommend always having sticky notes or index cards on hand to capture students' evolving questions.</td>
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<tr>
<td>Lesson 2</td>
<td><strong>Analyze and interpret data</strong> to identify patterns in how the structures of the digestive system and relative amounts of substances in a food sample appear in a healthy person as compared to in M'Kenna.</td>
<td><strong>Analyze and Interpreting Data; Structure and Function; Systems and</strong> While students are examining the illustrations of the organs of the digestive system, circulate among them to listen to group and/or pairs conversations to determine the prior knowledge and the similarities and differences between the different organs. Listen for students noticing the similarity that each organ is hollow inside based on the illustrations. However, you should avoid taking this as an opportunity to grade students on their understanding of these structures. It is more important to begin to determine how well students can analyze and draw comparisons using the illustrations. Students are not using the term “subsystem” at this point, even while they are examining organs, which are subsystems, but they are beginning to make connections between the structure of an organ and its ability to perform a job inside of the digestive system. They are just seeing the body as one system that has a digestive system, and that digestive system is made up of different structures. This understanding will be critical for future discussions of subsystems. <strong>Analyze and Interpreting Data; Patterns</strong> Students should be examining the endoscopy images in an attempt to determine if there are any patterns in the images that will help support their idea that M’Kenna’s symptoms are centered in the digestive system. When attempting to determine if a cause and effect relationship exists, students need to realize that phenomena may have more than one cause and the fact that two events are happening at the same time doesn’t necessarily imply causation. When students are analyzing the graph or food molecules in the small intestine, they will need to pay attention to the patterns in data that indicate that some of the molecules are not leaving M’Kenna’s small intestine. If some students are struggling with the data analysis, provide additional support by gathering them in a small group to facilitate a more structured analysis of the endoscopy images.</td>
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<tr>
<td>Lesson</td>
<td>Lesson-Level Performance Expectation(s)</td>
<td>Assessment Guidance</td>
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</tr>
<tr>
<td>Lesson 3</td>
<td><strong>Plan and conduct an investigation</strong> in order to produce data to determine whether <strong>food molecules</strong> can travel from one side of a <strong>system</strong> to the other side separated by a <strong>solid</strong> structure with properties similar to the walls of the small intestine. <strong>Argue from evidence to revise a model</strong> 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 <strong>function</strong> of the small intestine.</td>
<td><strong>Planning and Carrying Out Investigations; Systems and System Models; Structure and Function</strong> 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. <strong>At the end of day 1, look at Part 2 of Dialysis Tube Investigation</strong> 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. <strong>Developing and Using Models; Structure and Function</strong> 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><strong>Analyze and interpret data</strong> to determine <strong>patterns</strong> 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><strong>Analyzing and Interpreting Data; Patterns</strong> 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. Plan and conduct an investigation to produce data to determine whether food containing complex carbohydrates, but not glucose, undergoes a chemical reaction in the mouth and that this reaction turns the complex carbohydrates into glucose when mixed with a substance found in saliva (amylase), which is identified by a pattern change in the color of the food indicator.</td>
<td>Analyzing and Interpreting Data: Cause and Effect: Patterns After analyzing data from eating a graham cracker on Analyze Data from Eating a Graham Cracker, students record their analyses in their science notebooks. Look for students’ ability to recognize the pattern in the data that shows that, as complex carbohydrates decrease in the mouth, glucose increases. In addition, students should note that the relative quantities of the other food molecules in the mouth do not change. Students should be able to argue that the relationships that they observe are correlations, but not causations. If students struggle to identify patterns in the data, consider providing additional support in reading the graph provided. If students struggle to distinguish between causal and correlational relationships in the data, consider taking the time to distinguish between causal and correlational relationships. Planning and Conducting Investigations: Patterns Students record their plans and findings from an investigation that they have planned and conducted on Chemical Reactions in the Mouth Data Table. Prior to conducting the investigation, check student work to make sure that they have planned an investigation similar to the one provided on Unknown material with identifier: mr.15.tref. After conducting the investigation and recording their results, check student work using Unknown material with identifier: mr.15.tref to determine if students have identified the anticipated patterns in the data. During the Making Sense discussion, listen for students to connect their findings to their data analysis of the graham cracker graph. If students struggle to plan the investigation, consider spending more time framing the goals of the investigation. If students struggle to interpret their findings, consider returning to the investigation in Lesson 3 so that students can remind themselves about the use of the various indicators.</td>
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<td>Lesson 6</td>
<td>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.</td>
<td><strong>Analyzing and Interpreting Data; Patterns</strong> 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. <strong>Analyzing and Interpreting Data; Structure and Function</strong> 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. <strong>Analyzing and Interpreting Data; Patterns, Structure, and Function</strong> 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.</td>
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<td>Lesson 7</td>
<td><strong>Develop a model</strong> 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 <strong>subsystems</strong> within it, play in breaking down matter inputs through <strong>chemical reactions</strong>, absorbing food, and excreting unused matter.</td>
<td><strong>Developing and Using Models: Systems and System Models</strong> 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).</td>
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<td>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.</td>
<td>If students are missing ideas, prompt them to revisit their Progress Trackers or science notebooks for key ideas that they are missing. During small-group modeling time, there are suggested prompts to help students when develop their models. In addition to including ideas about the breakdown of food in the digestive system, make sure students are incorporating key ideas about systems and system models, specifically as they relate to the digestive system. Prompt students to include these ideas by asking questions, such as: &quot;What are the inputs, processes, and outputs that you will need to include in your model?&quot; and &quot;How can we differentiate between the processes happening in different parts of the digestive system?&quot; and &quot;Why do the processes need to occur in different parts of the system?&quot; 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.</td>
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<td>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.</td>
<td>Engaging in Argument from Evidence: Systems and System Models <em>Use</em> 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.</td>
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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's symptoms can be explained by her having celiac disease. Look for students to argue that M'Kenna has celiac because the villi in M'Kenna's small intestine cause her to have a reduced number of cells since taller villi in the small intestine cause there to be more cells, and this does not allow her body to absorb food molecules as effectively as a healthy digestive system. Students combine this evidence with the understanding that the data from her large intestine indicated that food molecules, other than fiber and water, remained in the large intestine after digestion, while in a healthy large intestine only fiber and water remain. While the assessment should be completed independently, some students might benefit from assistance with the organization of their writing. Additional guidance is provided in regard to how to support students with this organization. Then, students exchange written arguments with a peer and provide a critique of their argument based on the sufficiency of evidence provided. Look for students who attend closely to the strength of the argument and identify key pieces of evidence that support it. Provide a review for a small group of students or for the whole class about the key features of a strong scientific argument using Argument Rubric - Part 3 - M'Kenna's Disease for guidance. In Revisit the Driving Question Board, students select three questions from the DQB that they have made progress toward answering. They argue the answer to those questions using evidence that they have collected throughout the unit.</td>
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<td>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.</td>
<td>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.</td>
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<td>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, &quot;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?&quot; This should remind students without giving away key learning.</td>
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| Lesson 9 | **Ask questions** to gather more information about how problems in one **body system** interact with other **systems** after revisiting M’Kenna’s symptom list. | **Asking Questions and Defining Problems:** Teachers can collect *Let’s Answer Questions from Our DQB!* after revising the DQB. Look for every student to select questions from careful observation of the phenomenon with M’Kenna’s doctor’s note that pertain to the initial digestive system cluster of symptoms (on the DQB) and use evidence from lesson investigations. If students are unable to select digestive system questions and connect them to collected evidence, help students pick one lesson and explain how what they figured out in that lesson helps explain one of the questions listed. Students can look at their Progress Trackers from each lesson to help them identify what was figured out in each lesson.  
  
After revisiting M’Kenna’s doctor’s note and their mapping of her symptoms, students are problematizing M’Kenna’s symptoms in other systems. This is a place to formatively assess if they are able to see that not only is the digestive system a subsystem of other systems but that it is also interacting with other systems. Look for students to notice that their must be a connection between her digestive system problems with absorption and her other symptoms, since her symptoms seem to start in her digestive system. Students will return to this thinking throughout this lesson and in other lessons. If students are unable to come up with the idea that problems in one system could be caused by problems in another system have them look back at their system mapping. If students don’t suggest that their might be a connection between systems that we haven’t figured out yet, ask them to think about which systems we have we have collected evidence to explain and which symptoms remain unexplained.  
  
At the end of the lesson, students individually fill out their Progress Trackers for Lesson 9. Look for students to explain that we have figured out why most of M’Kenna’s digestive system symptoms occur (due to issues with absorption of food in her small intestine), but we can’t yet explain how that is causing her symptoms in other body systems, such as brain fog, fatigue, and weight loss. If students struggle to make this connection between systems, have them walk over to the DQB and look at the clusters of questions that don’t have any dots on them yet. If they are still not able to make the connection, take out M’Kenna’s *Doctor’s Note* to see which symptoms and systems are still not explained. |
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| Lesson 10 | **Analyze and interpret data** using graphical displays and statistics to identify temporal relationships to provide evidence for how M'Kenna’s pattern of body growth and weight have changed over time compared with typical children her age.  
**Obtain, evaluate, and communicate information** to determine the central ideas in an article to help determine where fat (matter) goes when people lose weight.  
**Plan and carry out an investigation** to produce data to serve as the basis for evidence to answer the question, Where does matter go when people lose weight? | 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.  
**Analyzing and Interpreting Data; Stability and Change**  
Students are introduced to using statistics in order to identify temporal relationships in M’Kenna’s growth chart. Look for students to identify that M’Kenna’s growth remained stable for about 11 years, and then began to slow down when she turned 13. If students don’t make this connection, you can pull them into small groups to do a more guided data analysis. Also, you might pull different student work samples of their WIS/WIM statements and have the whole class look at what classmates have written. Next, students examine DEXA scans of a human and/or a dog that have lost weight. Look for students to identify that fat was lost over time. This should prompt students to begin to think about where the fat goes when someone loses weight. If students are identifying this, you might ask a question like, “If the animal weighed 60 pounds in this photograph, but 45 pounds in the next photograph, what is the difference in weight? Let’s think about a 15-pound dumbbell you might lift at the gym—that’s quite heavy! Where do you think all that weight went?”  
**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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| Lesson 11 | 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. | Constructing Explanations; Stability and Change; Energy and Matter  
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.  
At the end of day 1, students will complete Making Sense of Burning Fat Investigation Results part 3 to make sense of their results from burning fat in open and closed systems and measuring changes in the composition of air during the burning of fat in a closed system. Look for students to be able to explain that, due to changes in the mass and amounts of different substances in a closed system and the production of energy, a chemical reaction must have occurred. For students who are having difficulty with the Making Sense questions in part 3, you could ask additional questions like, “How did what we started with compare to what we ended with?” and “Do you have any evidence from our investigation to support that a change has occurred in the system?”  
On day 2, after a Scientists Circle, students will return to their seats and individually process what they have figured out in their Consensus Discussion on their Progress Tracker. Look for students being able to make the connection that burning food undergoes a chemical reaction that produces energy. In order for the energy to be released, the reaction requires oxygen. If students do not make this connection, ask them to look back at Burning Fat in Open and Closed Systems. Remind students that using the evidence that they have collected helps support their arguments. When doing so, ask them to think about what changes they noticed from the beginning to the end of the investigation. Ask them to consider if this reminds them of any other chemical reactions they have seen (such as with the bath bombs and rusting iron) or the graphs of changing amounts of food molecules in M’Kenna’s digestive system. |
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<td>Lesson 12</td>
<td>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.</td>
<td><strong>Analyzing and Interpreting Data; Cause and Effect</strong>&lt;br&gt;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?”&lt;br&gt;&lt;br&gt;<strong>Obtaining, Evaluating, and Communicating Information; Cause and Effect</strong>&lt;br&gt;In Interpreting Activity Data, students receive oxygen and carbon dioxide 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 and clarified 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 __.”</td>
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<td>Lesson 13</td>
<td><strong>Develop models</strong> of three possible pathways showing how food is rearranged in the body to create energy, store matter for later use, and use matter for growth within a body system. <strong>Construct an explanation</strong> to explain the relationships between differences in M’Kenna’s digestive system and a healthy digestive system in order to predict symptoms (effects), such as M’Kenna’s decreased growth rate.</td>
<td><strong>Developing and Using Models; Systems and System Models</strong> Students work in small groups to develop models of three different pathways that food entering a body system could take: (1) how the body uses food for energy, (2) how the body uses food not needed right now, and (3) how the body uses food for growth. As groups develop these models, look for them to identify different matter inputs, such as food and oxygen, processes, such as digestion, storage, growth, and cellular respiration, and matter outputs, such as carbon dioxide, water, and fat. Models should also identify different energy flows; for example, in pathway 1, food is broken down and used for energy by the body right away. In pathways 2 and 3, energy from food, and molecules, is stored for later use or to be used in the growth of new tissues. Look for groups to generalize the processes for how healthy bodies use food in each of the three pathways. In pathway 1, models should indicate that food and oxygen enter the body system and are broken down to be used for energy. In pathway 2, models should indicate that excess food is used to create storage molecules, like fat and glucose stored in muscle and liver, which can be used later for energy or growth. In pathway 3, models should indicate that molecules from food can be rearranged to create different tissues in the body like muscle and bone. If groups struggle to identify how food is used differently in each of the pathways, refer them back to their Progress Trackers for Lessons 10-12 when we figured out that the body needs food for growth and that food can be burned for energy. <strong>Constructing Explanations; Cause and Effect</strong> After developing a classroom consensus model, students write an explanation for how M’Kenna’s body is functioning differently than a healthy body. In addition, students return to their Progress Trackers to update them with a 3-column entry. In this update, students use the model they built as a class to develop an explanation for how the systems in a healthy body work together to process matter and energy inputs, processes, and outputs. Students add to their explanations about how M’Kenna’s digestive system is functioning differently and how her digestive condition contributes to the symptoms that she experiences in other systems of her body. Use this opportunity to look for students to identify the cause and effect relationship between decreased food absorption affecting M’Kenna’s energy levels. Students should also explain the relationship between decreased food absorption causing M’Kenna to rely on stored food, or fat, leading to her slowed growth rate or decrease in weight. If students are struggling to make these connections, refer them back to their Progress Trackers for Lesson 12 when they figured out that, when we are active, our body needs more energy, which requires more food.</td>
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<td>Assessment Guidance</td>
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</table>
| Lesson 14 | Engage in an argument from evidence that, in animals, oxygen reacts with carbon-containing molecules to provide energy and produce carbon dioxide and that organisms might have different structures that work together to do similar functions. | Engaging in Argument from Evidence; Energy and Matter; Structure and Function
Students will be constructing an argument from evidence in small groups and getting an opportunity to revise their arguments. Look for students seeing similarities between their organism and humans by using the evidence connected from the readings that their animal does basically the same chemical reactions as humans to get energy from food, but they might have different structures inside their bodies that are involved. If students are struggling with their arguments, look for the callout box in the activity section of “Research How Other Organisms Get Energy” for questions to help them get started. During the time for students to revise their arguments, if students are struggling to identify how similar and different structures are functioning, help them map those structures to the human structures that they have previously studied.

When students are giving and receiving feedback, you will have an opportunity for students to self assess their ability to give and receive feedback using a rubric. Look for students to honestly assess themselves and their growth throughout the unit. There is a place in Lesson 7 during which students could have used the rubric to self assess their peer feedback. |
| Lesson 15 | Develop a model to explain how bears can rearrange matter in food through chemical reactions to release energy and use stored food in the form of fat to survive during hibernation. Construct an explanation by applying scientific ideas and evidence to show how bears obtain energy to survive for several months without eating during hibernation. | Developing and Using Models; Energy and Matter
This lesson includes a transfer task to give students an opportunity to use the three dimensions to make sense of a different phenomenon. This is meant to be a summative assessment task for the unit and gives you a grading opportunity. The task includes a scoring guide, as well as a modeling rubric for scoring the modeling question. Scoring guides are meant to highlight important ideas that students should be including in their responses to the prompts. They are listed as bullet points, so you can decide how to score them appropriately to the norms in your classroom. If students share these ideas elsewhere in the assessment, it is up to you to decide if that understanding is sufficiently demonstrated.

If your students are struggling or you think they will need support in creating the model, there is a modified student assessment that gives students the components and interactions they will need in their models. Reviewing what the class has figured out through answering the questions on the Driving Question Board is one way to help students to prepare for the summative assessment. Reviewing these questions is also a good formative assessment to see if there are any pieces that need to be revisited. |
LESSON 1: What is going on inside M’Kenna’s body that is making her feel the way she does?

PREVIOUS LESSON
There is no previous lesson.

THIS LESSON
ANCHORING PHENOMENON
3 days

In this lesson we meet M’Kenna, a 13-year-old girl who started feeling sick all the time. We analyze M’Kenna’s Doctor’s Note and develop initial models to explain what is going on inside M’Kenna’s body and why her symptoms are affecting so many different body systems. After generating a list of related phenomena, we develop a Driving Question Board to guide future investigations. We are particularly interested in figuring out what is different about M’Kenna’s digestive system compared to that of someone who is healthy.

NEXT LESSON
We will examine M’Kenna’s endoscopy report and graphs that compare what is in food when it enters the body to what can be found in the small intestine (of both a healthy body and M’Kenna’s body). This leads us to a series of investigations aimed at figuring out what is going on in M’Kenna’s small intestine.

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

WHAT STUDENTS WILL DO
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).

WHAT STUDENTS WILL FIGURE OUT
- M’Kenna, a 13-year-old girl, seems to be really sick, and we aren’t sure why.
- 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. However, we have some ideas for possible investigations we could pursue.
<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>INTRODUCE AN INTERESTING PHENOMENON</strong>&lt;br&gt;Introduce students to M’Kenna’s primary symptoms. Have students brainstorm other symptoms they might expect M’Kenna to have.</td>
<td>A</td>
<td>Transcript of M’Kenna’s symptoms, <a href="https://youtu.be/zGNxuJcSkMA">https://youtu.be/zGNxuJcSkMA</a>, speakers and computer to play the audio clip</td>
</tr>
<tr>
<td>2</td>
<td>7 min</td>
<td><strong>MAKE OBSERVATIONS OF THE DOCTOR’S NOTE</strong>&lt;br&gt;Engage students in a Notice-Think-Wonder routine around M’Kenna’s Doctor’s Note.</td>
<td>B</td>
<td>M’Kenna’s Doctor’s Note, Map M’Kenna’s Symptoms to Her Body Systems, tape</td>
</tr>
<tr>
<td>3</td>
<td>8 min</td>
<td><strong>INITIAL IDEAS DISCUSSION ABOUT DOCTOR’S NOTE</strong>&lt;br&gt;Have students share their initial ideas about M’Kenna’s symptoms in a whole-group discussion.</td>
<td>B</td>
<td>discussion norms poster</td>
</tr>
<tr>
<td>4</td>
<td>10 min</td>
<td><strong>DEVELOP INITIAL MODELS</strong>&lt;br&gt;Have students develop an initial model to explain what is going on with M’Kenna.</td>
<td>C</td>
<td>Initial model, tape</td>
</tr>
<tr>
<td>5</td>
<td>15 min</td>
<td><strong>SHARE INITIAL MODELS</strong>&lt;br&gt;Students share models with a partner then do a gallery walk to compare models.</td>
<td>D-E</td>
<td></td>
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<tr>
<td>6</td>
<td>20 min</td>
<td><strong>DEVELOP CONSENSUS MODEL IN SCIENTISTS CIRCLE</strong>&lt;br&gt;Students gather together in a Scientists Circle to share similarities and differences in their models and develop an initial consensus model.</td>
<td>F-G</td>
<td>chart paper, discussion norms poster, space for Scientists Circle</td>
</tr>
<tr>
<td>7</td>
<td>7 min</td>
<td><strong>PROGRESS TRACKER</strong>&lt;br&gt;Introduce the Progress Tracker.</td>
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<tr>
<td>8</td>
<td>8 min</td>
<td><strong>SHARE RELATED PHENOMENA</strong>&lt;br&gt;Have students consider when they or someone they know experienced concurrent symptoms similar to M’Kenna’s.</td>
<td>I</td>
<td>chart paper</td>
</tr>
<tr>
<td>9</td>
<td>10 min</td>
<td><strong>DEVELOP INITIAL QUESTIONS</strong>&lt;br&gt;Write down different questions students have about M’Kenna’s case and related experiences.</td>
<td>J</td>
<td>index cards, tape, markers</td>
</tr>
<tr>
<td>10</td>
<td>20 min</td>
<td><strong>DRIVING QUESTION BOARD</strong>&lt;br&gt;Develop a Driving Question Board to create a shared space for student questions.</td>
<td>K</td>
<td>index cards, tape, markers, space for Driving Question Board</td>
</tr>
<tr>
<td>11</td>
<td>15 min</td>
<td><strong>IDEAS FOR INVESTIGATIONS</strong>&lt;br&gt;Have students generate ideas for investigations that the class could do to figure out what is going on inside of our bodies.</td>
<td>L-M</td>
<td>Driving Question Board, chart paper</td>
</tr>
<tr>
<td>12</td>
<td>8 min</td>
<td><strong>UPDATE THE TABLE OF CONTENTS</strong></td>
<td>N</td>
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<tr>
<td>13</td>
<td>2 min</td>
<td><strong>NAVIGATION</strong></td>
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</table>
Lesson 1 • Materials List

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<thead>
<tr>
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<th>per student</th>
<th>per group</th>
<th>per class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesson materials</td>
<td>• Transcript of M’Kenna’s symptoms</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• M’Kenna’s Doctor’s Note</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Map M’Kenna’s Symptoms to Her Body Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Initial model</td>
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<tr>
<td></td>
<td>• science notebook</td>
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<td></td>
<td>• tape</td>
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<td>• index cards</td>
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<td>• markers</td>
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<td>speakers and computer to play the audio clip</td>
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<td>tape</td>
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<td></td>
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<td>discussion norms poster</td>
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<td></td>
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<td>chart paper</td>
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<td></td>
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<td>space for Scientists Circle</td>
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<td></td>
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<td></td>
<td>space for Driving Question Board</td>
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<td></td>
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<td>Driving Question Board</td>
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</tbody>
</table>

Materials preparation (15 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.

Clear a space in your classroom to create a Driving Question Board (DOB) that students can gather around.

Make and post a discussion norms poster near your DOB space if you haven't already.

Have tape available for students to attach handouts to their science notebooks.

Check that the https://youtu.be/zGNxUJcSkMA is loud enough for the whole class to hear.
Lesson 1 • Where We Are Going and NOT Going

Where We Are Going

This lesson elicits students' initial ideas about how body systems work together to help us grow and have the energy to do the things we want to do. In this lesson, students are introduced to the anchoring phenomenon—a 13-year-old girl named M’Kenna who feels very sick and is losing weight. Key symptoms are introduced in this lesson, specifically, M’Kenna’s digestive symptoms, weight loss, and lack of energy. The goal established in Lesson 1 is to figure out, “How do interactions inside our body make us feel the way we do?” By the end of the unit students will be able to answer this question in terms of describing how multiple body systems work together to rearrange food molecules through chemical reactions to support growth and provide energy for organisms.

Where We Are NOT Going

Students do not need an understanding of each body system prior to starting this unit. Students will build the pieces they need in order to meet the Performance Expectation MS–LS1-3. This PE emphasizes that the important conceptual understanding revolves around cells forming tissues and tissues forming organs specialized for particular body functions. This unit builds out this pattern with the digestive system first and then generalizes this pattern of organization to other body systems in the second lesson set. A detailed description of what each organ in the body does will not determine mastery for this PE.

This unit directly builds off of the OpenSciEd Scope and Sequence bundle 6.6 Cells and Systems. This unit does not build understanding of what cells are, so students should come in with that previous knowledge.
LEARNING PLAN for LESSON 1

1 · INTRODUCE AN INTERESTING PHENOMENON

MATERIALS: Transcript of M’Kenna’s symptoms, https://youtu.be/zGNxUJcSkMA, speakers and computer to play the audio clip

Introduce M’Kenna’s case. Present slide A and tell students that you learned about a girl in middle school named M’Kenna who recently started feeling very sick. Share that this is not a made-up story, but something that happened to a real girl about their age. Share that M’Kenna’s primary complaints are that her stomach hurts after she eats and that she has diarrhea and stomach cramping. Have students think individually first, then turn and talk about the following question.

Knowing that M’Kenna’s primary complaints are that her stomach hurts after she eats and that she has diarrhea and stomach cramping, what other kinds of symptoms might you expect M’Kenna to have?

KEY IDEAS

Purpose of this discussion: (1) To prepare students to think about the other symptoms on M’Kenna’s Doctor’s Note and (2) to help students build confidence in sharing their ideas publicly.

Listen for these ideas:
- Accept all student responses.

Play the audio clip https://youtu.be/zGNxUJcSkMA.

2 · MAKE OBSERVATIONS OF THE DOCTOR’S NOTE

MATERIALS: M’Kenna’s Doctor’s Note, Map M’Kenna’s Symptoms to Her Body Systems, tape

Introduce M’Kenna’s Doctor’s Note. Present slide B. Hand out a copy of M’Kenna’s Doctor’s Note and Map M’Kenna’s Symptoms to Her Body Systems. A color copy of the body systems is also available in the References section of the Student Edition. Tell students to leave 14 pages (28 front-to-back sides) in the front of their student notebooks blank to use for later use in their table of contents and Progress Trackers. Then have students add M’Kenna’s Doctor’s Note to their science notebooks using tape and instruct them to make a T-chart for the Notice-Think-Wonder routine.

Explain that when M’Kenna went to the doctor, the doctor documented all of her symptoms and that we are going to use M’Kenna’s Doctor’s Note to try to figure out what is going on. Tell students that in order to begin thinking more carefully about M’Kenna’s case using M’Kenna’s Doctor’s Note, they are going to engage in a Notice-Think-Wonder routine—first individually, then with a partner, and finally as a whole group. Prompt students to begin the Notice-Think-Wonder routine individually.

In their science notebooks, students should jot down responses to the following prompts:

- NOTICE: Make observations about M’Kenna’s Doctor’s Note. What do you NOTICE?
- THINK: Where do you THINK each symptom might occur in M’Kenna’s body? Write each symptom on the body system you think it is affecting On Map M’Kenna’s Symptoms to Her Body Systems.
- WONDER: What does this make you WONDER about M’Kenna and her symptoms?
<table>
<thead>
<tr>
<th>Notice</th>
<th>Think</th>
<th>Wonder</th>
</tr>
</thead>
<tbody>
<tr>
<td>I noticed that four of M’Kenna’s symptoms seem to involve her digestive system.</td>
<td>Students write each symptom on the body system on which they THINK it’s affecting Map M’Kenna’s Symptoms to Her Body Systems</td>
<td>This makes me wonder if something in her stomach started all of these symptoms. This makes me wonder if she has a food allergy. This makes me wonder if all of M’Kenna’s symptoms are related.</td>
</tr>
<tr>
<td>I noticed that many of the symptoms seemed to start first, then other symptoms started to happen later.</td>
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</table>

**WRITING IN SCIENCE**

A strategy for writing in science would be to provide a Notice-Think-Wonder graphic organizer to support students in organizing their thoughts.

**ADDITIONAL GUIDANCE**

Students should not be focused on trying to diagnose M’Kenna and it may be the case that some students already know that she has Celiac disease.

The focus of the unit is on figuring out how one issue could cause symptoms in so many other places in the body. We want students to figure out how M’Kenna’s body is being affected—what’s the underlying cause?—and that the body systems must be interacting or connected somehow. The class should wonder how these different systems are interacting. Here is more information about celiac disease if you are interested [https://www.niddk.nih.gov/health-information/digestive-diseases/celiac-disease](https://www.niddk.nih.gov/health-information/digestive-diseases/celiac-disease).

After giving students several minutes to jot down their ideas, prompt them to share their ideas with a partner. Pairs of students should determine two or three Notice-Think-Wonder groupings to share with the whole class.
3 · INITIAL IDEAS DISCUSSION ABOUT DOCTOR’S NOTE

MATERIALS: discussion norms poster

Gather students for an Initial Ideas Discussion. If you haven’t already, establish norms for whole-group discussions. If you have already established them, remind students of the norms for engaging in science discussions.

Choose a norm to work on today. Direct students to look over their classroom norms. Ask them to silent contribute their norms to help the learning community grow stronger and more productive for everyone.

Remind students of the Communicating in Scientific Ways sentence starters. Direct students to the Communicating in Scientific Ways poster or handout also found in the OpenSciEd Teacher Handbook. Tell students that they will be developing a consensus model together. Ask them which sentence starters they might want to use to help them talk to one another.

Begin the discussion by saying, There was a lot to notice in M’Kenna’s Doctor’s Note. Our goal in this discussion is to share out, with the whole group, what you have NOTICED, what your observations made you THINK might be going on with M’Kenna, and what your observations made you WONDER about.

Ask one of the small groups to share one of its Notice-Think-Wonder groupings. Then engage the class in building on the ideas presented by the first group, offering new ideas, or disagreeing with the ideas presented. Some suggested prompts are listed below. You may wish to keep a public record of this discussion on chart paper, in an electronic file (projected on the screen), or by annotating Map M’Kenna’s Symptoms to Her Body Systems. You may also wish to prompt students to jot down the ideas shared by their peers in their science notebooks.

When ideas about different symptoms being connected come up during discussion, encourage participants to go public with their ideas and ponder those ideas with the group.

KEY IDEAS

Purpose of this discussion: (1) to engage students in thinking very carefully about M’Kenna’s Doctor’s Note, (2) to generate a range of ideas to cultivate curiosity and uncertainty, and (3) to build student agency in science discussions. A diverse range of ideas is something to celebrate here! Have students practice using evidence from M’Kenna’s Doctor’s Note to explain one’s thinking.

Listen for these ideas:
- Accept all student answers and be careful to not evaluate them as right or wrong.
- There is likely something wrong with M’Kenna’s digestive system (and that could mean more than just the stomach).
- There also seem to be other systems involved (e.g., circulatory and respiratory).
- We probably can’t explain all of M’Kenna’s symptoms with a simple “stomach bug” or virus.
- It is weird that most of her symptoms seem to be in the digestive system, but she is also experiencing symptoms in other systems (e.g., circulatory and respiratory).
- The weight loss seems odd—we can hypothesize why M’Kenna isn’t gaining weight, but it is more difficult to figure out why she is losing weight.

Using the prompts below, encourage all students to go public with their ideas and support students as they begin to connect their thinking to the thinking of their peers:
- Can you say more about that? What do you mean by that?
- So let me see if I get what you are saying. Are you saying that…? (Leave space for the original student to agree, disagree, or say more.)

ATTENDING TO EQUITY

Initial Ideas Discussions allow all students to share their initial thinking on a topic, which supports a classroom culture that values students’ prior knowledge and experiences.

STRATEGIES FOR THIS INITIAL IDEAS DISCUSSION

Science discussions are most productive when all students can see and hear one another. It is helpful to establish norms for whole-group and small-group science discussions. See the OpenSciEd Teacher Handbook for more guidance on establishing classroom norms.

You may wish to have students help you create the norms or you may wish to create the norms yourself and then share them with students. If you create the norms yourself, consider spending some time thinking with students about why the norm is important, what it might look and sound like when students are “demonstrating” the norm, and how not following the norm could affect how others feel and interact with the learning community.
Wrap up the discussion only after many students have had a chance to go public with their ideas and after the key ideas above have emerged.

Tell students, It sounds like we have a lot of really interesting ideas about what we saw in M’Kenna’s Doctor’s Note and what might be causing M’Kenna’s symptoms. As we begin to investigate M’Kenna’s case, it might help if we can capture all of these ideas in an initial model that we can use to explain what is going on with M’Kenna.

Debrief how we did with our focal norm. Have students talk and share how they did with the norm they selected. Ask students, How did the norms help us talk together and come up with some ideas of what we think is happening? Allow a few students to share and tell them they will continue to work on the norms throughout this unit.

4 • DEVELOP INITIAL MODELS

MATERIALS: Initial model, science notebook, tape

Introduce students to modeling. Present slide C and remind students that we decided it might be helpful to capture all of our ideas about what could be going on with M’Kenna in an initial model.

Develop initial models. Hand out Initial model and have students tape it into their science notebooks. Have students individually sketch their initial models.

Encourage students to represent their initial ideas by incorporating ALL of the symptoms, and thus, likely many of the systems beyond the digestive system. Lead a brief discussion on what should be included in the initial models. Use the guidance on slide C to have students explain: “What is causing M’Kenna to have symptoms in all of these different parts of her body?”

Additional guidance to help students in their modeling:
- How could all of these symptoms be happening in different body systems at the same time?
- Why did some symptoms start happening before others?
- It may be useful to think about a healthy person compared to M’Kenna. You may wish to show the differences using different colors.

Tell students to record questions if they become stuck.

As students work, prompt them to deepen their thinking. At this point in the process, accept all students’ ideas but push them to clearly include components and interactions in their models that show what is going on with M’Kenna compared to a healthy person.

*SUPPORTING STUDENTS IN DEVELOPING AND USING MODELS

When engaging in modeling, the key should be on explaining the “how” and the “why” of a phenomenon, not just the “what.” To help students focus on the “how” and the “why” for M’Kenna’s case, remind students explain what might be causing M’Kenna to have symptoms in all these different parts of her body rather than trying to “diagnose” her condition.

*SUPPORTING STUDENTS IN DEVELOPING AND USING CAUSE AND EFFECT

When developing their initial models, students should focus on what is causing M’Kenna to have symptoms in all of these different parts of her body (effect). At this point, students will be using the Crosscutting Concept of Cause and Effect below grade level. They do not have enough information to use cause and effect relationships to make predictions about M’Kenna.
## ASSESSMENT OPPORTUNITY

Here is some guidance to help students if they are struggling when developing their initial models.

<table>
<thead>
<tr>
<th>If you see students . . .</th>
<th>Then you may want to say . . .</th>
</tr>
</thead>
<tbody>
<tr>
<td>Include only components in their models (and not interactions)</td>
<td>Wow, it looks like you have a lot of interesting components of your model. It may help to label the different components and explain how they those components interact with one another.</td>
</tr>
<tr>
<td>Use only pictures in their models</td>
<td>You are clearly thinking carefully about what must be going on with M’Kenna, but it might be hard for someone who is not in your group to understand what you are trying to show. Could you add words to your model so that other groups will know what you are trying to show?</td>
</tr>
<tr>
<td>Only account for one set of symptoms</td>
<td>It looks like you have really accounted for X symptom, but what about Y? Have you worked on accounting for Y yet?</td>
</tr>
<tr>
<td>Only show what is happening with M’Kenna (or a healthy person)</td>
<td>So how would this be different in a healthy person (or in M’Kenna)?</td>
</tr>
</tbody>
</table>

## 5 · SHARE INITIAL MODELS

**MATERIALS: science notebook**

**Share model with a partner.** Present slide D. Students should make a table in their notebooks to record similarities and differences and title it “Comparing our models.” Have students turn and talk to the person next to them and explain their model. Then students should record similarities and differences between models.

**Share initial models in a gallery walk.** Present slide E. Have students do a quick gallery walk to compare their ideas with others:

- Students should leave their models at their seats.
- Ask students to move so that they stand at another student’s model. Tell them they only have 10 seconds to get into position.
- Give students 30–60 seconds to look at someone else’s model and record similarities and differences about the ideas they see.
- Have students view three other models. It’s not necessary to draw out this part. The goal is to see a variety of models and prime the pump for building the consensus model in the next step.

**SAFETY PRECAUTIONS**

If your students are seated in groups, you can tell the groups of students where to go in order to control the flow of movement. For example, “Table A students, stand at another student’s model at Table B. Table B students, stand at another student’s model at Table C.”

Tell students, Next class we will share our similarities and differences out with the whole class to find areas we have in common and identify where we have differences.
**6 · DEVELOP CONSENSUS MODEL IN SCIENTISTS CIRCLE**

**MATERIALS:** science notebook, chart paper, discussion norms poster, space for Scientists Circle

Before beginning the discussion, remind students of the norms for science discussions.

**Choose a norm to work on today.** Display slide F. Direct students to look over the norms chart once more. Ask them again to silently choose a norm to intentionally work at and monitor for themselves in class today to help our learning community grow stronger and more productive for everyone.

**ADDITIONAL GUIDANCE**

The second day of this lesson is a strategic point to have students revisit their class norms because it requires students to participate in an extended amount of time in whole class discussion in the Scientists Circle.

Days when there is a large, whole-class discussion in the Scientists Circle are a great opportunity to have students pick a focal norm to work on, even if it isn’t written into the teacher guide. It is recommended that you add in similar revisits of classroom norms at such strategic places throughout the unit. Carve out an extra couple of minutes at the start of lessons with whole-class discussions and a few minutes at the end of these lessons to reflect (and debrief as a class as time permits). It is recommended that you look for opportunities to do this at least once a week across your first unit of study.

Bring students together in a Scientists Circle for a Consensus Discussion. Present slide G. Tell students that the goal of this discussion is to figure out areas of agreement and disagreement in our initial models. Knowing where we agree and disagree will help us figure out how we might want to proceed in figuring out M’Kenna’s case.

**KEY IDEAS**

Purpose of this discussion: There are two goals of this discussion: (1) to continue to help students build the habit of sharing their ideas publicly and (2) to generate a variety of initial ideas about what is going on in M’Kenna’s case. As such, it is again important to accept all student responses and to encourage students to share their ideas. Further, it is important to highlight areas of disagreement and help students clearly explicate their thinking in these areas. Be careful not to favorably respond to any one idea over others so as not to “give away” what might be going on with M’Kenna.

Listen for these ideas:

- We all agree that something is going wrong in M’Kenna’s digestive system.
- We all agree that there are other body systems involved in some way.
- We have different ideas about what is causing her digestive symptoms.

Ask, What do we all seem to agree on? What do we disagree on? What are some new ideas that we may want to consider?

It is useful to develop a public record of areas of agreement and disagreement so that students may refer back to their shared ideas. It might be easier to start with what all the models have in common, and then differences will naturally come up.

**ATTENDING TO EQUITY**

It is important to allow all students to share their initial thinking on a topic, which supports a classroom culture that values students’ prior knowledge and experiences. Be mindful not to evaluate ideas as “right” or “wrong” in this discussion. The class needs to collect evidence in subsequent lessons to support or refute ideas.

**ATTENDING TO EQUITY**

You will form a Scientists Circle in many future lessons as well. Setting up the norms and logistics for forming, equitably participating in, and breaking down that space is important to do if this is your first time forming such a space.

Having students sit in a circle so they can see and face each other can help build a sense of a shared mission and a community of learners working together. Returning to this Scientists Circle throughout the course of the unit to take stock of what the class has figured out and where they need to go next will be an important tool in helping the class steer the direction of their learning.

This circle will also help build a sense of pride in their work. You may want to inform students that professional scientists also collaborate with each other to brainstorm, discuss, and review their work.

**ATTENDING TO EQUITY**

Add the word “interaction” to the Word Wall, which will become a useful space for recording a shared meaning of these new words as students develop a deeper meaning of them.
Represent areas of agreement and disagreement in a systems model. Most groups of students will only agree on two things in this model: (1) there is something going on in M’Kenna’s digestive system that is affecting other systems in her body and (2) this may have something to do with what is going into her digestive system or moving from this system to her other systems. Build an abstract representation of this using boxes, arrows, and question marks.

Say, *It looks like many of us have the digestive system somehow affecting or connecting with other body systems in some way. Maybe there is an interaction there. Anytime there is a connection or relationship between two things, we call that an “interaction.”*

Write the word “interaction” on a word wall and add a working definition next to it, such as a “connection or relationship between two things.”

An initial class consensus model will help the class converge on areas of agreement and areas of uncertainty and help foreground systems thinking in the work in future lessons.

A helpful distinction for determining if a word should be added to the Word Wall is to decide if it’s a “word we earn” versus a “word we find out.” A “word we earn” is one we work together to understand through investigation and collaborative sense-making, so we should celebrate our growing understanding of the word by adding it to the word wall. A “word we find out” may be encountered through text or media and is defined for us. These words are less important to add to our Word Wall, though they may become a “word we earn” if our understanding of the word grows and changes.

Throughout this lesson we will help students develop a deeper meaning for this word as we have students discuss different types of interactions going on inside our bodies. By the end of the lesson, this will have become a “word we earned,” even though its initial definition was presented to us by the teacher. For now, it is on the Word Wall so that we can reference it as needed across this lesson.

An alternative to a Word Wall is to have students note these words in their science notebook through a personal glossary in which they record the meaning of the word and a vocabulary doodle to represent it.

When developing new vocabulary, strategies that may benefit emergent language learners include using student-friendly definitions, making connections to cognate words when possible, and including a visual representation of the word.

**SUPPORTING STUDENTS IN THREE-DIMENSIONAL LEARNING**

Here, students are practicing modeling with the Crosscutting Concept lens of systems and systems thinking and integrating small pieces of evidence they will use to build disciplinary core ideas over time. Some classes may suggest labeling other known outputs of the model they’ve seen as evidence, such as vomit and diarrhea. Include these details only if your students bring them up.
Conclude the discussion after many students have had the opportunity to share their ideas and after several competing models have emerged and have clearly been explicated in the consensus model you develop as a class.

Here is an example of a consensus model your class might develop.

![Consensus Model](image)

### 7 · PROGRESS TRACKER

**MATERIALS:** science notebook

**Introduce the Progress Tracker.** Present slide H. Have students count off 4 blank pages in the front of their notebooks for a table of contents. Then have students draw the T-chart directly in their science notebooks. Explain that as we investigate what is going on with M’Kenna, we are going to keep track of how our model changes and develops over time. To do this, we are going to use a Progress Tracker.

Tell students, *This is a tool designed to help us keep track of ideas we figure out from each lesson. In the “What I figured out column” you can draw pictures or write in words, bullet points, or whatever way is most meaningful for you. Individually take 3 minutes to think about what you figured out last class. You can draw from anything we’ve done so far.*

By having no structured box, students can take up a lot of space or a little space on their Progress Trackers. Whenever a student is done writing, they can draw a line after their work to make space for the next time a teacher instructs them to write in their Tracker.

**ATTENDING TO EQUITY**

This Tracker serves as teacher guidance for what students might say at various points throughout the unit. However, some students may say more and others may say less. It is important that what the students write in the two-column tracker reflects their own thinking at that particular moment in time.
In the example Progress Tracker row for this lesson, each of columns has been completed with possible student ideas.

<table>
<thead>
<tr>
<th>Question</th>
<th>What I figured out in words/pictures</th>
</tr>
</thead>
</table>
| What is going on inside M'Kenna's body that is making her feel the way she does? | - M'Kenna has symptoms in all different parts of her body.  
- We don't know what's causing her to feel this way, and we all have different ideas about what's going on. |

Have students individually write down what they have figured out so far in their Progress Tracker.

### 8 · SHARE RELATED PHENOMENA

**MATERIALS:** chart paper

**Brainstorm related phenomena.** Prompt students to recall some of M'Kenna's symptoms. You may want to orient students to the *Doctor's Note* or the noticings in their science notebooks. Present slide H. After several students have shared out some of M'Kenna's symptoms, direct students to do a stop and jot in their notebooks about the questions on the slide.

Say, *As we are figuring out M'Kenna's case, it may help to think about other related cases. When have you or someone you know experienced more than one of these symptoms happening at the same time, like M'Kenna? If you knew the cause of the symptoms, was the cause occurring in the same body part as the symptom or in a different part of the body? For example, I had a headache and started to get tired, but what was actually causing it was that I didn't drink enough water (not actually something going on with my head).*

**ATTENDING TO EQUITY**

A key element of the Anchoring Phenomenon routine is letting students share their experiences with related phenomena. By doing this, students can connect their diverse experiences with the shared phenomenon that is the focus of the unit.
Have students turn and talk with a partner about their ideas before sharing out with the whole group (slide 1). Accept all student responses. Try to draw out a wide variety of related phenomena. Encourage students to consider how the related phenomena are similar to or different from M’Kenna’s case. Keep a public record of the related phenomena (you will revisit this poster in Lesson 8). You may also want to prompt students to keep a record of the related phenomena in their science notebooks. Some related phenomena may include these things:

- food allergies (lactose intolerance, gluten intolerance, and so forth)
- infection (virus or bacteria)
- intense exercise or overexertion
- asthma
- diabetes

We want students to figure out how M’Kenna’s body is being affected—what’s the underlying cause?—and that the body systems must be interacting or connected somehow. The class should wonder how these different body systems are interacting.

Conclude the discussion by saying, It seems like a lot of people in our class have experienced symptoms ourselves or know of someone that has experienced symptoms that are similar to M’Kenna’s. These symptoms seem to be happening in all different parts of our bodies and in different body systems! Sometimes, what might have been causing the symptoms was in the same part of our body where we experienced the symptoms and sometimes it was in a part of our body that seemed totally unrelated. It’s like the different parts of our body are interacting or working together in some way. Maybe if we can figure out how M’Kenna’s symptoms are connected, we can figure out how other symptoms in our bodies might be connected, too.

Before we started thinking about these related experiences, what we were trying to figure was just about M’Kenna, “What is going on inside M’Kenna’s body that is making her feel the way she does?” Now, in light of this broader set of things we are wondering about, it seems like we need to modify our question a bit. Perhaps something like, “How do things inside our bodies work together to make us feel the way we do?”

9 · DEVELOP INITIAL QUESTIONS

**MATERIALS:** index cards, tape, markers, science notebook

**Prepare for the Driving Question Board.** Remind students that we are going to try to capture all of our questions about what is going on with M’Kenna and all of these related experiences so that we can use our questions to guide our investigation into what is going on. To do this, we are going to build a Driving Question Board (DQB).

Prompt students to take out and review the following resources (in their science notebooks) as you show slide 1:

- M’Kenna’s Doctor’s Note
- Notice-Think-Wonder charts
- initial models
- list of related phenomena

After students have had a chance to review their resources, have students generate a list of questions that they have about M’Kenna’s case and other related cases. Students should record their questions on sticky notes—one question per sticky note. They should write their questions so that they are big and bold—so everyone can see the questions clearly.

Give students several minutes to populate their sticky notes with questions. In order to generate a diverse array of questions, it helps to have students think carefully about M’Kenna’s case and any other related phenomena. Encourage students to write questions about how all of these different symptoms might be connected.
10 · DRIVING QUESTION BOARD

**Materials:** index cards, tape, markers, science notebook, space for Driving Question Board

**Share questions to develop the Driving Question Board.** Next, begin the process of developing a shared DQB. Say the following prompt to students:

We have a lot of really good questions about M’Kenna’s case and other related cases. It is important that we hear everybody’s questions, and we might find that we have questions similar to some of our classmates’ questions. In order to help us group similar questions, we are going to create a Driving Question Board. We are going to use our DQB to guide our investigation into what is going on with M’Kenna and in our work of figuring out how stuff inside our bodies makes us feel the way we do.

**Instruct students to share their questions, one by one, with the whole group.** Explain to students how you will create the DQB (use slide K if needed):

- The first student reads his or her question aloud to the class, then posts it on the DQB.
- Students who are listening should raise their hands if they have a question that relates to the question that was just read aloud.
- The first student selects the next student whose hand is raised.
- The second student reads his or her question, says why or how it relates, and posts it near the question it most relates to on the DQB.
- The student selects the next student.
- Continue until everyone has at least one question on the DQB.

If the question is a new question and doesn’t fit with any questions that are already on the board, students should create a new cluster.

**Assessment Opportunity**

Student questions should seek to determine additional information, based on their observations, in order to identify the cause and effect relationships among different organ systems within the body in order to determine a diagnosis. As students share out their questions, work with them to form “how” and “why” questions. For example, someone might ask the question, “What is a stomach ulcer?” Say, That’s an interesting question! I wonder if we can work as a group to add to this question so that we have a “how” or “why” question around our phenomenon, too? Do you want to give it a shot? An example of an expanded question is, “What is a stomach ulcer and how could it cause symptoms like vomiting and diarrhea?”

**Cluster the questions.** After all students have shared their questions, you will end up with a DQB that has several different clusters of questions. As a class, decide on ‘umbrella’ questions or topics for the clusters of questions.

If you haven’t already done so, draw students’ attention to the scope of all the sub-questions that seem related to figuring out how things inside our bodies are connected. Propose and post this question at the top of the DQB as the driving question for all of the sub-questions under it: “How do things inside our body work together to make us feel the way we do?” Also, have students add the driving question at the top of their Progress Trackers.

**Attending to Equity**

First and foremost during the formation of the DQB is reinforcing a classroom community wherein all ideas are valued and everyone has a question up on the board. Use your judgement on how to press students to form “how” and “why” questions. If a student struggles with sharing, encourage them to go public with questions rather than focusing specifically on forming a “how” or “why” question.
Here is one example of the kinds of questions students might come up with.
11 · IDEAS FOR INVESTIGATIONS

**MATERIALS:** science notebook, Driving Question Board, chart paper

Brainstorm ideas for how to investigate M’Kenna’s case. Now that the class has created a Driving Question Board, tell students that it is time to really dig into the hard work of figuring out what is going on! Present slide L. Ask students the following:

What investigations could we do to help us figure out what is going on inside M’Kenna and to help us answer our questions?

Have students turn and talk about their ideas before sharing out with the whole group (slide M). Make a class record of the investigations. You may also want to prompt students to keep a record of the proposed investigations in their science notebooks.

**Possible Future Investigations**

- Eat foods and see what they do
- Test to see what is in food
- Wash up food and put stomach acid on it
- Camera inside of M’Kenna
- Research what the digestive system is

**SUPPORTING STUDENTS IN ENGAGING IN ASKING QUESTIONS AND DEFINING PROBLEMS**

In addition to generating a list of possible investigations, the primary goal of this step is to develop coherence as we lead into Lesson 2. In Lesson 2, students will examine M’Kenna’s endoscopy report. For that reason, it is important that the idea of “looking inside” M’Kenna’s digestive system emerges during this discussion. If students bring up the idea of “seeing” inside M’Kenna’s digestive system, push on the idea by saying, How might we be able to see inside? How could we know more about what is happening inside M’Kenna’s digestive system?

Student questions should incorporate observations made from M’Kenna’s Doctor’s Note, the initial model, and prior knowledge of the phenomena. Their questions should identify additional information required to determine a possible diagnosis for M’Kenna’s condition. After developing the Driving Question Board, they should generate possible investigations that would enable them to answer their questions.

12 · UPDATE THE TABLE OF CONTENTS

**MATERIALS:** science notebook

Update the table of contents with students. Say, Before we start on one of our investigation ideas, let’s organize the work we have done so far.
Show slide N. Remind students to reserve at least 4 pages (8 pages front-to-back) for the table of contents for a single unit. After the table of contents, they should reserve the next 10 pages (20 pages front-to-back) for their Progress Tracker for the unit. This is the place where students will individually reflect on their progress and also add key consensus modeling work completed by the class.

**SCIENCE NOTEBOOK**

For more information on Science Notebook Management, refer to this section of the OpenSciEd Teacher Handbook.

Organize the table of contents. Have students update their table of contents and page numbering to include references to all the work they have done so far. Use a poster to develop a sample table of contents with students to show one way to name the work they have in their notebooks and reference the pages related to each part of that work. Remember to have students start the page numbering — and only make a table of contents for the work to be completed — after the 10 pages reserved for their Progress Tracker section.

Have students finish numbering the rest of the pages of their notebook.

**SCIENCE NOTEBOOK**

You may also want to remind students to update their notebook on days when you have some extra time available. It is recommended that you make time to have students update the table of contents whenever they are adding to their Progress Tracker for the unit. This will happen individually at the end of most lessons and collectively at other key points in the unit.

This periodic time for organization helps students look back on the trajectory of their learning journey. For many students, this is a helpful way to support coherence.

### 13 · NAVIGATION

**MATERIALS:** None

Decide where to go next. Conclude the lesson by working with students to decide next steps.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where did most of M’Kenna’s symptoms sound like they were coming from?</td>
<td>Inside of her body</td>
</tr>
<tr>
<td></td>
<td>Her digestive system</td>
</tr>
<tr>
<td>What symptoms started happening first?</td>
<td>Her digestive symptoms started before the others.</td>
</tr>
<tr>
<td>Where do you think it makes sense to start our investigations?</td>
<td>Maybe we can look inside her body in some way?</td>
</tr>
<tr>
<td></td>
<td>Maybe we should start with her digestive system?</td>
</tr>
</tbody>
</table>

Summarize for the class, We were also thinking it would be useful to be able to “see” inside M’Kenna’s digestive system. Doctors have tools to do that these days. They can put small cameras into patients’ bodies to see what is going on inside of them. If doctors used one of these cameras and put it down through M’Kenna’s digestive system, I wonder what we would see? Let’s start here tomorrow.
Collaborative discussions (one-on-one, in groups, and teacher-led) are embedded in nearly every lesson of this unit. There are many opportunities to connect with CCSS.ELA-LITERACY.SL.6-8.1: “Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6-8 topics, texts, and issues, building on others’ ideas and expressing their own clearly.”
Exploring a Real Case About a Girl Who Gets Sick

We will hear a real case study about a girl, M’Kenna, who has recently started feeling sick all the time. Her primary complaints are that her stomach hurts after she eats and that she has diarrhea and stomach cramping.

Audio clip of M’Kenna’s symptoms: https://youtu.be/zGNxUJcSkMA

Turn and Talk

Knowing that M’Kenna’s primary complaints are that her stomach hurts after she eats and that she has diarrhea, are there other symptoms you might expect M’Kenna to have as well?

M’Kenna’s Doctor’s Note

Make a T-chart in your science notebook.

Notice

M’Kenna’s symptoms to her body systems: Write each symptom on the body system you think it is affecting.

Wonder

What does this make you wonder about M’Kenna and her symptoms?

Developing Initial Models

Develop an initial model. Use pictures, symbols, and words in your model to further explain:

“How can M’Kenna be having symptoms in all of these different parts of her body?”

Additional guidance:

- How could all of those symptoms in different body systems be happening at the same time?
- Why did some symptoms start happening before others?
- It may be useful to think about a healthy person compared to M’Kenna. You may wish to show the differences using different colors.

Sharing Our Initial Models

Make a T-chart in your science notebook titled, “Comparing our models” to record similarities and differences between models.
Write down similarities and differences between models in your notebook first with a partner, then during a silent gallery walk.

- Leave your model at your seat.
- Walk to another student’s model.
- Record similarities and differences you see about the ideas in the model.
- Wait until I say “go” to find another model.

Sharing Our Initial Models

Individually Plan

Silently choose a norm from the norms chart that you will intentionally work on and monitor today to help our learning community grow stronger and more productive for everyone.

Initial Consensus Model in a Scientists Circle

- What do we all seem to agree on?
- What do we disagree on?
- What are some new ideas that we may want to consider?

Progress Trackers: What have you figured out?

- Keep track of the important discoveries you make during this unit.
- Write the question we are working on in the left column:
  1. What’s going on with M’Kenna’s body that is making her feel the way she does?
- Write what you have figured out so far in the column on the right.

Count off 4 pages in your science notebook. Then create a T-chart under the heading “Progress Tracker.” Leave some space after the heading.
Stop and Jot then Turn and Talk

1. When have you or someone you know experienced more than one of these symptoms happening at the same time like M’Kenna?

1. If you knew the cause of the symptoms, was the cause occurring in the same body part as the symptom or a different part of the body? For example, I had a headache and started to get tired, but what was actually causing it was that I didn’t drink enough water (not actually something going on with my head).

What questions do you now have?

Look back at
➔ your Notice-Think-Wonder notes about the Doctor’s Note,
➔ your initial model, and
➔ our list of related phenomena.

Take a minute to review these to find questions that you have about the phenomena we have explored so far (including any of our related phenomena).

Driving Question Board (DQB)

Let’s build our Driving Question Board (DQB).

1. The first student reads his or her question aloud to the class, then posts it on the DQB.
2. Students should raise their hands if they have a question that relates to the question that was just read aloud.
3. The first student selects the next student whose hand is raised.
4. The second student reads his or her question, says why or how it relates, and posts it near the question it most relates to on the DQB.
5. The student selects the next student.
6. We will continue until everyone has at least one question on the DQB.

Ideas for Investigations

What investigations could we do to help us figure out what is going on inside M’Kenna and to help us answer our DQB questions?

With a partner, add ideas to a new notebook page titled: Ideas for future investigations and data we need.
What investigations could we do to help us figure out what is going on inside M'Kenna and to help us answer our DQB questions?

Share your ideas for investigations with the whole class.

Add the titles and page numbers to the table of contents to include all of the work we have done so far.
Lesson 1: What is going on inside M'Kenna's body that is making her feel the way she does?

Exploring an Interesting Phenomenon

We will hear about a real case study from a 13-year-old girl, M'Kenna, who has recently started feeling sick all the time. Her primary complaints are that her stomach hurts after she eats and that she has diarrhea and stomach cramping.

1. Knowing that M'Kenna's primary complaints are that her stomach hurts after she eats and that she has diarrhea, are there other symptoms you might expect M'Kenna to have as well?

Make Observations of the Doctor's Note

2. Create a table in your science notebook.

<table>
<thead>
<tr>
<th>Notice</th>
<th>Wonder</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Make observations about M'Kenna's Doctor's Note. What do you NOTICE?
4. Where do you THINK each symptom might occur in M'Kenna's body? Write each symptom on the body system you think it is affecting Map M'Kenna's Symptoms to Her Body Systems.

5. What does this make you WONDER about M'Kenna and her symptoms?

With a partner

6. Share your Notice-Think-Wonderings with a partner and add to them.
Develop Initial Models

On your own 8. Develop an initial model to explain: “How can M’Kenna be having symptoms in all of these different parts of her body?” Use pictures, symbols, and words.
Additional guidance:
- How could all of those symptoms in different body systems be happening at the same time?
- Why did some symptoms start happening before others?
- It may be useful to think about a healthy person compared to M’Kenna. You may wish to show the differences using different colors.

Share Our Initial Models

Turn and talk 9. Make a T-chart in your science notebook titled, “Comparing our models.”
10. Write down similarities and differences between you and your partner’s models in your notebook.

With your class 11. Compare models during a silent gallery walk.
- Leave your model at your seat.
- Walk to another student’s model.
- Record similarities and differences you see about the ideas in the model.
- Wait until your teacher says “go” to find another model.

Initial Consensus Model in a Scientists Circle

With your class 12. Develop a whole-group record of what we agree on and where we have competing ideas across the initial models.
- What do we all seem to agree on?
- What do we disagree on?
- What are some new ideas that we may want to consider?

Progress Trackers: What have you figured out?

In your notebook 13. Count off 4 pages in your science notebook. Then create a T-chart under the heading “Progress Tracker.” Leave some space after the heading.
14. Keep track of the important discoveries you make during this unit in your Progress Tracker.
- Write the question we are working on in the left column:
  - What’s going on with M’Kenna’s body that is making her feel the way she does?
- Write what you have figured out so far in the column on the right. You can write in pictures or words. Take as much space as you need to record your thoughts.
Share Related Phenomena

On your own

15. Write about when you or someone you know experienced more than one of these symptoms happening at the same time, like M’Kenna.

16. If you knew the cause of the symptoms, was the cause occurring in the same body part as the symptom or a different part of the body?

   *For example, I had a headache and started to get tired, but what was actually causing it was that I didn’t drink enough water (not actually something going on with my head).*

Be ready to share these ideas with others.

Turn and talk

17. Share your related experiences with a partner, then share them out loud with the whole class.

Develop Questions

On your own

18. Look back at:
   - your Notice-Think-Wonder notes about the Doctor’s Note,
   - your initial model, and
   - our list of related phenomena.

19. Take a minute to review these to find questions that you have about the phenomena we have explored so far (including any of our related phenomena).

   - Write one question per index card.
   - Write in marker—big and bold.
   - Put your initials on the back in pencil.
   - Write only one question per card.

Driving Question Board

With your class

20. Bring your index cards with questions to our Scientists Circle, along with your science notebook.

21. Build a Driving Question Board with your class.

   - The first student reads his or her question aloud to the class, then posts it on the DQB.
   - Students should raise their hands if they have a question that relates to the question that was just read aloud.
   - The first student selects the next student whose hand is raised.
   - The second student reads his or her question, says why or how it relates, and posts it near the question that it most relates to on the DQB.
   - The student selects the next student.
   - We will continue until everyone has at least one question on the DQB.
Ideas for Investigations

With a partner  
22. Write what investigations we could do to help us figure out what is going on inside M’Kenna and to help us answer our DQB questions.
   - Add your ideas to a new notebook page titled, “Ideas for future investigations and data we need.”

With your class  
23. Share your ideas for investigations with your class.

Update Your Table of Contents

In your notebook  
24. Add the titles and page numbers to the table of contents to include all the work we have done so far.

Navigation

With your class  
25. Decide as a class which question you want to investigate next.
Transcript of M’Kenna’s symptoms

Narrator: Today you’ll hear about a girl named M’Kenna. She is a real person and was in middle school when she started to feel really sick. She was 13 years old when she first got sick. Her doctors were trying to figure out what was causing all of her symptoms. And we’re lucky enough to be able to hear from M’Kenna herself. So thank you, M’Kenna, for sharing your story with us! Can you tell us how you felt when you first started feeling bad?

M’Kenna: At first, I thought it was just an upset stomach, but then I started to throw up three times a week or more. And so then I started to get a sense that maybe this isn’t just a stomach bug. This is kind of embarrassing, but I also had a lot of diarrhea during this time and became very hungry; but I just couldn’t eat.

Narrator: Why wouldn’t you eat?

M’Kenna: It just made it worse. I’d throw it up, and I’d feel worse.

Narrator: Oh, OK. You said this was happening when you first started feeling bad. Did the symptoms change as you continued to feel sick?

M’Kenna: It got worse.

Narrator: Oh.

M’Kenna: I got tired all the time. I couldn’t play sports because I had muscle cramps, uh, my heart was pounding, and I was breathing really hard. As if I was out of shape, but I—I wasn’t. I was just so sick. I also started to fall asleep in class, and my head was really fuzzy. And, and towards the end I got really skinny and just couldn’t do anything ‘cause I wasn’t eating.

Narrator: I’ll bet you were scared! I know your parents were. M’Kenna, thanks for sharing your story and your medical information with us. Hopefully we can learn from your experience and figure out what is causing your body to have all these different symptoms.
Initial model

Build an initial model to explain the following question:

What is causing M’Kenna to have symptoms in all of these different parts of her body?

- Use pictures, symbols, and words to try to explain what is going on inside M’Kenna.
- How could all of these symptoms be happening in different body systems?
- Why did some symptoms start happening before others?
- Record questions that you have if you become stuck.
Map M’Kenna’s Symptoms to Her Body Systems

What parts of M’Kenna’s body are being affected? Map M’Kenna’s symptoms to where you THINK they occur. Write each symptom on the body system you think it is affecting.

- Record questions if you become stuck.
**M'Kenna’s Doctor’s Note**

Patient’s Name: **M’Kenna**  
Age: **13**

**Symptoms**

<table>
<thead>
<tr>
<th>Symptoms that started first</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔ Nausea</td>
<td>The patient complains that her stomach hurts after she eats and that she feels nauseated. Her parents say she eats regular meals but has suddenly started losing a lot of weight. The patient says she often 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>✔ Vomiting</td>
<td></td>
</tr>
<tr>
<td>✔ Abdominal cramps</td>
<td></td>
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<tr>
<td>✔ Diarrhea</td>
<td></td>
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<tr>
<td>Constipation</td>
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</table>

<table>
<thead>
<tr>
<th>Symptoms that started later</th>
<th></th>
</tr>
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<tbody>
<tr>
<td>✔ Fever</td>
<td></td>
</tr>
<tr>
<td>✔ Fatigue</td>
<td></td>
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<tr>
<td>✔ Weight loss</td>
<td></td>
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<tr>
<td>Fainting</td>
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<tr>
<td>Weight gain</td>
<td></td>
</tr>
<tr>
<td>Back pain</td>
<td></td>
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<tr>
<td>Leg pain</td>
<td></td>
</tr>
<tr>
<td>✔ Muscle cramps</td>
<td></td>
</tr>
<tr>
<td>✔ Rapid heartbeat with exercise</td>
<td></td>
</tr>
<tr>
<td>Swollen joints</td>
<td></td>
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<tr>
<td>Difficulty walking or moving</td>
<td></td>
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<tr>
<td>Confusion</td>
<td></td>
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<tr>
<td>Dizziness</td>
<td></td>
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<tr>
<td>✔ Brain fog or difficulty concentrating</td>
<td></td>
</tr>
<tr>
<td>Headaches</td>
<td></td>
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<tr>
<td>Numbness</td>
<td></td>
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<tr>
<td>Slow heartbeat</td>
<td></td>
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<tr>
<td>Cold feet or hands</td>
<td></td>
</tr>
<tr>
<td>Chest pain</td>
<td></td>
</tr>
<tr>
<td>High blood pressure</td>
<td></td>
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<tr>
<td>✔ Difficulty breathing with exercise</td>
<td></td>
</tr>
<tr>
<td>Difficulty breathing all the time</td>
<td></td>
</tr>
<tr>
<td>Chest pain</td>
<td></td>
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<tr>
<td>Wheezing</td>
<td></td>
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<tr>
<td>Asthma</td>
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</tbody>
</table>
## Science Classroom Norms

<table>
<thead>
<tr>
<th>Classroom Norms</th>
<th>Descriptions</th>
</tr>
</thead>
</table>
| **Respectful**                                       | - Our classroom is a safe space to share.  
- We provide each other with support and encouragement.  
- We share our time to talk. We do this by giving others time to think and share.  
- We critique the ideas we are working with, but not the people we are working with. |
| **Equitable**                                        | - Everyone’s participation and ideas are valuable.  
- We monitor our own time spent talking.  
- We encourage others’ voices who we have not heard from yet.  
- We recognize and value that people think, share, and represent their ideas in different ways. |
| **Committed to our community**                       | - We come prepared to work toward a common goal.  
- We share our own thinking to help us all learn.  
- We listen carefully and ask questions to help us understand everyone’s ideas.  
- We speak clearly and loud enough so everyone can hear. |
| **Moving our science thinking forward**              | - We use and build on other’s ideas.  
- We use evidence to support our ideas, ask for evidence from others, and suggest ways to get additional evidence.  
- We are open to changing our minds.  
- We challenge ourselves to think in new ways. |
LESSON 2: Can we see anything inside M’Kenna that looks different?

PREVIOUS LESSON
We analyzed M’Kenna’s Doctor’s Note and developed initial models to explain how M’Kenna can be having symptoms in all of these different places in her body. We created a Driving Question Board and brainstormed ideas for investigations. We concluded that we want to be able to “see” inside M’Kenna’s digestive system to figure out what is going on.

THIS LESSON
INVESTIGATION
We examine M’Kenna’s endoscopy report and look at 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 that some of the food that M’Kenna eats is not leaving her small intestine. We add our new ideas to our initial models and our Driving Question Board. We decide we want to know more about what is going on in M’Kenna’s small intestine and what could be happening to the food that seems to be going away.

NEXT LESSON
We will conduct an investigation to determine how molecules could be absorbed into the body from the small intestine. We will find that really small food molecules can cross membranes, but large food molecules cannot.

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
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.

WHAT STUDENTS WILL FIGURE OUT
• The digestive system is made up of different parts called organs. The different organs have similarities and differences in their structures.
• M’Kenna’s small intestine doesn’t look the same as a healthy one.
• In a healthy person, many different substances in a graham cracker decrease as they travel through the small intestine.
• Some substances in M’Kenna’s small intestine decrease, but others do not decrease as much compared to a healthy person.
<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>NAVIGATION Students review some of the artifacts that the class created and notice that we seem to zero in on the digestive system as a key player for what might be going on with M’Kenna. The class decides that they need to know a little more about the digestive system.</td>
<td>A</td>
<td>Students’ completed Initial model, consensus model</td>
</tr>
<tr>
<td>2</td>
<td>10 min</td>
<td>LOOK AT STRUCTURES OF THE DIGESTIVE SYSTEM</td>
<td>B-C</td>
<td>Analyzing Endoscopy Images</td>
</tr>
<tr>
<td>3</td>
<td>15 min</td>
<td>ANALYZE ENDOSCOPY IMAGES USING THE COMPUTER INTERACTIVE Students engage with the interactive to compare organs in a healthy person’s digestive system and M’Kenna’s digestive system.</td>
<td>D-E</td>
<td>Analyzing Endoscopy Images, Students will need access to the computers that are connected to the internet in order to view and use the interactive, <a href="http://bit.ly/tour-digestive-system">http://bit.ly/tour-digestive-system</a></td>
</tr>
<tr>
<td>4</td>
<td>15 min</td>
<td>BUILDING UNDERSTANDINGS DISCUSSION Build some agreement that there seems to be something wrong with M’Kenna’s small intestine. Motivate the next investigation, which is to follow the food through the small intestine.</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>5 min</td>
<td>NAVIGATION Help students focus on the question, “What happens to food in the small intestine?”</td>
<td>G</td>
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</tr>
<tr>
<td>6</td>
<td>22 min</td>
<td>INTERPRET GRAPHS OF FOOD IN THE SMALL INTESTINE Students examine data showing what happens when food passes through the digestive system of a healthy person as compared to that of M’Kenna’s. They realize that some food isn’t leaving M’Kenna’s small intestine.</td>
<td>H-J</td>
<td>What happens in the small intestine?</td>
</tr>
<tr>
<td>7</td>
<td>8 min</td>
<td>ADD TO THE PROGRESS TRACKER Update the two-column Progress Tracker with students to summarize what they have figured out in this lesson.</td>
<td>K</td>
<td>Progress Tracker</td>
</tr>
<tr>
<td>8</td>
<td>10 min</td>
<td>INITIAL IDEAS AND NEXT STEPS Students share initial ideas about what is happening to the molecules that seem to be disappearing in the small intestine and how they might go about investigating them.</td>
<td>L</td>
<td></td>
</tr>
</tbody>
</table>

End of day 1

End of day 2
Lesson 2 • Materials List

<table>
<thead>
<tr>
<th>Lesson materials</th>
<th>per student</th>
<th>per group</th>
<th>per class</th>
</tr>
</thead>
<tbody>
<tr>
<td>science notebook</td>
<td>•</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What happens in the small intestine?</td>
<td>•</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Progress Tracker</td>
<td>•</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students’ completed Initial model</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>consensus model</td>
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</tr>
<tr>
<td>Students will need access to the computers that are connected to the internet in order to view and use the interactive</td>
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</tbody>
</table>

Materials preparation (30 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.

Make sure that there is a stable internet connection or that you have downloaded the interactive http://bit.ly/tour-digestive-system to computers before class begins.

Engage with the interactive as a student would so that you will be able to anticipate some student responses to it.

Clear a space to display individual group models and the consensus model for use during class discussion.
Lesson 2 • Where We Are Going and NOT Going

Where We Are Going

Students are introduced to a second set of data related to the anchoring phenomenon. This lesson is essential as it lays the groundwork for the remainder of the unit. Students uncover key differences in the structure and relative amounts of food molecules in M’Kenna’s small intestine as compared to that of a healthy person. All these data sources suggest that there might be something that students can explain in terms of how the body processes, transports, and uses food molecules.

Students may come into this lesson with a wide variety of ideas about what is happening to the substances traveling through the digestive system. For example, substances moving through the digestive system can

- move into other parts of the body,
- travel to the next part of the digestive system,
- leave the body as waste,
- change into a different substance,
- be converted to energy, or
- disappear.

However, it is not necessary for students to come into this lesson with background information about the different body systems or anatomy of the digestive system organs. The goal of the performance expectations for this unit is to develop lines of evidence for how different organs and body systems work together to obtain the necessary matter and energy for growth and regular body functions.

This unit will reinforce the idea that matter and energy are different things and that matter doesn't disappear or appear.

Where We Are NOT Going

The system-level organization of the digestive system is emphasized in this lesson. There is no need for students to have a deep understanding of the anatomy of this system in order to gain understanding that the digestive system is a set of related organs that work together to perform a function. While students will be introduced to several organs in the digestive system, the focus will not be on the memorization of organs or a detailed study of their structures. The focus for this lesson is on determining which organ in M’Kenna’s system is not functioning like the healthy person's.
LEARNING PLAN for LESSON 2

1 · NAVIGATION

MATERIALS: Students' completed Initial model, consensus model

**Review the ideas for next steps generated in the previous lesson.** Present slide A and remind students that we just learned about M'Kenna who is really sick, and we think something might not be working right in her digestive system.

Review the consensus model that was created by the class and remind students that we seemed to zero in on the digestive system as a key player. Then review the questions on the DQB around her digestive symptoms and the ideas for investigations that the class came up with. Have students discuss the questions presented on the slide with a partner.

Say, **We have some suspicions that M'Kenna's symptoms seem to be somehow related to the digestive system. 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.**

2 · LOOK AT STRUCTURES OF THE DIGESTIVE SYSTEM

MATERIALS: Analyzing Endoscopy Images, science notebook

**Examine structures that are part of the digestive system.** Present slide B. Ask students which structures come to mind when they think of the digestive system.

<table>
<thead>
<tr>
<th>Suggested prompts</th>
<th>Sample student responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>What structures inside our bodies come to mind when you think of the digestive system?</td>
<td>Accept all answers. Students might know many of the following: mouth, throat, stomach, small intestine, large intestine, rectum, salivary glands, pharynx (this term is less likely to surface), teeth, and tongue.</td>
</tr>
</tbody>
</table>

Distribute copies of Analyzing Endoscopy Images. Present slide C.

Then say, **We have some pictures of those structures and some pictures of other structures that make up the digestive system, too. We wanted to take a closer look inside of M'Kenna's digestive system to see if we can find any evidence to support our thinking that her problems are centered in the digestive system. Before we look at actual images of M'Kenna's organs, let's take a look at some illustrations of the structures.**

Direct students to locate the first column in their worksheet and tell them to record what they notice about the structure of each of these parts of the digestive system. Allow time for students to individually examine the structures and record what they notice about them. Arrange students into small groups to share what they have noticed before having students share with the whole class.

**ASSESSMENT OPPORTUNITY**

This is an opportunity to determine prior knowledge and the similarities and differences between organs. Listen for students noticing the similarity that each organ is hollow inside based on the illustrations. However, you should avoid taking this as an opportunity to grade students on their understanding of these structures. It is more important to begin to determine how well students can analyze and draw comparisons using the illustrations.
**KEY IDEAS**

**Purpose of this discussion:** To orient students to the general organization and structures of the digestive system before they look at internal camera shots of real intestines. This discussion also lays the foundation for making connections to the crosscutting concepts of structure and function. Students will start noticing similarities and differences in the structures of the digestive system; and in Lessons 3-8, students figure out the function of these organs and how they relate to M'Kenna's case.

**Listen for these ideas:**
- All of the structures along the digestive tract seem to be hollow and tube-like.
- Accept all responses.

Look at Analyzing Endoscopy Images for some ideas that students might notice.

**ADDITIONAL GUIDANCE**

The term “organ” may have already been introduced and used by your students. Use the language that your students bring to the lesson. If students are using “organ,” ask them to explain what they mean by this term and consider adding it to the word wall at the end of the lesson as a “word we earned.” If students do not volunteer the word, let them know that the structures that we have been studying are called organs, and we can add this term to the word wall as “organs = structures inside the body.” Note: The class will build upon this definition in later lessons.

After students have finished discussing what they noticed by studying the illustrations, ask them the following questions to help motivate them to wonder what the structures of the digestive system look like inside of a human body.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you think that the diagrams you saw look the same way that organs do in the body?</td>
<td>No, these are simple drawings, and the body is more complicated. The body isn't perfect like in these drawings. They are also in black and white, and that's not what our actual body looks like in color.</td>
</tr>
<tr>
<td>What do you think doctors do when they want to get a better look at real organs inside of a healthy person?</td>
<td>They cut people open during surgery and look inside. Doctors use x-rays to look inside the body. Doctors use cameras to look inside the body and take pictures.</td>
</tr>
</tbody>
</table>

Draw out the idea that, since the digestive system is a continuous tube, doctors can use a camera to look inside the digestive system.

Tell students, M’Kenna’s doctors were also interested in seeing what M’Kenna’s digestive system looked like, so they used a procedure called an endoscopy, meaning they extended a camera on a long cable through McKenna’s mouth and captured images.

Share with the students that you were able to get the images!

We are going to look at two sets of images of the organs that we just studied. One set belongs to a healthy person and the other belongs to M’Kenna. You will compare each set of organs and see if you notice any differences between the healthy person’s organs and M’Kenna’s.
Use the suggested prompts to help students recall the ideas they had for figuring out what's wrong with M'Kenna's digestive system in particular.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>How would we (or doctors) decide if anything was different in M'Kenna's digestive system?</td>
<td>We could compare hers with someone who is healthy.</td>
</tr>
<tr>
<td>What are some things that the doctors might be looking for in the images?</td>
<td>We might see changes in color, swelling, scabs or cuts, or things that look like they are going away.</td>
</tr>
</tbody>
</table>

3 · ANALYZE ENDOSCOPY IMAGES USING THE COMPUTER INTERACTIVE

**MATERIALS:** Analyzing Endoscopy Images. Students will need access to the computers that are connected to the internet in order to view and use the interactive, http://bit.ly/tour-digestive-system

**Prepare to Analyze Endoscopy Images.** Present slide D. Orient students to what an endoscopy is by using the image on slide D. Tell students, Doctors performed an endoscopy procedure that took photographs at each of the locations in the diagram. We have endoscopy images in a computer interactive that we will use to look at the organs in M'Kenna and a healthy person to see if we can find any evidence that M'Kenna's digestive system might be the cause of her symptoms.

Arrange students in groups of 2-3 to engage with the interactive endoscopy report. Allow time for students to open the interactive http://bit.ly/tour-digestive-system and keep track of their noticings on the graphic organizer. Present slide E and have students return to Analyzing Endoscopy Images where they will record their observations from the endoscopy report.

Tell students, We will keep track of our observations using a data table that you will place in your notebooks.

Allow time for students to either tape the handout into their notebook, or to draw the data table into their notebooks. When examining the endoscopy reports, students make sense of data by recognizing similarities and differences between a healthy digestive system and M'Kenna's. This will help students support their idea that M'Kenna's symptoms are centered in the digestive system.

ADDITONAL GUIDANCE

Students will examine images of the digestive system to determine if they can recognize similarities and differences between the structures that make up the system. Encourage students to be thorough in their examination of the images, but try to steer them away from getting too focused on subtle differences between the organs.

For example, some students might note that M'Kenna's esophagus picture looks slightly redder than the healthy esophagus. They can record this if they like, as some of them may make a connection between the redness and inflammation or some type of irritation. However, the differences between the images of the small intestine (both beginning and middle) are more striking. If students are noting both subtle and major differences, encourage them to record which differences are slight and which are more pronounced.

**ATTENDING TO EQUITY**

For those students whom you know will benefit from additional support with image analysis, gather them into a small group to facilitate a more structured analysis of the endoscopy images. You may elect to open the invitation to the whole class for those who would like additional guidance.

Support students in their analysis by providing the following steps:

1. Have students examine the pictures closely one at a time, paying attention to color, shape, size, and anything that strikes them as notable.

2. After a couple minutes, invite students to independently write down what they observed without making any interpretations.

3. Ask students, “what questions do you have about these images?” and have them ask as many questions as they can come up with.

4. Lead students in a discussion of their questions, guiding them to write down any ideas that they think are important.
Building Understandings Discussion.

Present slide F and have students come to the front and show which organ they are discussing as they share what they noticed while comparing the organs. Use the prompts below to help students recognize that a lot of us saw that the small intestine seems to look different in M’Kenna compared to a healthy person.

**KEY IDEAS**

**Purpose of this discussion:** By the conclusion of this discussion, students will be able to recognize that the beginning and the middle of M’Kenna’s small intestine is different from a healthy person’s. Students should not necessarily be able to explain what, exactly, is wrong with the small intestine and how it is impacting M’Kenna because they do not have enough evidence to do so yet.

**Listen for these ideas:**
- The coloring of both are similar, and the lining of some of the organs looks similar. There were ridges in some structures.
- M’Kenna’s small intestine looks smooth compared to the healthy person’s.

**Suggested prompts**

<table>
<thead>
<tr>
<th>Suggested prompts</th>
<th>Sample student responses</th>
<th>Follow-up questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>What inside of M’Kenna’s digestive system looks similar to the healthy patient?</td>
<td>The coloring of both are similar and the lining of some of the organs looks similar. They had ridges.</td>
<td>Where, in the endoscopy report, did you see that?</td>
</tr>
<tr>
<td>What inside of M’Kenna’s digestive system looks most different from the healthy patient’s?</td>
<td>M’Kenna’s small intestine looks very pale and smooth compared to the healthy person’s.</td>
<td>Where, in the endoscopy report, did you see that?</td>
</tr>
<tr>
<td>Which organ(s) do you suspect is the problem?</td>
<td>The beginning and the middle of the small intestine seem to be the problem.</td>
<td>What is it about the structures that makes you think that this organ is the source of the problem?</td>
</tr>
</tbody>
</table>

Ask students to let you know if they agree with the information they just heard or if they have any additional ideas they would like to share. Students can be encouraged to provide more detail about what they saw and what that made them think.

**ADDITIONAL GUIDANCE**

Students will find that the organ in M’Kenna’s system that is most different from the healthy person’s is the small intestine. This may lead them to believe that they have found the cause of M’Kenna’s problems. However, it is important to help students understand that they will need additional evidence before they can draw that conclusion because it is possible that M’Kenna’s small intestine might happen to look different.

**STRATEGIES FOR THIS BUILDING UNDERSTANDINGS DISCUSSION**

It is important to remember that Building Understandings Discussions are not necessarily focused on arriving at a full consensus. Rather, students should arrive at some sense of agreement that there is a structural difference in the small intestine, even if they also identify structural differences in other organs.

**SUPPORTING STUDENTS IN DEVELOPING AND USING STRUCTURE AND FUNCTION**

Students examined the structures of the digestive system, comparing a healthy one with M’Kenna’s. They identified differences in the shape of the small intestine, which may lead to changes in function. In a future lesson, students will examine the microscopic structures of the small intestine.

**SUPPORTING STUDENTS IN ENGAGING IN ANALYZING AND INTERPRETING DATA**

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. After examining the endoscopy images, students will examine a second set of data What happens in the small intestine?
Motivate needing more information about what the small intestine does.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where does the food go after it is in the small intestine?</td>
<td>It looks like it goes to the large intestine after the small intestine.</td>
</tr>
<tr>
<td>What's the purpose of the small intestine?</td>
<td>I am not completely sure what the small intestine does, but I see that food changes in the small intestine of a healthy person.</td>
</tr>
<tr>
<td>Does the structure of the tube have anything to do with its function?</td>
<td>The tube is like a path for food as it goes through the body.</td>
</tr>
<tr>
<td>Just because the structures look different, do you think that's the cause of M'Kenna feeling sick? Or could it just be a coincidence?</td>
<td>Yeah, it could be the cause. It's kind of like a clue.</td>
</tr>
<tr>
<td>Do you think we have enough evidence to say that this is the cause of M'Kenna's issues?</td>
<td>I'm not really sure; it could just be random differences between different people, too.</td>
</tr>
<tr>
<td></td>
<td>No, this probably isn't enough evidence.</td>
</tr>
<tr>
<td></td>
<td>We can't claim that the different looking structures are the cause just yet. We need something else to really say we have the cause of her symptoms.</td>
</tr>
</tbody>
</table>

Say, We have some ideas that something is going on in one particular organ, the small intestine, but we need to figure out more about what the small intestine does. I have some data about what is happening to food as it passes through M'Kenna's small intestine.

End of day 1

5 · NAVIGATION

**MATERIALS:** None

Motivate the looking at the small intestine data. Present slide G to help students focus on the question, “What happens to food in the small intestine?” If the idea of figuring out what happens to the food comes up naturally in the discussion, continue to push on the idea by using the prompts below. If the idea hasn't already come up, you may utilize the prompts below to motivate looking more into the small intestine.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>What did we figure out last class?</td>
<td>We figured out that it looks like there is something off with M'Kenna's small intestine.</td>
</tr>
<tr>
<td>Do we know what is wrong or how it could be impacting M'Kenna?</td>
<td>Sort of. It looks smooth and the healthy small intestine looks bumpy. It's probably impacting her digestion.</td>
</tr>
</tbody>
</table>
### 6 · INTERPRET GRAPHS OF FOOD IN THE SMALL INTESTINE

**MATERIALS:** What happens in the small intestine?, science notebook

**Introduce and prepare for the I² sensemaking strategy** Tell students, “We have estimates of the average percentage of breakdown of food molecules of a graham cracker as it is passing through the digestive system for a healthy person and M’Kenna. The relative amounts of each substance is shown in graph form. You should look to see if there are any patterns that seem to indicate that one substance is increasing while another one is decreasing at the same rate. We are going to look at some of those graphs next.”

**Present slide H** to students and explain how to use I² to analyze and interpret data. Students will be analyzing food molecule graphs several times throughout this unit. This activity has extra time allotted to help students get used to using the I² sensemaking strategy for the first time. You also can have students take some time using I² sensemaking strategy on their own, before putting them into groups.

**Arrange students into groups of two or three.** Pass out to each student a copy of What happens in the small intestine?, and have students tape it into their science notebook.

**Make observations of the graphs using “What I see” statements.** Prompt students to write “What I see” statements while in their small groups. Remind students to write directly on the graphs, drawing arrows to their observations. Complete one or two “What I see” examples with the students, then allow them to continue on their own. After about four minutes, bring students together to discuss their observations of the graphs (e.g., What did you notice? Did anybody else notice something similar?). Focus the discussion on what the eight bars are and the differences in the glucose and complex carbohydrates bars. Then broaden to other observations students make. Students can mention observations about the healthy data, M’Kenna’s data, or comparisons between the two.

**Interpret observations using “What it means” statements.** Present slide I and have students write “What it means” statements next to each of their “What I see” statements. These statements are students’ initial explanations of what they think is happening to cause the change in data. Give groups four minutes to work on their interpretations then have several groups share their interpretations aloud. Probe deeper into a few of the interpretations, specifically about the disappearance of many of the bars in the healthy system but not in M’Kenna’s.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you think happens to M’Kenna’s food when it gets to her small intestine?</td>
<td>We aren’t sure. I wonder if we could figure out what happens. Is there any way to see what happens to her food compared to that of a healthy person?</td>
</tr>
</tbody>
</table>

When students start discussing the idea of looking more into the small intestine say, “Following the food through the small intestine is another way that we might be able to figure out what is going on. Data from different food samples in M’Kenna’s case were compiled in the form of graphs that show some information about what happens to food in the small intestine. Should we take a look?”

**SUPPORTING STUDENTS IN ENGAGING IN ANALYZING AND INTERPRETATING DATA**

Students will use the Identify and Interpret (I²) sensemaking strategy to analyze the graph. If this is their first time using this strategy, consider modeling one observation (“What I see”) and one interpretation (“What it means”) with your students before they begin small-group work. This strategy helps students break down an information-rich graph into smaller pieces to interpret which will allow them to use the data to provide evidence for a phenomenon.

**SUPPORTING STUDENTS IN DEVELOPING AND USING PATTERNS**

Be sure to emphasize the portions of the questions in which students are asked, “... and how did you explain it?” This discussion should extend beyond simply reporting what students saw in the data. Students should use the patterns they have identified in the data and images to begin to identify cause and effect relationships in order to explain the differences between the healthy digestive system and M’Kenna’s. At this point in the unit, students will likely struggle to explain what they are seeing, but it is helpful to continually push them to try to explain why something might be happening.
Make sense of the patterns in the data. Facilitate a discussion by following the graham cracker through the small intestine. This discussion can piggyback off of the sharing of “What it means” statements but with the intention of steering the students toward noticing certain patterns if they have not yet emerged during discussion. Project slide J so that the class can see the graphs for the beginning of the small intestine and the middle of the small intestine as they discuss.

At this point, organize the conversation more specifically around what students already know about these different substances and their molecules; and how they would explain the changes they observe in relative amounts of these in a healthy person as compared to in M’Kenna (pointing students to green bars for healthy data and orange bars for M’Kenna’s data). Use the suggested prompts below. *

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do we already know about all these different substances?</td>
<td>We’ve heard of some of these things before, like protein, fat, water, and complex carbohydrates. We know they are the stuff in the food. We’re not sure about the amino acids, fatty acids, and glucose.</td>
</tr>
<tr>
<td>Do you think there was any reason for why they grouped certain substances together?</td>
<td>We’re not sure. We’ve seen complex carbohydrates before on nutrition labels. Fats and fatty acids are probably related to each other. Maybe one is a form of another?</td>
</tr>
<tr>
<td>What’s happening to the amount of water and fiber over time and how did you explain it (both green and orange bars)?</td>
<td>They stay the same for both M’Kenna and a healthy person. We think it might pass through the system.</td>
</tr>
<tr>
<td>What’s happening to the amount of these other types of molecules (protein, amino acids, fats, fatty acids, glucose, other complex carbohydrate) in a healthy person over time, and how did you explain it? (green bars)</td>
<td>Everything went down to zero in the middle of the small intestine, except fatty acids, which stayed the same, and glucose also went down, just not to zero. We think it is disappearing or maybe breaking down.</td>
</tr>
<tr>
<td>What’s happening to the amount of these other types of molecules (protein, amino acids, fats, fatty acids, glucose, other complex carbohydrate) in M’Kenna over time, and how did you explain it?</td>
<td>M’Kenna’s went down a little or stayed the same. She still had a lot of glucose and some complex carbohydrates in the middle of the small intestine. We think her body isn’t breaking them down or maybe isn’t taking them in.</td>
</tr>
</tbody>
</table>

Conclude the discussion by summarizing: It seems like some really important things are happening to some of these substances in the small intestine of a healthy person that appear to either not be happening or may not be happening as much in M’Kenna. Let’s keep track of this in our Progress Tracker.
7 · ADD TO THE PROGRESS TRACKER

MATERIALS: Progress Tracker

Provide time for students to update their Progress Tracker. Project slide K. Students will fill in their Progress Tracker with the lesson question and describe what they have figured out. This is a time for students to record their own thinking about what is happening inside of M’Kenna’s body.

While this is not a time to grade student responses, this does present an opportunity to formatively assess how well student understanding is moving towards the idea that the amount and type of food molecules change as they move through the digestive system. In a healthy person, food molecules seem to vanish from the small intestine, but they don’t vanish as much in M’Kenna.

Have students add these ideas to their Progress Trackers using words and pictures.*

<table>
<thead>
<tr>
<th>Question</th>
<th>What I figured out in words/pictures</th>
</tr>
</thead>
</table>
| How is M’Kenna’s digestive system different from a healthy person’s? | The digestive system is made up of different parts called organs. The different organs have similarities and differences in their structures. M’Kenna’s small intestine doesn’t look like a healthy one. It has bumps and is smoother than a healthy one (which has more ridges).
 |

In a healthy person, all the substances in a graham cracker seem to disappear as they travel through the small intestine, but these substances don’t decrease as much in M’Kenna.

8 · INITIAL IDEAS AND NEXT STEPS

MATERIALS: None

Discuss initial ideas about the question: What is happening to the molecules that seem to be disappearing? Many students will be wondering about this, and it is where we are headed next.

Focus students on the question for the next investigation. Emphasize that we know that matter can’t just disappear completely.

Project slide L and ask students to turn and talk with a partner to brainstorm ways we might investigate that question further.
<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
</table>
| We know that matter can't just disappear. What ideas do we have about what is happening to the molecules that are disappearing in the small intestine? | No, maybe something else is happening to it.  
They might be moving somewhere else, maybe traveling on through the digestive system to Location E (large intestine).  
It is moving somewhere else, maybe going through the walls of the intestine out of the digestive system. Maybe it's traveling into the blood vessels we saw under the surface?  
It is changing into something else?  
It is vanishing completely? |

What questions are you wondering about now?  
|                                                                              | Accept all answers.                                                                                                                                 |

Tell students, **We'll investigate all these possibilities in the unit and a good next step would be to start looking into one of them.** Foreground the idea that one possibility you heard was that food is somehow moving into the body as it travels through the small intestine.

**Update the table of contents.** Have students update the table of contents in their science notebook.

**ASSESSMENT OPPORTUNITY**  
Have students record their ideas from the Turn and Talk as an optional exit ticket. Though the prompt and anticipated responses are geared toward helping students brainstorm initial ideas, looking at students’ responses can be helpful for you in gauging how to adjust the navigation routine at the start of the next lesson. This can help you determine if you will need to add prompts for Lesson 3 to help students articulate and reason out why simulating the small intestine would make sense to pursue as a next investigation based on where we left off in our thinking last time. 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 as a navigation into the next lesson.
Lesson-Specific Teacher Materials
Lesson 2: Answer Key

**Key for Analyzing Endoscopy Images**

Examine the pair of endoscopy images from a healthy person and from M’Kenna at each location along the digestive tract.

1. Record your observations in the data table column “Observations of M’Kenna’s endoscopy images.” Use descriptive words to illustrate what you see.
2. Review the data you collected and decide whether M’Kenna’s organs look mostly similar to or very different from the healthy organs. Record your findings in the last column of the data table.

<table>
<thead>
<tr>
<th>Organ</th>
<th>What I notice from the illustrations</th>
<th>Observations of M’Kenna’s endoscopy images</th>
<th>Is M’Kenna’s image mostly similar or very different from the healthy person?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Esophagus</td>
<td>The esophagus looks like a hollow tube. It has a wavy inside lining.</td>
<td>Very pink and smooth with red blood vessels. The tube seems to close off in M’Kenna but not in the healthy person.</td>
<td>Mostly Similar</td>
</tr>
<tr>
<td>Stomach</td>
<td>The stomach looks like an empty sack. It has a tube on both ends that connect it to the esophagus, and it looks like it might be connected to the small intestine.</td>
<td>M’Kenna’s stomach is pale, and there are ridges on the inside lining. There are some smooth areas on M’Kenna’s that are not on the healthy person.</td>
<td>Mostly Similar</td>
</tr>
<tr>
<td>Beginning of small intestine</td>
<td>The beginning of the small intestine is a hollow wavy tube. It has a very wavy inside lining. It looks like it might be connected to the stomach.</td>
<td>M’Kenna’s seems lumpy and doesn’t have many ridges. The color is more red and irritated looking.</td>
<td>Mostly Different. The healthy small intestine doesn’t seem as red and irritated. There are ridges in the healthy patient that are not in M’Kenna. M’Kenna’s seem very swollen.</td>
</tr>
<tr>
<td>Middle of small intestine</td>
<td>The middle of the small intestine looks the same as the beginning of the small intestine.</td>
<td>M’Kenna’s is very pale and very smooth. The end seems to be pinched off.</td>
<td>Very Different. The healthy patient has lots of ridges, and it appears to be more moist than M’Kenna’s.</td>
</tr>
<tr>
<td>Large intestine</td>
<td>The large intestine is also hollow, but it looks bigger and lumpier than the small intestine.</td>
<td>M’Kenna’s is very pale and smooth with deep ridges and lots of blood vessels.</td>
<td>Mostly Similar</td>
</tr>
</tbody>
</table>
Last time, we met M’Kenna and learned that she was really sick and was having a lot of alarming symptoms. Many of these were in her digestive system.

**Discuss with a partner:**

What ideas did we have for ways to investigate what was going on with M’Kenna’s digestive system?

How would we (or doctors) be able to see if anything was different in M’Kenna’s digestive system?

What makes up the digestive system?

**Quick pair share**

Talk with a partner about the following question:

What structures inside our bodies come to mind when you think of the digestive system?

Look at the structure of the digestive system

1. What do you notice about the structure of these organs?
2. What are some things that you are wondering about?

M’Kenna’s Endoscopy Report

With your class discuss, “What is an endoscopy report?”

Patient name: M’Kenna
Age: 13
Sex: Female
Date: 10/26/15

Attending Physician: Dr. M. Campbell

Complaints: Patient complains of abdominal pain, nausea and vomiting, diarrhea, being tired and weak, and is losing a lot of weight.

Procedure: Upper GI Endoscopy

The endoscopy procedure took photographs at each of the locations in the diagram. Images reference endoscopy images for M’Kenna and a healthy patient.
Studying Endoscopy Images

Can we see anything inside of M’Kenna’s digestive system that looks different compared to a healthy digestive system?

Engage with the interactive version of M’Kenna’s Endoscopy Report. This is where you will examine images and make observations.

Add Lesson 2 - Student Handout 2 to your science notebook. This is where you will keep a record of your observations.

Use the interactive endoscopy report and record observations

Make sense of your observations


Making Sense of Endoscopy Images

1. What inside of M’Kenna’s digestive system looks the most different from the healthy patient?

1. What questions are you wondering about?

Navigation

Discuss with a partner:

What did we figure out last class?

Do we know what is wrong with M’Kenna or how it could be impacting her?

What do you think happens to M’Kenna’s food when it gets to her small intestine?

Analyzing data with the I² strategy - WIS

What happens to a graham cracker as it passes through M’Kenna’s small intestine versus a healthy person’s?

We’ll use the Identify and Interpret (I²) strategy to help us analyze graphs of food as it enters and reaches the middle of the small intestine.

First, make observations:

a. Draw an arrow to something you notice in the graphs.

b. Write “What I see” (or WIS), then write your observation in a complete sentence.

c. Share your observations.
What happens to a graham cracker as it passes through M'Kenna’s small intestine versus a healthy person’s?

Now, interpret your observations:
1. Think about what each observation means.
2. Write “What it means” (or WIM) and then add your explanation next to the observation.

Progress Trackers: What have you figured out?

- Write the question we are working on in the left column:
  1. How is M’Kenna’s digestive system different from a healthy person’s?
- Write what you have figured out so far in the column on the right. You can write in pictures or words. Take as much space as you need to record your thoughts.

Next Steps

Turn and Talk
1. What ideas do we have about what is happening to the molecules that are disappearing from the small intestine?
2. What questions are you wondering about now?

Take some time to update the table of contents in your science notebook.
Lesson 2: Can we see anything inside M’Kenna that looks different?

Navigation

Last time, we met M’Kenna and learned that she was really sick and was having a lot of alarming symptoms. Many of these were in her digestive system.

With a partner

1. Turn and talk with your partner about the following questions:
   - What ideas did we have for ways to investigate what was going on with M’Kenna’s digestive system?
   - How would we (or doctors) be able to see if anything was different in M’Kenna’s digestive system?

What makes up the Digestive System?

With a partner

2. Turn and talk with your partner about the following question:
   - What structures inside our bodies come to mind when you think of the digestive system?

Look at structures of the Digestive System

With your group

4. Examine a set of illustrations of a few structures that make up the digestive system.
   - Use Analyzing Endoscopy Images to record what you notice about similarities and differences between the structures.
5. Think about the following questions:
   - Do you think the diagrams you saw look the same as organs do in the body?
   - What do you think doctors do when they want to get a better look at real organs inside a healthy person?

M’Kenna’s Endoscopy Report

We have endoscopy images in a computer interactive that we will use to look at the organs in M’Kenna and a healthy person to see if we can find any evidence that M’Kenna’s digestive system might be the cause of her symptoms.

With your class

6. Examine M’Kenna’s endoscopy report and identify the organs in the digestive system that will be examined using the computer interactive.
Studying Endoscopy Images


Making Sense of Endoscopy Images

Can we see anything in M’Kenna’s digestive system that looks different compared to a healthy digestive system?

9. Turn and talk to your group about the following questions:
   - What inside M’Kenna’s digestive system looks most different from the healthy patient?
   - What questions are you wondering about?

Navigation

Focus on the question: “What happens to food in the small intestine?”

10. Turn and talk with your partner about the following questions:
    - Do we know what is wrong with M’Kenna or how it could be impacting her?
    - What do you think happens to M’Kenna’s food when it gets to the small intestine?

Analyzing data with the I^2 strategy - WIS

What happens to a graham cracker as it passes through M’Kenna’s small intestine versus a healthy person’s? We’ll use the Identify and Interpret (I^2) strategy to help us analyze graphs of food as it enters and reaches the middle of the small intestine.

Make observations of graphs of food as it enters and reaches the middle of the small intestine using the Identify and Interpret (I^2) strategy. Write “What I see” statements:

11. Draw an arrow to something you notice in the graphs.
12. Write “What I see” (or WIS)
13. Then write your observation in a complete sentence.
14. Share your observations.
Analyzing data with the I² strategy - WIM

15. Interpret what your observations mean.
16. Write “What it means” (or WIM) statements next to the observations.

Analyzing data with the I² strategy

17. Use the I² strategy to analyze the graph below or on the handout *What happens in the small intestine?* to see what is happening to the amount of these types of molecules as they enter the *beginning of the small intestine* in a healthy person and M'Kenna.

![Graph of Food Molecules](image)

18. Analyze the graph below or on the handout *What happens in the small intestine?* to see what is happening to the amount of these types of molecules as they enter the *middle of the small intestine* in a healthy person and M'Kenna.

![Graph of Food Molecules](image)
Progress Trackers: What have you figured out?

In your notebook

19. Set up your 2-column Progress Tracker.
   • Write the question in the left column (How is M’Kenna’s digestive system different from a healthy person’s?)
   • Write what you have figured out so far in the right column.

Next Steps

Turn and talk

20. Turn and talk to your partner about the following questions:
   • What ideas do we have about what is happening to the molecules that are disappearing from the small intestine?
   • What questions are you wondering about now?
Analyzing Endoscopy Images

Examine the pair of endoscopy images from a healthy person and from M’Kenna at each location along the digestive tract.

1. Record your observations in the data table column “Observations of M’Kenna’s endoscopy images.” Use descriptive words to illustrate what you see.
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<th>Observations of M’Kenna's endoscopy images</th>
<th>Is M’Kenna's image mostly similar or very different from the healthy person’s? If different, what are the differences?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Esophagus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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</tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>Large intestine</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What happens in the small intestine?

**Directions:** These graphs show what happens to food molecules in a graham cracker as they pass through the small intestine. Draw arrows to parts of the graph and write “What I see” (WIS) and “What it means” (WIM) notes in the space below.