Metabolic Reactions

Lesson 5-6

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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<td>M'Kenna, a 13-year-old girl, seems to be really sick and we aren't sure why. We notice she has symptoms in all different parts of her body and some symptoms started before others. We figure out:</td>
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<td>- We think that it has to do with her digestive system, but we have a lot of questions that we need to answer in order to figure out what is causing M'Kenna's symptoms.</td>
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<td>- We have some ideas for possible investigations we could pursue.</td>
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<td>M'Kenna's Doctor's Note describes the symptoms in different parts of her body.</td>
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**Navigation to Next Lesson:** We figured out that most of M'Kenna's symptoms were coming from her digestive system and that those symptoms started happening first. Also, we wondered if we could “see” inside M'Kenna’s body in some way. So, we want to somehow see inside her digestive system next.

| **LESSON 2**    |                            |                          |                     |
|                  |                            | 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. |                     |
|                  | There are differences between M'Kenna's small intestine and the small intestine from a healthy person. | |                     |

**Navigation to Next Lesson:** We have evidence that something is going on in M’Kenna’s small intestine. Also, the graphs showed that some food substances seem to disappear in a healthy small intestine. Where are they going? What is the small intestine doing with food molecules?
Lesson Question | Phenomena or Design Problem | What we do and figure out | How we represent it
--- | --- | --- | ---
**LESSON 3**
2 days
**Why do molecules in the small intestine seem like they are disappearing?**
Investigation
![Dialysis tube system of the small intestine allows small but not large molecules to pass through its walls.](image)
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).

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

---

**LESSON 4**
1 day
**What happens to food molecules as they move through the small intestine and large intestine?**
Investigation
![Data about what's in the large intestine of a healthy person shows that only water and fiber remain, but M'Kenna's large intestine still has other molecules, such as complex carbohydrates, glucose, and fatty acids.](image)
We investigate food data from the mouth to the large intestine and determine that (1) most of the molecules are gone by the time they reach the large intestine, and only fiber and water remain, and (2) M'Kenna has other molecules in her large intestine. We examine poop data to confirm what molecules should be expected. We figure out:
- As food moves through a healthy digestive system, food molecules disappear. We think they might be getting absorbed.
- Fiber always stays the same in the digestive system and leaves the body as poop.
- Most other molecules are gone when they reach the large intestine in a healthy person. Only fiber and water remain.
- M'Kenna's poop contains some additional food molecules (glucose, starch, fatty acids), too, which are not found in a healthy person's solid waste.

**Navigation to Next Lesson:** We figured out that fiber comes out of our bodies, but other complex carbohydrates, like starch, don't. Where are the other complex carbohydrates going? Is it changing somehow? Sometimes when we're not sure about what's going on in a system, we have to go back to the beginning. Our digestive system starts in the mouth, so maybe if we start there, that will help us.
LESSON 5

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.

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 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?

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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| LESSON 7        |                            | We developed a model to represent the inputs, processes, and outputs of the digestive system and the role that the system plays in breaking down matter through chemical reactions, absorbing food, and excreting unused matter. We constructed an argument, based on evidence, to eliminate two of five possible conditions that could be causing the symptoms that M'Kenna is experiencing in her digestive system. We figure out:  
- In a healthy digestive system, multiple subsystems, or organs, work together to help the body break large food molecules down into smaller food molecules.  
- Large food molecules are broken down into smaller food molecules through chemical reactions that occur in the mouth, stomach, and small intestine.  
- Each organ plays a different role in the breakdown of large food molecules.  
- In a healthy person, the small intestine absorbs the small food molecules that had been broken down in preceding organs in the digestive system. |
| 2 days          |                            |                           |                     |
| What is the function of the digestive system, and how is M'Kenna's digestive system different? | Putting Pieces Together | All previous phenomena |                     |

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

| 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:  
- 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. |
| 2 days          |                            |                           |                     |
| What does the surface of M'Kenna's small intestine look like up close compared with a healthy one? | Investigation | When you look closely at the lining of the small intestine, you see long finger-like projections. |                     |

» Navigation to Next Lesson: We argued from evidence why M'Kenna is experiencing many of her digestive symptoms. Now we are ready to answer some questions on our Driving Question Board.
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<td>1 day</td>
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<tr>
<td>How can a problem in one body system cause problems in other systems?</td>
<td><strong>Problematizing</strong></td>
<td>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?”</td>
<td>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.</td>
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**M’Kenna’s Doctor’s Note shows symptoms in other body systems.**

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<th>Why is M’Kenna losing so much weight?</th>
<th>Investigation</th>
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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 and see that they seem to disappear, too. We wonder what actually happens to fat when it burns? 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?

**When you burn fat, the matter seems to vanish.**

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Lesson Question | Phenomena or Design Problem | What we do and figure out | How we represent it
---|---|---|---
**LESSON 11**

2 days

*What happens to matter when it is burned?*

**Investigation**

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

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

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

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

**LESSON 12**

2 days

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

**Investigation**

> Percent saturation of gasses in the blood changes throughout the body.

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

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

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

2 days

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

Putting Pieces Together

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

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

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

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

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

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

LESSON 15

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

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.
TEACHER BACKGROUND KNOWLEDGE

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

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

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

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

This unit builds towards the following NGSS Performance Expectations (PEs):

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

This unit applies the following NGSS PEs in a new context:

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

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

The current version of the unit expands students’ understanding of metabolic reactions, which include these Grade 6-8 DCI elements:

**LS1.A Structure and Function**
- In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.

**LS1.B Growth and Development of Organisms**
- The growth of an animal is controlled by genetic factors, food intake, and interactions with other organisms, and each species has a typical adult size range.

**LS1.C Organization for Matter and Energy Flow in Organisms**
- Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.

**PS3.D Energy in Processes and Everyday Life**
Cellular respiration in plants and animals involves chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

- **CCSS.MATH.CONTENT.6.NS.C.8**: Solve real-world and mathematical problems by graphing points in all four quadrants of the coordinate plane.
- **CCSS.MATH.CONTENT.6.RP.A.2**: Understand the concept of a unit rate \(\frac{a}{b}\) 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

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<th>When</th>
<th>Assessment and Scoring Guidance</th>
<th>Purpose of Assessment</th>
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| Lesson 1      | Initial Model                   | **Pre Assessment**  
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.  
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. |
| Lesson 7      | Student (group sensemaking)     | **Formative**  
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.  
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. |
| Lesson 8      | Student Assessment              | **Summative+Formative**  
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.  
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. |
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| 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


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.

<p>| Lesson | Lesson-Level Performance Expectation(s) | Assessment Guidance |</p>
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| Lesson 1 | 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). | **Developing and Using Models; Cause and Effect; Systems and System Models**
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.

**Asking Questions; Cause and Effect**
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.

| Lesson 2 | 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. | **Analyze and Interpreting Data; Structure and Function; Systems and**
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.

**Analyze and Interpreting Data; Patterns**
Students should be examining the endoscopy images in an attempt to determine if there are any patterns in the images that will help support their idea that M’Kenna’s symptoms are centered in the digestive system. When attempting to determine if a cause and effect relationship exists, students need to realize that phenomena may have more than one cause and the fact that two events are happening at the same time doesn’t necessarily imply causation.

When students are analyzing the graph or food molecules in the small intestine, they will need to pay attention to the patterns in data that indicate that some of the molecules are not leaving M’Kenna’s small intestine. If some students are struggling with the data analysis, provide additional support by gathering them in a small group to facilitate a more structured analysis of the endoscopy images.
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<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 structure</strong> with properties similar to the walls of the <strong>small intestine</strong>. <strong>Argue from evidence to revise a model</strong> to show how the results of this investigation and graphs of different types of <strong>food molecules</strong> traveling through the <strong>small intestine</strong> explain how the <strong>structure</strong> of the walls impacts the <strong>function</strong> of the <strong>small intestine</strong>.</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. At the end of day 1, look at Part 2 of Dialysis Tube Investigation to see students make their predictions about which molecule(s) will go through the structure of the dialysis tube system. Look at the connections between student predictions and the reasoning they use to justify their explanations. Student answers will vary based on their ideas from Lesson 2. If students struggle to connect their predictions with reasoning, prompt them to think about why they set up the pieces of the dialysis tube system in the way they did. <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 <strong>different molecules in food</strong> as it <strong>moves through the digestive system</strong> 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><strong>Analyze and interpret data to identify a relationship</strong> within the data that shows that the amount of certain <em>food molecules (complex carbohydrates)</em> decrease, and other <em>food molecules (glucose)</em> increase as they move through the mouth, which is a <strong>correlational relationship</strong>. Students argue that we need more data to determine the <strong>cause</strong> of the observed increases and decreases in food molecules.</td>
<td><strong>Analyzing and Interpreting Data; Cause and Effect; Patterns</strong>&lt;br&gt;After analyzing data from eating a graham cracker on <em>Analyze Data from Eating a Graham Cracker</em>, 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.</td>
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<td><strong>Plan and conduct an investigation</strong> to produce data to determine whether <em>food containing complex carbohydrates, but not glucose</em>, undergoes a <strong>chemical reaction</strong> in the mouth and that this reaction turns the complex carbohydrates into <strong>glucose</strong> when mixed with a substance found in saliva (amylase), which is identified by a <strong>pattern change</strong> in the color of the food indicator.</td>
<td><strong>Planning and Conducting Investigations; Patterns</strong>&lt;br&gt;Students record their plans and findings from an investigation that they have planned and conducted on <em>Chemical Reactions in the Mouth Data Table</em>. Prior to conducting the investigation, check student work to make sure that they have planned an investigation similar to the one provided on <em>Unknown material with identifier: mr.15.tref</em>. After conducting the investigation and recording their results, check student work using <em>Unknown material with identifier: mr.15.tref</em> 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. Analyze and interpret these data as evidence that the digestive system is a system of interacting subsystems composed of organs that each perform different functions.</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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| Lesson 7 | **Develop a model** based on multiple lines of evidence to represent the inputs, processes, and outputs of the digestive system and the role that the system, and the **subsystems** within it, play in breaking down matter inputs through chemical reactions, absorbing food, and excreting unused matter. | **Developing and Using Models: Systems and System Models** Students will develop models throughout this lesson individually, in small groups, and as a whole group. Students should identify the following ideas in their models:  
- The digestive system is a long tube with different parts to it.  
- In one part of the digestive system, the small intestine, small food molecules are absorbed, and large food molecules aren’t.  
- Absorption means that the molecules cross the lining of the small intestine.  
- Fiber is not digested at all and is excreted from the body.  
- Large food molecules can be broken down into smaller food molecules.  
- In another part of the digestive system, the mouth, some types of complex carbohydrates are broken down into smaller pieces through chemical reactions.  
- Other types of food molecules (proteins and fats) are broken down in other parts of the digestive system (stomach and small intestine).  
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 developing their models. In addition to including ideas about the breakdown of food in the digestive system, make sure students are incorporating key ideas about systems and system models, specifically as they relate to the digestive system. Prompt students to include these ideas by asking questions, such as: “What are the inputs, processes, and outputs that you will need to include in your model?” and “How can we differentiate between the processes happening in different parts of the digestive system?” and “Why do the processes need to occur in different parts of the system?” After students develop their Gotta-Have-It Checklists, students use the ideas in the list to develop a model to describe what is happening in a healthy digestive system.  
After students update their 3-column Progress Trackers at the end of day 1 of this lesson, collect their Progress Trackers to provide formative feedback to students on their ideas. First, look for all of the ideas from the Gotta-Have-It Checklist represented. Second, provide feedback on the DCIs LS1.A and LS1.C, the CCC systems and system models, and the SEP developing and using models. Specifically, look for students representing ideas that the digestive system is one system within the human body and that it is made up of smaller parts called organs, which are viewed as subsystems in the digestive system. Students should also show that food is digested through a series of chemical reactions that break large food molecules down into smaller food molecules. The chemical reactions involved in digestion occur in different parts of the digestive system. Students should also use the model to show which component they think may function differently in M’Kenna’s digestive system. This is a key moment to provide formative assessment. If students struggle to include all of the key ideas in the model, consider working individually or in small groups with struggling students to return to previous investigations and make sense of the findings.  
**Engaging in Argument from Evidence: Systems and System Models** Use **Task Parts 1 and 2: Eliminate Possible Conditions and Identify Missing Evidence** to assess students’ ability to construct an argument, based on evidence, to eliminate two of five possible gastrointestinal conditions that could be causing the symptoms that M’Kenna is experiencing in her digestive system. Look for students to share ideas referenced on **Task Parts 1 and 2: Eliminate Possible Conditions and Identify Missing Evidence**. If choosing from five possible conditions is overwhelming to students, consider eliminating one condition by modeling the process for students. If students struggle to back up their claims with evidence, consider revisiting Lessons 1–6 to provide more time for students to make sense of the ideas in those lessons. |

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<td>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>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>
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| Lesson 8 | **Engage in an argument from evidence supported by scientific reasoning for how a healthy digestive system rearranges matter through chemical reactions and absorbs food, and how and why M’Kenna’s digestive system is functioning differently.**<br>
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. | **Engaging in an Argument from Evidence; Systems and System Models; Structure and Function**<br>In the Part 3: Argue from Evidence What’s Causing M’Kenna’s Symptoms, students argue from evidence that M’Kenna has celiac because the villi in M’Kenna’s small intestine cause her to have a reduced number of cells since taller villi in the small intestine cause there to be more cells, and this does not allow her body to absorb food molecules as effectively as a healthy digestive system. Students combine this evidence with the understanding that the data from her large intestine indicated that food molecules, other than fiber and water, remained in the large intestine after digestion, while in a healthy large intestine only fiber and water remain. While the assessment should be completed independently, some students might benefit from assistance with the organization of their writing. Additional guidance is provided in regard to how to support students with this organization. Then, students exchange written arguments with a peer and provide a critique of their argument based on the sufficiency of evidence provided. Look for students who attend closely to the strength of the argument and identify key pieces of evidence that support it. Provide a review for a small group of students or for the whole class about the key features of a strong scientific argument using Argument Rubric - Part 3 - M’Kenna’s Disease for guidance. In Revisit the Driving Question Board, students select three questions from the DQB that they have made progress toward answering. They argue the answer to those questions using evidence that they have collected throughout the unit. **Analyzing and Interpreting Data; Structure and Function**<br>In Examine the Function of the Villi, students collect data from the NetLogo interactive simulation of the small intestine. Students organize data into a table and create graphical displays of the data to demonstrate that villi height increases the number of cells, which has a direct relationship to the rate of absorption of food molecules into the bloodstream. Circulate and observe students to determine whether they are drawing a connection between villi height and the rate of absorption of food molecules into the bloodstream. Listen for students who explain that the cause of the food molecules that remain in M’Kenna’s large intestine are a result of her villi being flat and, therefore, having fewer cells. If students are not drawing a connection between villi height, number of cells, and rate of absorption, gather them into a small group and adjust the simulation together, making the villi height 0, then 5, then 10. After each adjustment, count the number of cells together, writing them down in a public space for comparison. Ask students what they notice about the data, guiding them to see that taller villi have more cells. Have students run three trials—one for each of these villi height adjustments—and add the rate of absorption to the data table. Ask students what they notice about the relationship between the number of cells and the rate of absorption. Scaffolding the activity in such an explicit manner should help students come to the conclusion that taller villi = more cells = higher rate of absorption. Some students may struggle to visualize a data table, and, therefore, have trouble initiating the task of creating a data table to organize their data. Additional guidance is provided to support students who are not constructing an organized data table. In Add to the 3-Column Progress Tracker, students use all that they have figured out to develop a model to represent what is happening in M’Kenna’s digestive system as compared with a healthy digestive system. Look for students who incorporate the items in the bulleted list into their models in words and pictures. If students do not include an element, ask a targeted question to help students recall something that they figured out in this lesson. For example, if a student does not include something about villi height affecting the number of cells and, therefore, the rate of absorption of food molecules into the bloodstream, ask, “Where can I find information in your model about the villi? How did you show what you learned about the height of the villi from the NetLogo simulation?” This should remind students without giving away key learning. |
Lesson 9

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

Ask questions to gather more information about how problems in one body system interact with other systems after revisiting M’Kenna’s symptom list.

**Assessment Guidance:**

**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 there must be a connection between her digestive system problems with absorption and her other symptoms, since her symptoms seem to start in her digestive system. Students will return to this thinking throughout this lesson and in other lessons. If students are unable to come up with the idea that problems in one system could be caused by problems in another system, have them look back at their system mapping. If students don’t suggest that there might be a connection between systems that they haven’t figured out yet, ask them to think about which systems we have 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 this is causing her symptoms in other body systems, such as brain fog, fatigue, and weight loss. If students struggle to make this connection between systems, have them walk over to the DQB and look at the clusters of questions that don’t have any dots on them yet. If they are still not able to make the connection, take out *M’Kenna’s Doctor’s Note* to see which symptoms and systems are still not explained.
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<td>Lesson 10</td>
<td><strong>Analyze and interpret data</strong> using graphical displays and statistics to identify temporal relationships to provide evidence for how M’Kenna’s pattern of body growth and weight have changed over time compared with typical children her age. <strong>Obtain, evaluate, and communicate information</strong> to determine the central ideas in an article to help determine where fat (matter) goes when people lose weight. <strong>Plan and carry out an investigation</strong> to produce data to serve as the basis for evidence to answer the question, Where does matter go when people lose weight?</td>
<td>As a formative, pre-assessment for Lesson Set 2, use the Initial Ideas Discussion in the Navigation activity about what could be causing M’Kenna’s weight loss to see if students could connect to what was figured out in Lesson Set 1 when she could not get enough matter inside her body because her villi in her small intestine are damaged. If students do not make this connection, that’s OK. They will have the opportunity to do so later on. <strong>Analyzing and Interpreting Data; Stability and Change</strong> Students are introduced to using statistics in order to identify temporal relationships in M’Kenna’s growth chart. Look for students to identify that M’Kenna’s growth remained stable for about 11 years, and then began to slow down when she turned 13. If students don’t make this connection, you can pull them into small groups to do a more guided data analysis. Also, you might pull different student work samples of their WIS/WIM statements and have the whole class look at what classmates have written. Next, students examine DEXA scans of a human and/or a dog that have lost weight. Look for students to identify that fat was lost over time. This should prompt students to begin to think about where the fat goes when someone loses weight. If students are identifying this, you might ask a question like, “If the animal weighed 60 pounds in this photograph, but 45 pounds in the next photograph, what is the difference in weight? Let’s think about a 15-pound dumbbell you might lift at the gym—that’s quite heavy! Where do you think all that weight went?” <strong>Obtaining, Evaluating, and Communicating Information; Energy and Matter</strong> After the students read the article <em>Children Need More Fat in Their Diets Compared to Adults</em> for the second time, they answer questions with a partner and discuss those questions as a whole class. During that discussion, look for students thinking about one way people use fat is to “burn” it, but what does burning fat really mean? Students should be wondering where the matter really goes when fat is burned. If this idea does not come out, ask if they have ever heard people say that they are “burning calories” when they exercise, and what do they think that means? <strong>Planning and Carrying Out Investigations; Energy and Matter</strong> During part 3 of the investigation, students will be answering the “Making Sense” questions to start to think through what happens to the matter when fat is burned. Look for students being able to make connections from their understanding of chemical reactions from a previous unit with the data they collected during this experiment. For students who are having difficulty with the “Making Sense” questions in Part 3, you could ask additional questions, such as: “What do the changes in the substance color, odor, or state of matter indicate about what happened?” and “Where did the matter in the vegetable oil/animal fat go?”</td>
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| 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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| Lesson 12 | Analyze and interpret data to identify spatial and temporal relationships in order to determine causes for changes to blood glucose, oxygen, and carbon dioxide levels in the body. Obtain, evaluate, and communicate information to clarify a claim that a chemical reaction that produces energy in the body is occurring in different parts of the body and that the body uses more glucose and oxygen to provide energy to cells (effect) during exercise (cause) than while resting. | **Analyzing and Interpreting Data; Cause and Effect**  
In the activity, Collect Evidence of a Chemical Reaction: BTB Investigation, students collect data to determine whether the air they breathe out contains carbon dioxide. They also collect data to answer questions about the presence of a chemical reaction in the body that may be related to the chemical reaction they experienced in Lesson 11. Look for students who interpret the data from the investigation to understand that, because we breathe in oxygen (reactant) and we breathe out carbon dioxide (product), a chemical reaction is taking place inside the body. If students do not draw this parallel to the chemical reactions from Lesson 11 during which they burned food, ask students to revisit the models they created in their Progress Trackers. Guide students to examine the reactants and products in their Progress Trackers for reactions that occurred when they burned food outside of the body. Then, ask “Do we have food as fuel? Do we have evidence of carbon dioxide being released as a product?”  
In the activity, Analyze Oxygen and Carbon Dioxide Levels in the Blood for Evidence of a Chemical Reaction, students are given data that tracks oxygen and carbon dioxide levels at different locations coming to and from the heart and lungs. Look for students who notice that the point at which oxygen levels decrease is the same point at which carbon dioxide levels increase. Students should also note the significance of the location being between blood going to other parts of the body and returning back to the heart and lungs. Students should infer that oxygen that travels in the blood is being transferred to other parts of the body, which accounts for the decrease. Students use their knowledge of the products of chemical reactions to assume the increase in carbon dioxide is the result of chemical reactions occurring in other parts of the body. If students do not demonstrate this understanding then return again to the Progress Tracker from Lesson 11, which details the reactants and products of a chemical reaction. Work with students in a small group or individually to connect the decrease in oxygen with the concept of oxygen acting as an input in a chemical reaction. Do the same with carbon dioxide as an output of a chemical reaction. If students are unsure of how to answer question 7 on Oxygen and Carbon Dioxide in the Blood - Part 1, you may need to use a picture of the circulatory system to show students where the blood vessels travel in the body. Say, “If the blood is full of oxygen here (point to Location 1) and that amount decreases as it travels throughout the body (trace pattern that outlines where blood travels in the system before bringing it back to Location 4), where else in the body could the oxygen be going?”  
**Obtaining, Evaluating, and Communicating Information; Cause and Effect**  
In Interpreting Activity Data, students receive oxygen and glucose data over time they must interpret to determine that the body uses more oxygen and glucose to provide energy to different parts of the body when the body is active versus at rest. Look for students who notice that the muscles, brain, and digestive organs use the bulk of the oxygen when the body is at rest because, even when the body is not active, these parts of the body are necessary to keep you alive. Students may claim that increased activity causes the body to need more energy. They identify data they would need to analyze to clarify and support their claim and then interpret data that tracks glucose levels in the blood over a 24-hour period, both with and without exercise after every meal. Students should notice glucose levels drop significantly after exercise, indicating more glucose is needed to provide energy to the body when it is active than at rest. If students do not come to this conclusion, try connecting to students’ past experiences with exercise. Ask students to consider a time when they have exercised, such as during P.E. class or outside playing with friends. Ask students what they noticed about the way their breathing changed as compared to when they are sitting quietly, at rest. Help students understand that the body takes in more oxygen by breathing rapidly because the body needs it when active. Similarly, students may have experienced a time when they have worked very hard or been very active, and it has made them feel hungry. This is a signal the body is in need of glucose because it is used more quickly when the body is active. Review the claims that students have written after examining the data described above. Look for students who include specific data or refer explicitly to the data to write a clear claim. If students do not write a clear claim, provide a sentence stem as support, such as: “The parts of the body that use the most energy when active are ___. I know this because ___.” |
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<td>Lesson 13</td>
<td><strong>Develop models</strong> of three possible pathways showing how food is rearranged in the body to create energy, store matter for later use, and use matter for growth within a body system. <strong>Construct an explanation</strong> to explain the relationships between differences in M’Kenna’s digestive system and a healthy digestive system in order to predict symptoms (effects), such as M’Kenna’s decreased growth rate.</td>
<td><strong>Developing and Using Models; Systems and System Models</strong> Students work in small groups to develop models of three different pathways that food entering a body system could take: (1) how the body uses food for energy, (2) how the body uses food not needed right now, and (3) how the body uses food for growth. As groups develop these models, look for them to identify different matter inputs, such as food and oxygen, processes, such as digestion, storage, growth, and cellular respiration, and matter outputs, such as carbon dioxide, water, and fat. Models should also identify different energy flows; for example, in pathway 1, food is broken down and used for energy by the body right away. In pathways 2 and 3, energy from food, and molecules, is stored for later use or to be used in the growth of new tissues. Look for groups to generalize the processes for how healthy bodies use food in each of the three pathways. In pathway 1, models should indicate that food and oxygen enter the body system and are broken down to be used for energy. In pathway 2, models should indicate that excess food is used to create storage molecules, like fat and glucose stored in muscle and liver, which can be used later for energy or growth. In pathway 3, models should indicate that molecules from food can be rearranged to create different tissues in the body like muscle and bone. If groups struggle to identify how food is used differently in each of the pathways, refer them back to their Progress Trackers for Lessons 10-12 when we figured out that the body needs food for growth and that food can be burned for energy. <strong>Constructing Explanations; Cause and Effect</strong> After developing a classroom consensus model, students write an explanation for how M’Kenna’s body is functioning differently than a healthy body. In addition, students return to their Progress Trackers to update them with a 3-column entry. In this update, students use the model they built as a class to develop an explanation for how the systems in a healthy body work together to process matter and energy inputs, processes, and outputs. Students add to their explanations about how M’Kenna’s digestive system is functioning differently and how her digestive condition contributes to the symptoms that she experiences in other systems of her body. Use this opportunity to look for students to identify the cause and effect relationship between decreased food absorption affecting M’Kenna’s energy levels. Students should also explain the relationship between decreased food absorption causing M’Kenna to rely on stored food, or fat, leading to her slowed growth rate or decrease in weight. If students are struggling to make these connections, refer them back to their Progress Trackers for Lesson 12 when they figured out that, when we are active, our body needs more energy, which requires more food.</td>
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| Lesson 14 | Engage in an argument from evidence that, in animals, oxygen reacts with carbon-containing molecules to provide energy and produce carbon dioxide and that organisms might have different structures that work together to do similar functions. | Engaging in Argument from Evidence; Energy and Matter; Structure and Function  
Students will be constructing an argument from evidence in small groups and getting an opportunity to revise their arguments. Look for students seeing similarities between their organism and humans by using the evidence connected from the readings that their animal does basically the same chemical reactions as humans to get energy from food, but they might have different structures inside their bodies that are involved. If students are struggling with their arguments, look for the callout box in the activity section of “Research How Other Organisms Get Energy” for questions to help them get started. During the time for students to revise their arguments, if students are struggling to identify how similar and different structures are functioning, help them map those structures to the human structures that they have previously studied.  
When students are giving and receiving feedback, you will have an opportunity for students to self assess their ability to give and receive feedback using a rubric. Look for students to honestly assess themselves and their growth throughout the unit. There is a place in Lesson 7 during which students could have used the rubric to self assess their peer feedback. |
| Lesson 15 | Develop a model to explain how bears can rearrange matter in food through chemical reactions to release energy and use stored food in the form of fat to survive during hibernation.  
Construct an explanation by applying scientific ideas and evidence to show how bears obtain energy to survive for several months without eating during hibernation. | Developing and Using Models; Energy and Matter  
This lesson includes a transfer task to give students an opportunity to use the three dimensions to make sense of a different phenomenon. This is meant to be a summative assessment task for the unit and gives you a grading opportunity. The task includes a scoring guide, as well as a modeling rubric for scoring the modeling question. Scoring guides are meant to highlight important ideas that students should be including in their responses to the prompts. They are listed as bullet points, so you can decide how to score them appropriately to the norms in your classroom. If students share these ideas elsewhere in the assessment, it is up to you to decide if that understanding is sufficiently demonstrated.  
If your students are struggling or you think they will need support in creating the model, there is a modified student assessment that gives students the components and interactions they will need in their models.  
Reviewing what the class has figured out through answering the questions on the Driving Question Board is one way to help students to prepare for the summative assessment. Reviewing these questions is also a good formative assessment to see if there are any pieces that need to be revisited. |
LESSON 5: Why do large food molecules, like some complex carbohydrates, seem to disappear in the digestive system?

PREVIOUS LESSON
We figured out that large molecules that are not absorbed by the small intestine move to the large intestine and then leave the body as poop. The original food molecules that leave as poop are mostly fiber and water, but M’Kenna has other molecules in her large intestine that are likely not supposed to be there. We wondered more about the unusual ups and downs of molecules across time and what happened to the starch.

THIS LESSON
INVESTIGATION
3 days
We make observations about what happens to some types of complex carbohydrates in one subsystem in the digestive system—the mouth. We analyze data from food molecules in the mouth, noting that the decrease in complex carbohydrates and simultaneous increase in glucose in the mouth seem to be correlated. We argue that the patterns we notice may be caused by a chemical reaction occurring in the mouth, but, in order to prove causation, we need to gather evidence to support our claim. We plan and conduct an investigation to determine whether some kinds of complex carbohydrates can undergo a chemical reaction when mixed with a substance in saliva to produce glucose. Based upon the data we collect and our observations of patterns in the data, we argue that some complex carbohydrates are broken down into glucose molecules through chemical reactions occurring in the mouth.

NEXT LESSON
We will analyze more food data starting from before it enters the mouth and continuing through the large intestine, noting how it changes across different parts of a healthy digestive system. We will notice patterns in which some molecules decrease by the same amount that other molecules increase. We will argue that this is a sign of chemical reactions happening in the digestive system.

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 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.

WHAT STUDENTS WILL 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.
<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>7 min</td>
<td><strong>NAVIGATION</strong>&lt;br&gt;As a whole class, look back to the previous lesson and summarize what students have figured out, their new questions, and how they decided to investigate those questions.</td>
<td>A-B</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>9 min</td>
<td><strong>MAKE OBSERVATIONS ABOUT EATING COMPLEX CARBOHYDRATES</strong>&lt;br&gt;Make predictions followed by observations about what happens when we eat a cracker, which has complex carbohydrates in it.</td>
<td>C-D</td>
<td>1-2 crackers, <a href="https://youtu.be/ZKy6wZ92hGI">https://youtu.be/ZKy6wZ92hGI</a></td>
</tr>
<tr>
<td>3</td>
<td>7 min</td>
<td><strong>CONNECT OBSERVATIONS TO CHEMICAL REACTIONS UNIT</strong>&lt;br&gt;Draw connections between student observations about eating the cracker and the previous unit about chemical reactions. Help students recall the science ideas related to chemical reactions and physical changes.</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>12 min</td>
<td><strong>ANALYZE DATA FROM EATING A GRAHAM CRACKER</strong>&lt;br&gt;Support students as they analyze graphed data showing what happens to a graham cracker in the mouth. Focus students on identifying patterns in molecules that increase and decrease.</td>
<td>F-G</td>
<td>ruler, Analyze Data from Eating a Graham Cracker</td>
</tr>
<tr>
<td>5</td>
<td>10 min</td>
<td><strong>READ “WHAT’S SPIT?”</strong>&lt;br&gt;Obtain information about saliva by reading an article called, “What’s spit?” Connect the information in the article to our ideas about what might be happening to complex carbohydrates in the mouth.</td>
<td>H</td>
<td>What’s Spit?</td>
</tr>
<tr>
<td>6</td>
<td>7 min</td>
<td><strong>LOOK FOR PATTERNS IN FOOD MOLECULES</strong>&lt;br&gt;Provide students with cards of molecular representations of complex carbohydrates, other than fiber, and glucose to use to look for patterns in their structures. Ask students to use these food molecules to explain whether chemical reactions could be happening in the mouth that could cause complex carbohydrates, other than fiber, to turn into glucose.</td>
<td>I-J</td>
<td>Food molecule card sets (only complex carbohydrates and glucose cards) created from Food Molecule Cards</td>
</tr>
<tr>
<td>7</td>
<td>10 min</td>
<td><strong>PLAN AN INVESTIGATION TO TEST FOR CHEMICAL REACTIONS IN THE MOUTH</strong>&lt;br&gt;Ask students to brainstorm ideas for how we might investigate whether a chemical reaction is taking place in the mouth. Introduce the materials that students will use, and have students work in groups to create a procedure for determining if their selected food has complex carbohydrates and/or glucose in it.</td>
<td>K-N</td>
<td>tape, Chemical Reactions in the Mouth Investigation, Chemical Reactions in the Mouth Data Table</td>
</tr>
<tr>
<td>8</td>
<td>15 min</td>
<td><strong>CONDUCT AN INVESTIGATION TO TEST FOR CHEMICAL REACTIONS IN THE MOUTH</strong>&lt;br&gt;Monitor students as they work in small groups in lab to complete Parts 3-6 of the investigation.</td>
<td>N</td>
<td>Chemical Reactions in the Mouth Investigation, Chemical Reactions in the Mouth lab</td>
</tr>
<tr>
<td>9</td>
<td>10 min</td>
<td><strong>BUILDING UNDERSTANDINGS DISCUSSION—INTERPRETING OUR DATA</strong>&lt;br&gt;Pull students together in a Scientists Circle. Ask students to make claims, supported by evidence, about whether chemical reactions occur in the mouth.</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>3 min</td>
<td><strong>NAVIGATION</strong>&lt;br&gt;Students complete an exit ticket to help them think about where else in the digestive system chemical reactions occur.</td>
<td>P</td>
<td></td>
</tr>
</tbody>
</table>

End of day 1

End of day 2
Lesson 5 • Materials List

<table>
<thead>
<tr>
<th>Chemical Reactions in the Mouth lab materials</th>
<th>per student</th>
<th>per group</th>
<th>per class</th>
</tr>
</thead>
<tbody>
<tr>
<td>• safety goggles</td>
<td>4 pipettes</td>
<td>30 mL of iodine in a 3 oz plastic cup</td>
<td>hot water (it is recommended that you boil the water in an electric kettle)</td>
</tr>
<tr>
<td>• 4 microcentrifuge tubes</td>
<td>a beaker or coffee cup</td>
<td>30 mL of Benedict’s solution in a 3 oz plastic cup</td>
<td>1 cup taco shells in a 20oz cup</td>
</tr>
<tr>
<td>• 30 mL of iodine in a 3 oz plastic cup</td>
<td>a spoon</td>
<td>a spoon</td>
<td>1 cup cooked rice in a 20oz cup</td>
</tr>
<tr>
<td>• 30 mL of Benedict’s solution in a 3 oz plastic cup</td>
<td>fine tip permanent marker</td>
<td>1 cup crackers in a 20oz cup</td>
<td></td>
</tr>
<tr>
<td>• a beaker or coffee cup</td>
<td></td>
<td></td>
<td>1 gram dextrose-free amylase enzyme</td>
</tr>
<tr>
<td>• 30 mL of iodine in a 3 oz plastic cup</td>
<td></td>
<td></td>
<td>200 mL distilled water</td>
</tr>
</tbody>
</table>

Lesson materials

| • science notebook                          | Food molecule card sets (only complex carbohydrates and glucose cards) created from Food Molecule Cards | https://youtu.be/ZKy6wZ92hGl |
| • 1-2 crackers                             |                                                         |                         |
| • ruler                                     |                                                         |                         |
| • Analyze Data from Eating a Graham Cracker|                                                         |                         |
| • What’s Spit?                              |                                                         |                         |
| • tape                                     |                                                         |                         |
| • Chemical Reactions in the Mouth Investigation |                                                         |                         |
| • Chemical Reactions in the Mouth Data Table|                                                         |                         |

Materials preparation (Overnight time needed plus 60 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.

Day 1: Prepare 1-2 crackers per student for them to sample. If you cannot have food in your classroom space, an alternate video has been provided https://youtu.be/ZKy6wZ92hGl .

Cut out and laminate Food Molecule Cards. Assemble the cards into sets and place in a plastic bag. For this lesson, students will only need access to the complex carbohydrate and glucose cards.

Day 2: Chemical Reactions in the Mouth Lab

- **Group size:** Groups of 2-3 students

- **Setup:**
  - **Prepare the Food Samples:** Mash up each of the following on separate plates: 1 cup of precooked rice, 1 cup of saltine crackers, 1 cup of taco shells. Add 500mL of water to each of the mashed foods in a 20oz cup. This should be enough for 6 class periods. Let soak for 24 hours. Label the cups and make them available for students to use. It is important to double check the food labels for each of the samples to be sure that they don’t already have sugar in them.
  - **Prepare Amylase Solution:** Weigh out 1 g of the enzyme. Add to 160 mL of room-temperature distilled water in a beaker. This can be used for 6 class periods. Stir gently to dissolve. Add distilled water to adjust to a final volume of 200 mL. Store at 4°C in fridge or on ice during use. *Please note that it is important to purchase sugar-free (or dextrose free) amylase. Some sugar-free amylase will come in a bottle with 90 capsules. Cut open the end of 4 capsules to get the 1 g of amylase powder needed.
  - **Iodine:** Each group will need a small 3 oz plastic cup with about 5 mL of iodine and an eyedropper. You can use this for multiple classes.
  - **Benedict’s:** Each group will need a small 3 oz plastic cup with about 30 mL of Benedict’s and a pipette. This prep of Benedict’s can be reused between 6 class periods.
  - **Tea kettle:** Set up one (or more) tea kettles around the room. It helps to get the water boiling before class and then to run the tea kettle again in class right before students need the hot water.
• **Notes for during the lab:** It may help to set up 2-3 supply stations for groups to access during the lab.

• **Safety:** Students will be working with the enzyme, amylase. Ensure students handle the enzyme according to the safe handling instructions on the MSDS sheet. Students will be working with very hot water. Ensure water is not boiling before dispensing into each coffee cup. Make sure you have enough safety goggles for each student who will be working with hot water, iodine, and Benedict's solution.

• **Disposal:** Iodine and Benedict's solutions should not be poured directly down the drain. Make sure to dispose of each solution per your school's waste management policy. If you plan to reuse the microcentrifuge tubes, make sure students dump the contents into a waste container before rinsing the tubes.

• **Storage:** Store amylase at 4°C (fridge) or on ice during use.
Lesson 5 • Where We Are Going and NOT Going

Where We Are Going

This lesson provides students evidence for the bolded section of the LS1.C DCI element. “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.” In this lesson, these ideas are elicited and reused:

- Chemical reactions produce new substances from old substances.
- In this process the atoms that make up the molecules of the old substance break apart and rearrange to make new types of molecules.

Where We Are NOT Going

Different chemical reactions occur through interactions with different substances produced by the human body in different digestive organs. Many of these substances, like amylase, are catalysts, which means that they help the reaction happen but are not a reactant in it. Students do not need to know these different substances (e.g., pepsin), where they are produced, or that they are catalysts. For explaining the phenomenon so far, it is sufficient to know that substances are produced in the mouth and interact with large food molecules to break them down into small food molecules.

In this lesson, we are not focused on figuring out what a chemical reaction is. It is assumed that students come to this lesson with previous conceptions of chemical reactions and physical changes from an earlier unit of instruction. Students will be using this knowledge in this lesson.
**LEARNING PLAN for LESSON 5**

**1 · NAVIGATION**

**MATERIALS: science notebook**

Look back at what we have figured out that happens to large and small food molecules in the digestive system. Present slide A and remind students that, in our previous investigation, we examined data from the digestive system and from poop to figure out what happens to large and small food molecules as they pass through the digestive system. Have students turn and talk with a partner about the two questions on slide A. After talking with their partners several groups share out their ideas.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>What were some discoveries we made about what might be different about M’Kenna’s digestive system?</td>
<td>M’Kenna has more molecules (both large and small food molecules) in her large intestine that probably leave as poop, including some of those small molecules we don’t see in healthy poop.</td>
</tr>
<tr>
<td>What are some discoveries we made about what happens to large and small food molecules as they pass through the digestive system?</td>
<td>Very large food molecules, like fiber, stay the same in the digestive system and leave the body as poop.</td>
</tr>
<tr>
<td>If the large food molecules, like complex carbohydrates, are gone when they reach the large intestine, what do you think happens to them?</td>
<td>We noticed that, in the graphs from last class, other complex carbohydrates seemed to be decreasing, but we know that other complex carbohydrates, besides fiber, don’t show up in the poop of a healthy person. We know that the complex carbohydrates can’t just be disappearing, so something must be happening to them in the digestive system.</td>
</tr>
</tbody>
</table>

Summarize the ideas shared during the discussion. Emphasize the idea that, in our previous investigation, we noticed that some large food molecules, like fiber, seemed to appear as both an input and an output in the digestive system. Other large food molecules, like some types of complex carbohydrates, appear as an input, but not an output. Remind students that we also know that complex carbohydrates, like starch, are large food molecules and that they cannot pass through the small intestine.

Summarize by saying, At this point we know that some types of complex carbohydrates are an input, but not an output, of the digestive system. We also know that complex carbohydrates can’t be absorbed in the small intestine. So now we are wondering, what is happening to large food molecules, like complex carbohydrates, in the digestive system?

**ALTERNATE ACTIVITY** The next section builds heavily on the last section of Lesson 4. If you feel that you have made sufficient progress on this at the end of Lesson 4, you can speed up this section of the activity. If you were short on time at the end of Lesson 4, be sure to take time to make sure students understand what they are trying to figure out today.
Look forward to what we decided to investigate today. Present slide B and ask students to recall, from our previous investigation, what we decided we needed to figure out today.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>How would figuring this out help us to explain what is going on with M'Kenna?</td>
<td>We noticed in the graphs from last class that there were differences in what was happening to the complex carbohydrates in M'Kenna's digestive system as compared to a healthy person. We think that, if we are able to figure out what is happening to complex carbohydrates in a healthy digestive system, it might give us some clues about what is happening to M'Kenna. In Lesson 3, we figured out that M'Kenna's digestive system didn't seem to be absorbing small food molecules, such as glucose, like the healthy digestive system did. We know that this is an issue, but we weren't sure if this was an issue because: (a) the small food molecules can't get to wherever they are going next OR (b) the small food molecules are causing an issue later in the digestive system. We still haven't really figured this out, but we think that focusing specifically on what is happening to the complex carbohydrates might help us.</td>
</tr>
<tr>
<td>Do we have any ideas on our Ideas for Investigations board that may help us with our investigation today?</td>
<td>We had the idea of following some food as it is digested in a healthy system and in M'Kenna's system. We had an idea about eating some food to see what would happen to it as we eat it. We thought it might be interesting to try to “digest” something outside of the body to observe what happens to it.</td>
</tr>
</tbody>
</table>

**KEY IDEAS**

- Listen for these ideas:
  - “Other complex carbohydrates” are an input, but not an output, of the digestive system.
  - Complex carbohydrates other than fiber can't just disappear in the digestive system, so we think that maybe they are either getting absorbed somewhere other than the small intestine or that they are being broken down into something else. We are really motivated to figure out what is happening to complex carbohydrates in the digestive system!
  - We noticed that something different is happening in M'Kenna's digestive system with respect to complex carbohydrates. We think that, if we can figure out what is happening in a healthy digestive system, we might find some clues about what is going on with M'Kenna.

Summarize our looking back and looking forward discussion. Be sure to emphasize the idea we decided to focus on is about what is happening to complex carbohydrates, other than fiber, as they pass through the digestive system. We think that this will help us get a better sense of what is happening in a healthy digestive system, which may give us some clues about what is working differently in M'Kenna's.

Say, *It sounds like we definitely need to follow the complex carbohydrates as they pass through the digestive system. Let's make that the focus for our investigations today.*

Mention to students that, for the rest of the investigation, when we reference “complex carbohydrates,” we are referring to any complex carbohydrate other than fiber.
2 · MAKE OBSERVATIONS ABOUT EATING COMPLEX CARBOHYDRATES


Make predictions about what will happen to the cracker in the mouth. Present slide C and instruct students to set up the next page in their science notebooks. Tell students that you brought in crackers as an example of a food that is made up mostly of complex carbohydrates. Starting at the beginning of the digestive system and actually eating a cracker might help us get a better sense of what the graphs that we have been looking at are showing.

In a few minutes, students will slowly eat the cracker and make observations about what happens to the cracker as it is in the first “stop” of the digestive system—the mouth. Have students stop and jot down their ideas about what they think will happen to the cracker when they put it in their mouths. If you have time, have students share out some of their ideas.

Make observations about what happens to the cracker in the mouth. Pass out the crackers and present slide D. Instruct students to slowly eat the cracker while taking note of what is happening to it in their mouths. As students eat, they should jot down their observations in their science notebooks. Remind students that the goal of our investigation is to figure out what happens to complex carbohydrates as they pass through the digestive system. Right now, we are focusing on what happens in the mouth.

| SAFETY PRECAUTIONS | Prior to passing out the crackers, be sure to check for food allergies. If students have food allergies that prevent them from eating the cracker, consider using the Alternate Activity. |
| ALTERNATE ACTIVITY | If your school prevents you from eating in the classroom, consider watching this video of a person chewing at https://youtu.be/ZKy6wZ92hGI. |

After eating the cracker and jotting down observations, have students share out some of their observations.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>What observations did you make about what happens to the cracker in your mouth?</td>
<td>I crunched up the cracker with my teeth. As I chomped down with my teeth, the cracker broke down into smaller pieces. My mouth seemed to get more watery—it seemed like more spit was added to my mouth. My spit mixed with the cracker to make it mushy. I moved my tongue around in my mouth, which seemed to mix things up.</td>
</tr>
</tbody>
</table>

As students share their observations about what happened to the cracker when they ate it, prompt them to identify some of the physical changes they observe in the cracker.
### Suggested prompt

<table>
<thead>
<tr>
<th>What kinds of physical changes do you observe happening with the cracker?</th>
</tr>
</thead>
<tbody>
<tr>
<td>The cracker is being broken into smaller pieces.</td>
</tr>
<tr>
<td>The cracker is mixing with spit.</td>
</tr>
</tbody>
</table>

### MATERIALS: science notebook

#### CONNECT OBSERVATIONS TO CHEMICAL REACTIONS UNIT

Connect observations about eating the cracker to previous units on chemical reactions. After several students have shared some of their observations about the physical changes happening to the cracker, present slide E.

Say, "This reminds me of our unit on chemical reactions. In that unit, we noticed that some changes to matter can be physical changes and other changes can be chemical reactions. Let's take a second to remind ourselves about the differences between chemical reactions and physical changes.

#### Suggested prompt

<table>
<thead>
<tr>
<th>In our previous unit on chemical reactions, how did we describe what is happening to the substances we start out with when a chemical reaction happens?</th>
</tr>
</thead>
<tbody>
<tr>
<td>The molecules of the substances we start with break apart and the atoms that make them form new arrangements (new molecules).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How do the properties of the substances we start with in a chemical reaction and end with in a chemical reaction compare?</th>
</tr>
</thead>
<tbody>
<tr>
<td>The properties of the substances we start with in a chemical reaction are different from the properties of the substances that we end with.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>In our previous unit on chemical reactions, how did we describe physical changes?</th>
</tr>
</thead>
<tbody>
<tr>
<td>When a process like smashing it, melting it, freezing it, boiling it, etc., occurs.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How do the properties of the stuff we start with compare to the stuff we end with in a physical change?</th>
</tr>
</thead>
<tbody>
<tr>
<td>The substances before the processes have the same properties as those after the processes.</td>
</tr>
</tbody>
</table>

After making sure that all students feel comfortable recalling the differences between chemical reactions and physical changes, add both terms to the word wall. Then ask students to think about the changes happening in their mouths as they eat the cracker.
<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>What kinds of changes do you think are happening to the substances in the cracker in our mouths?</td>
<td>I think it is a physical change because our teeth are chomping down on the cracker and breaking it apart, and our tongue is moving it around. I think it is a chemical reaction because the cracker started tasting a little sweet in my mouth and that makes me think that something new is formed. I'm not really sure. I know that, in a chemical reaction, we make new stuff from old stuff, but I don't really have any evidence to say what is actually happening.</td>
</tr>
<tr>
<td>How might we figure out whether there is a physical change or a chemical reaction happening to the substances in a cracker in the mouth?</td>
<td>If there is a physical change happening in the mouth, we would see the same “stuff” before and after we chew. We could somehow test to see if we have the same stuff before and after. If there is a chemical reaction happening, we might see some old “stuff” going away and new “stuff” appearing. We could test to see if new stuff seems to be coming from old stuff.</td>
</tr>
</tbody>
</table>

**ASSESSMENT OPPORTUNITY**

Use this discussion as an opportunity to formatively assess students' recollection of the differences between physical changes and chemical reactions. If students seem unsure of the science ideas or have not yet completed the chemical reactions unit, you may wish to spend more time reinforcing the ideas of chemical reactions and physical changes.

**ADDITIONAL GUIDANCE**

If you have defined the words “chemical reaction” and “physical change” in previous instruction, you may consider adding them to the word wall with their previous definitions as a reminder. If you have not defined the terms in previous instruction, add the terms to the word wall using students' working definitions. Ensure that the term “chemical reactions” includes the idea that atoms in molecules are broken apart and rearranged, and that the term “physical changes” includes the idea that the properties of the substance change but not the arrangement of the atoms in the molecule.

Navigate to looking at the data of food in the mouth. In our effort to figure out what is happening to complex carbohydrates in the digestive system, it might help to figure out if there is a chemical reaction or a physical change happening to the complex carbohydrates in the cracker when it is in our mouths. One way to do this is to figure out whether the complex carbohydrates are changing into something different in our mouths.

Say, It sounds like one way that we can figure out if there is a chemical reaction or a physical change happening in the mouth is by figuring out if we are making new stuff from old stuff or if we are just crunching old stuff into smaller pieces. Let's look at some data to help us figure this out!
Orient students to their data analysis task. Present slide F. Remind students that the goal is to figure out whether we are making new stuff from old stuff in the mouth. So, we are going to look for new stuff appearing and old stuff disappearing in the mouth.

An example image of a completed analysis has been provided to the right. Consider doing water and fiber together to provide an example.

While analyzing the graph, students may use the language of "goes up" and "goes down" to describe the changes in food molecules. Build toward using the language of "increase" and "decrease" to describe the changes observed in food molecules.

In Lesson 6, students will be analyzing a series of similar graphs. By introducing students to the mouth data first, students have the opportunity to orient to the graphs and to practice analyzing data using the graphs. If students struggle to analyze the data in the graph, it may help to spend some time analyzing the graph as a class to better prepare students for the analysis in Lesson 6.

Students should use patterns of changes in the data to identify that a chemical reaction is occurring in the mouth.

In this portion of the lesson, students are determining whether the patterns that they observe in the data are causal or correlational. With the data that they are provided, students may only claim that the relationships are correlational. In order to establish causation, students will need to show that complex carbohydrates are being broken down into glucose. The investigation that students design in the remainder of this lesson is aimed at helping students establish a causal link between the decrease in complex carbohydrates and the increase in glucose.

It is important that students establish the causal relationship between the decrease in complex carbohydrates and the increase in glucose in this lesson because it helps them make progress on the idea that digestion is a series of chemical reactions that break food down. In the next lesson, students will examine similar relationships in the data that occur in different subsystems of the digestive system and will need to apply their understanding from this lesson in order to make the claim that the relationships they observe between food molecules in other organs of the digestive system are likely causally related.

Distinguishing between causal and correlational relationships in the data helps students make progress on element 4.3 for the science and engineering practice "analyzing and interpreting data."
Analyze data to figure out what happens to food in mouths. Give groups several minutes to examine the data and record increases, decreases, and trends that stay the same directly on the graphs. The graph is provided on slide G if you wish to project it.

### Make sense of patterns in data.
Have students share out what patterns they noticed in the data.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What patterns did you notice in the data?</strong></td>
<td>Everything except for complex carbohydrates and glucose stayed the same.</td>
</tr>
<tr>
<td></td>
<td>Complex carbohydrates seemed to be decreasing in the mouth.</td>
</tr>
<tr>
<td></td>
<td>Glucose seemed to be increasing in the mouth.</td>
</tr>
<tr>
<td><strong>What can we conclude from the data?</strong></td>
<td>We know that there can’t be a chemical reaction happening with anything other than complex carbohydrates and glucose.</td>
</tr>
<tr>
<td></td>
<td>We think that we might be making new stuff (glucose) from old stuff (complex carbohydrates), but we can’t be totally sure if that is exactly what is happening. If it’s true, what could be causing a chemical reaction?</td>
</tr>
</tbody>
</table>

**Distinguish between correlational and causal relationships in data.** Some students may see the connection between complex carbohydrates going down and glucose going up. Others may not connect the two at all. Seed the idea that there might be a chemical reaction happening that breaks complex carbohydrates down into glucose molecules. It is important that students begin to note the connection, but they should also be able to distinguish between causal and correlational relationships in data. We don’t yet have evidence to support the claim that complex carbohydrates are actually being broken down into glucose molecules. At this point, we can only claim that there seems to be a correlation between the increasing glucose and decreasing complex carbohydrates.★

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Do you think we have enough evidence to say what is causing the decrease in complex carbohydrates and the increase in glucose?</strong></td>
<td>We have enough evidence to say that the decrease in complex carbohydrates and the increase in glucose is happening, but we don’t have enough evidence to claim why it is happening yet.</td>
</tr>
<tr>
<td><strong>Is the decrease in complex carbohydrates and the increase in glucose a correlation? Why or why not?</strong></td>
<td>Yes, it is a correlation. We know that they are happening at the same time, but we haven’t done anything yet to prove that one is causing the other or that one is the result of the other.</td>
</tr>
</tbody>
</table>

**ADDITIONAL GUIDANCE**

Students should have been introduced to Crosscutting Concept 2, Element 2.1 and the ideas of correlational and causal relationships in the data during previous instruction. Take some time here to help students recall the differences between causal and correlational relationships.

Say, **It looks like there might be a relationship between the decreasing complex carbohydrates and increasing glucose molecules. We think that there might be a chemical reaction taking place in which complex carbohydrates are broken down into glucose, but we don’t yet have evidence to claim that they are directly related. It might just be a correlation.★**
Prompt students to consider how we might determine if there is a chemical reaction occurring in the mouth. Frame this discussion by saying that, if we think there is a causal relationship in the data, it means that there is a chemical reaction occurring. In other words, new stuff (glucose) would be made from old stuff (complex carbohydrates) through a chemical reaction. That means that there would be a chemical reaction occurring in our mouths! Make a point to emphasize how odd it seems that a chemical reaction could occur in our mouths.

Say, If there is a chemical reaction occurring in our mouths, we might be able to figure out what is happening by looking more closely at our spit.

Lead a brief discussion to elicit ideas from students about spit. Ask students to share their ideas about what spit is, what it is made of, and why it might be useful.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you think spit is?</td>
<td>I think it is mostly water. Maybe there is some other stuff in it too, but it is mostly water or drool.</td>
</tr>
<tr>
<td></td>
<td>It seems like our mouths sometimes have more spit in them than others—like when I am really hungry or smell something good. I also seem to get more spit if I am exercising.</td>
</tr>
<tr>
<td>What do you think spit is made of?</td>
<td>I think it is mostly water, but maybe there is some other stuff in it too.</td>
</tr>
<tr>
<td></td>
<td>It tastes like nothing, so it is probably water.</td>
</tr>
<tr>
<td>Why do you think our bodies make spit?</td>
<td>Our mouths would get really dry without it!</td>
</tr>
<tr>
<td></td>
<td>I think spit helps us to eat things. Our food mixes with spit and gets all mushy, like what we saw (or noticed) when we made observations about eating a cracker.</td>
</tr>
</tbody>
</table>

5 · READ “WHAT’S SPIT?”

**MATERIALS:** science notebook, *What’s Spit*

Introduce the article, “What’s spit?” Remind students that the goal of reading this article is to try to obtain information that might help us figure out if there is a chemical reaction happening in our mouths when we eat.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>What kinds of evidence should we look for to suggest that there is a chemical reaction happening in our mouths when we eat?</td>
<td>We might read about new stuff showing up in our mouths or old stuff going away.</td>
</tr>
<tr>
<td></td>
<td>We might read about other kinds of chemicals in our mouths.</td>
</tr>
</tbody>
</table>

Pass out *What’s Spit*? Give students enough time to read the article individually. When they are done reading the article, students should jot down their responses to the questions on slide H.
HOME LEARNING OPPORTUNITY

If you are running short on time, consider having students complete the reading as a home learning assignment.

When all students have finished reading the article, begin a whole-group discussion by asking students what they learned about spit.

**Suggested prompt**

**Sample student response**

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>What did you learn about spit?</td>
<td>Spit is actually saliva.</td>
</tr>
<tr>
<td></td>
<td>It's made up of water and some other chemicals, including a chemical</td>
</tr>
<tr>
<td></td>
<td>called amylase.</td>
</tr>
<tr>
<td></td>
<td>Spit is made by our salivary glands.</td>
</tr>
<tr>
<td></td>
<td>We make a lot of spit—2–4 pints every day!</td>
</tr>
<tr>
<td></td>
<td>Spit is important in digestion. The article says that spit helps to</td>
</tr>
<tr>
<td></td>
<td>break down food before it even gets to our stomachs. An enzyme called</td>
</tr>
<tr>
<td></td>
<td>amylase helps with breaking down food in our mouths.</td>
</tr>
</tbody>
</table>

Then, have students share their responses to the questions on slide H.

**Suggested prompt**

**Sample student response**

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>What kinds of evidence did the article provide to help you answer the</td>
<td>The article said that the mouth starts the process of digestion, which</td>
</tr>
<tr>
<td>question, “Do chemical reactions occur in the mouth?”</td>
<td>is when food is broken down in the mouth.</td>
</tr>
<tr>
<td></td>
<td>The article mentioned special molecules called enzymes, which help</td>
</tr>
<tr>
<td></td>
<td>with digestion.</td>
</tr>
<tr>
<td>How might we use what we learned from the article to plan and conduct</td>
<td>The article mentioned that enzymes in saliva help in the process of</td>
</tr>
<tr>
<td>an investigation to help us answer the question, “Do chemical reactions</td>
<td>digestion. Maybe we could use some of these enzymes to try to</td>
</tr>
<tr>
<td>happen in the mouth?”</td>
<td>digest food outside of the body. We could try testing the food before</td>
</tr>
<tr>
<td></td>
<td>and after digestion to see if it changes.</td>
</tr>
</tbody>
</table>

Generate some excitement around testing whether chemical reactions can actually happen in the mouth. Share that you can bring in the enzyme mentioned in the article, amylase. Tell students to be thinking about ways that they could use amylase to test for chemical reactions in the mouth.

**End of day 1**
6 · LOOK FOR PATTERNS IN FOOD MOLECULES

MATERIALS: science notebook, Food molecule card sets (only complex carbohydrates and glucose cards) created from Food Molecule Cards

Remind the class where we left off. Present slide I to the class and ask students to turn and talk with a partner about the ideas we developed so far and how comparing molecular representations of different food molecules could help us determine if one of these ideas could be possible (chemical reactions). Two suggested Turn-and-Talk prompts are on slide I.

ADDITIONAL GUIDANCE

Encourage students to look back in their science notebooks to review some of the ideas that the class came up with at the end of the last lesson.

Listen in on some of the discussions. After a couple of minutes, ask students to share ideas related to these questions with the whole group.

Suggested prompt | Sample student response
--- | ---
One of the ideas I heard you talking about again was that maybe one substance is turning into another substance. What are some phenomena we’ve encountered where we saw evidence of one substance turning into another? | (Experiences related to working with chemical reactions explored in prior instruction.)
If we know that chemical reactions are why old substances can turn into new substances, what else do we know about what happens to the atoms in the molecules that we start out with during any chemical reaction? | Atoms in substances rearrange in chemical reactions to form new substances.
How might comparing the types of atoms in the molecules in two different substances help us determine if it is possible to use one of them as a reactant in a chemical reaction to produce the other substance? | If we could compare what types of atoms are in the substances that are appearing and disappearing, that could tell us whether a chemical reaction is the cause because atoms get rearranged in chemical reactions. New types of atoms can’t just appear out of nowhere. So, if we think that a product is getting produced in a chemical reaction, then the same atoms that are in the molecules of that substance should be in the molecules of the things we think are the potential reactants.

Tell students that you have molecular representations of complex carbohydrates and glucose that they can use to look for patterns that might help us figure out if some of the substances in food could be turning into other substances through chemical reactions in our digestive system.

Project slide J and use it to show the molecular representations of complex carbohydrates and glucose. Pass out the cards that you prepared from the Food Molecule Cards. Only pass out the complex carbohydrate and glucose cards. Instruct students to compare and contrast the molecular representations for glucose and complex carbohydrates. Prompt students to consider the question: How do these patterns help explain why the amount of one type of molecule (e.g., complex carbohydrate) might be decreasing by the same amount that another type of molecule is increasing (e.g., glucose) in the mouth?

After several minutes, pull students together to report out some of the patterns they noticed. Project slide J as you do this. Encourage students to come up to the projected image to show what they noticed.

★ ATTENDING TO EQUITY

Hang a copy (zoomed in) of the food molecules and key that students used in this lesson on the word wall for future reference. It may help to hang the molecules under the words they represent (e.g. glucose, complex carbohydrate).
ADDITIONAL GUIDANCE
Encouraging students to come to the front of the room to present a noticing to the class in this way (around an artifact that everyone has analyzed) helps provide a concrete reference point for other students to add their ideas to the discussion. It also helps grow a culture where students see that, in order for the class to make progress on figuring things out together, students must have a space to present their ideas that all their classmates to work with.

Say, Several students pointed out that there are some similarities in the structures of glucose and starch, a complex carbohydrate. The glucose molecules look like they are chunks or pieces of the complex carbohydrates.

Suggested prompt

How do these patterns help explain why the amounts of one type of molecule (e.g., a complex carbohydrate) might be decreasing by the same amount as another type of molecule is increasing (e.g., glucose) in the foods we eat as they travel through our digestive system?

Sample student response

These representations show that certain chemical reactions could be possible, where the same type of atoms would be in the reactant as are in the product.

It seems like breaking apart the bigger molecules into smaller pieces would get you certain smaller molecules (e.g., a starch molecule looks like it can be broken into glucose molecules).

7 · PLAN AN INVESTIGATION TO TEST FOR CHEMICAL REACTIONS IN THE MOUTH

MATERIALS: science notebook, tape, Chemical Reactions in the Mouth Investigation, Chemical Reactions in the Mouth Data Table

Project slide K. Ask students to turn and talk with a partner to generate ideas about how we might get firsthand data for whether complex carbohydrates (like starch) are actually turning into glucose after we put it in our mouths. Give one minute for this.

Then, project slide L and use it to introduce the materials that students will use to investigate this question. Read through the text on the slide to remind students that amylase is a substance found in saliva. Again have students turn and talk about ideas of how amylase could be used to investigate our question. Give two minutes for this.

Then, project slide M. Point out where these food sources are located in the lab, and explain that students can select one of them to use in their investigation design as you pass out copies of Chemical Reactions in the Mouth Investigation (located in the student edition) and Chemical Reactions in the Mouth Data Table. Have students tape Chemical Reactions in the Mouth Data Table into their science notebooks.

Project slide N. Tell students that they will complete Parts 1, 2, and 3 of the investigation today. Show students where the supplies for the investigation are located, including the three food sources that have been mashed up and mixed with water. Give students the remaining time to record their plan for Parts 1, 2, and 3 in their science notebooks. It may be helpful to review the example student responses provided on Chemical Reactions in the Mouth Data Table Key. An example video has also been provided at https://youtu.be/9omZ63sR0z0. It may also be helpful to approve each group’s procedures before they begin conducting the investigation.

8 · CONDUCT AN INVESTIGATION TO TEST FOR CHEMICAL REACTIONS IN THE MOUTH

MATERIALS: Chemical Reactions in the Mouth lab, science notebook, Chemical Reactions in the Mouth Investigation

Monitor students as they work in small groups to complete Parts 3-6 of the investigation. As students work, you may wish to focus them on the goal of the investigation by asking the questions below.
**Suggested prompt**

How will collecting data from this investigation help us answer the questions we had about what might be happening to complex carbohydrate molecules in the foods we eat after they start mixing with our saliva?

**Sample student response**

If saliva causes a chemical reaction to happen with the starch, then there will be a new type of molecule that wasn’t there before. We will see whether complex carbs really turn into sugars when mixed with the substances in saliva. This will tell us if chemical reactions are happening during digestion. This may provide an explanation of why some food molecules are appearing or increasing by the same amount that other molecules are decreasing.

Use slide O as a transition to the next step of lab, and tell students to relocate in a Scientists Circle when they are done with the investigation and to bring their science notebooks with them.

Collect the copies of Chemical Reactions in the Mouth Investigation before students leave, to reuse with other classes.

### 9 · BUILDING UNDERSTANDINGS DISCUSSION—INTERPRETING OUR DATA

**MATERIALS:** None

Show slide O. Facilitate a Building Understandings Discussion in a Scientists Circle. The goal of this discussion is to have students argue from evidence to answer the question, “Do chemical reactions occur in the mouth?” In order to answer this question, students will need to consider what happens to complex carbohydrate molecules (like starches) that are in the foods once they start mixing with substances in our saliva.

Say, What claims can you now make to answer this question: Do chemical reactions occur in the mouth?

Encourage students to share their ideas. In this discussion, it is important to support students as they hone in on the key ideas for the discussion.

**KEY IDEAS**

**Purpose of this discussion:** The purpose of this discussion is to have students argue from evidence to answer the question, “Do chemical reactions occur in the mouth?” To answer this question, students will need to consider what happens to complex carbohydrate molecules when they start mixing with substances, like amylase, in our saliva.

**Listen for these ideas:**

- When starches start mixing with substances in our saliva, they turn into sugars. We know this because we had a positive Benedict’s test for sugar.
- A chemical reaction happens when starches interact with stuff in our saliva. We know this because we didn’t have a positive Benedict’s test for sugar in the samples without amylase, but we did have a positive Benedict’s test for sugar in the samples with amylase.
- Saliva starts chemically breaking down the complex carbohydrate molecules into smaller molecules.

Ask students to think about how this result also supports the patterns of change they saw in the graphs of the food molecules when they saw the other complex carbohydrates bar go down by the same amount that the glucose bar went up.
For an additional opportunity for assessment, consider having students create a model to help answer the question, “Do chemical reactions occur in the mouth?” Provide the following guidance.

Develop a Model

1. Consider the question, “Do chemical reactions occur in the mouth?”
2. Incorporate inputs and outputs in your model.
3. Support your claim using evidence. You may wish to include evidence from your investigation or from the graphs on slides G and J.

As students create their models, prompt students to consider how they would represent larger molecules breaking down into smaller ones without having to account for individual atoms. They will do this again in Lesson 8 for complex carbohydrates, proteins, and fats, but this is a good opportunity to elicit student ideas focused only on complex carbohydrates.

**Suggested prompt**

**Sample student response**

| How does this help us further explain what is happening in the graphs of the food molecules when we see one substance’s bar go down by the same amount another substance’s bar goes up? | The atoms in the complex carbohydrates became the atoms in the sugar through a chemical reaction. |
| In our models, how could we represent larger molecules breaking down into smaller ones without having to account for individual atoms? | Maybe we can show a line of boxes that are all attached and then show the boxes separated from each other. |

**ADDITIONAL GUIDANCE**

If you have time, consider having students slowly eat a cracker again. This time, prompt students to pay attention to the taste of the cracker. Some students may notice that the cracker gets sweeter. This observation is consistent with the claim that amylase breaks complex carbohydrates down into glucose molecules, which taste sweet!

Be sure to purchase unsalted crackers. Not all students will notice the change in taste.

**10 · NAVIGATION**

**MATERIALS: None**

Project slide P. Have students complete an exit ticket responding to the prompts on the slide. The point of this exit ticket is to help navigate to the next lesson and to facilitate thinking about how what we are investigating might help us explain what is going on with M’Kenna. You may also wish to provide students with time to add to the table of contents in their science notebooks and add ideas to their Progress Tracker.

**EXIT TICKET**

Have students complete an exit ticket to respond to the following prompts:

- Do you think that chemical reactions could occur in other places in the digestive system? Where do you think the chemical reactions would take place?
- If so, what do you predict the “old stuff” and the “new stuff” in the chemical reaction would be?
- How does what we figured out today help us figure out what might be going on with M’Kenna?
Lesson-Specific Teacher Materials
**Lesson 5: Answer Key 1**

**Key for Chemical Reactions in the Mouth Data Table**

<table>
<thead>
<tr>
<th>Part 1: Diagram of Tube</th>
<th>Tube A</th>
<th>Tube B</th>
<th>Tube C</th>
<th>Tube D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Label each tube with the substances you plan to add.</td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>Note: The order of the tubes (to the right) does not matter as long as there are two tubes that have amylase and two tubes that have water. One of each should be tested with iodine and one of each should be tested with Benedict’s.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Part 2: Procedures | | | | |
| Record the order of procedures you will follow to set up your tubes. Record the procedure titles you need in each box (remember to add your indicator last and MIX after adding everything!). |
| Example: | | | | |
| 1. RICE | 2. WATER | 3. IODINE | 4. MIX |

| Part 3: Prediction | | | | |
| What color do you predict the indicators will be after the investigation? |
| Black/Dark Purple | Black/Dark Purple | Blue | Orange/Dark Red |

| Part 4: Results | | | | |
| What color were the indicators after the investigation? |
| Black/Dark Purple | Black/Dark Purple | Blue | Orange/Dark Red |

| Part 5: Interpretation | | | | |
| Which food molecules were detected in each tube? |
| Starch | Starch | Nothing | Glucose |
Navigation

Last time, we examined data from the digestive system and from poop to figure out what happens to large and small food molecules as they pass through the digestive system.

Turn and Talk

1. What were some discoveries we made about what might be different about M’Kenna’s digestive system?

2. What are some discoveries we made about what happens to large and small food molecules as they pass through the digestive system?

Looking Forward to Our Investigation

1. How would figuring this out help us to explain what is going on with M’Kenna?

2. Do we have any ideas on our “Ideas for Investigations” board that may help us with our investigation today?

Predict: What will happen (in our mouths) when we eat a cracker?

We are going to slowly eat a cracker to make observations about what happens to complex carbohydrates in the mouth.

Add a “Make Observations About Eating Complex Carbohydrates” section to your science notebook, and jot down your ideas in response to the following question:

- Think about the first “stop” for a complex carbohydrate in the digestive system—the mouth. What kinds of things do you think will happen to the cracker when in the mouth?

Make Observations: What happens to the cracker in the mouth?

Slowly eat the cracker or watch a video of someone eating and make observations about what happens to the cracker when it is in the mouth.

In the same “Make Observations About Eating Complex Carbohydrates” section of your science notebook, jot down your ideas in response to the following question:

- What happens to the cracker when you slowly chew it in your mouth?

Video link: [https://youtu.be/ZKy6wZ92hGI](https://youtu.be/ZKy6wZ92hGI)
Think back to our unit on chemical reactions:
- How did we describe chemical reactions?
- How did we describe physical changes?

What kinds of changes do you think are happening in your mouth when you eat the cracker?

**Connections to Previous Instruction**

**Analyze Data from Eating a Graham Cracker**

How to analyze the data:
1. The light-colored bar shows the amount of the molecule in the previous location in a healthy person. The dark-colored bar shows the amount of the molecule in the new location in a healthy person.
2. Record whether or not the food molecule goes up (↑), goes down (↓), or stays the same (=).

**What's Spit?**

Read the article, “What’s spit?,” and respond to the following questions in your science notebook under the heading, “What’s spit?”

1. What kinds of evidence did the article provide to help you answer the question, “Do chemical reactions happen in the mouth?”
2. How might we use what we learned from the article to plan and conduct an investigation to help us answer the question, “Do chemical reactions happen in the mouth?”
Navigation

In our last class, we made observations about what happens when we eat a cracker, we analyzed data from a graham cracker in someone's mouth, and we read an article, "What's spit?"

Turn and Talk

1. What ideas have we generated so far related to this question, "When eating a graham cracker, why do complex carbohydrates decrease in the mouth while glucose increases?"

1. How could comparing molecular models of these substances (showing the atoms that make them up) help us determine what might be happening?

Look for Patterns in Food Molecules

How do these patterns help explain why the amount of one type of molecule (e.g., a complex carbohydrate) might be decreasing by the same amount that another type of molecule is increasing (e.g., glucose) in the mouth?

Plan an Investigation to Test for Chemical Reactions in the Mouth

We think that there might be a chemical reaction happening in our mouths to break complex carbohydrates down into glucose molecules, but we don't have enough evidence, yet, to support this claim.

Turn and Talk

Brainstorm ideas: What kind of additional evidence could we collect to test our ideas about what is happening to the complex carbohydrates once we put them in our mouths?

Plan an Investigation to Test for Chemical Reactions in the Mouth

- Our mouths produce saliva when we eat. Saliva is a mixture of different substances. Ninety-eight percent of it is water, and, as we read in the article, one of the other substances in saliva is amylase.
- Scientists have isolated this substance so that it can be used in digestion-related investigations in place of real saliva.
- We have a small supply of amylase available to plan and conduct our own investigations.

Turn and Talk

1. Brainstorm ideas: How could we use this substance to test our ideas about what is happening to a food that has complex carbohydrates in it when it is put in our mouths, without needing to actually put that food into our mouths?
Plan an Investigation to Test for Chemical Reactions in the Mouth

With your group

Select one of these to use as your food source.

- Crackers
- Taco shells
- Rice

Each one been smashed up and sitting in water for over eight hours.

Do chemical reactions occur in the mouth?

Refer to Lesson 5 - Reference 3: Do chemical reactions occur in the mouth? This is what you will read to figure out what you need to do next.

Add Lesson 5 - Handout 1: Do chemical reactions occur in the mouth? to your science notebook. This is where you will keep a record of your findings.

Building Understandings Discussion—Interpreting Our Data

Bring your notebooks with you to our Scientists Circle.

What claims can you now make to answer this question:

Do chemical reactions occur in the mouth?

Navigation—Exit Ticket

Today we figured out that chemical reactions can happen in the mouth! Complex carbohydrates can be broken down into glucose with the help of a molecule called amylase.

- Do you think that chemical reactions could occur in other places in the digestive system? Where do you think the chemical reactions would take place?
- If so, what do you predict the “old stuff” and the “new stuff” in the chemical reaction will be?
- How does what we figured out today help us figure out what might be going on with M’Kenna?

Make sure you update your table of contents and complete your Progress Tracker for today!
Lesson 5: Why do large food molecules, like some complex carbohydrates, seem to disappear in the digestive system?

Navigation

Last time, we examined data from the digestive system and from poop to figure out what happens to large and small food molecules as they pass through the digestive system.

Turn and talk

1. Turn and talk with your partner about the following questions:
   - What are some discoveries we made about what happens to large and small food molecules as they pass through the digestive system?
   - What are some discoveries we made about what might be different about M'Kenna's digestive system?

Looking Forward to Our Investigation

With your class

2. With your class, discuss the following questions:
   - What did we decide we needed to figure out today?
   - How would figuring this out help us to explain what is going on with M'Kenna?
   - Do we have any ideas on our “Ideas for Investigations” board that may help us with our investigation today?

Predict: What will happen (in our mouths) when we eat a cracker?

We are going to slowly eat a cracker to make observations about what happens to complex carbohydrates in the mouth.

In your notebook

3. Add a “Make Observations About Eating Complex Carbohydrates” section to your science notebook and jot down your ideas in response to the following question:
   - Think about the first “stop” for a complex carbohydrate in the digestive system—the mouth. What kinds of things do you think will happen to the cracker when it is in the mouth?
   - Be prepared to share these ideas with the whole class.
Make Observations: What happens to the cracker in the mouth?

In your notebook

4. Slowly eat the cracker or watch a video https://youtu.be/ZKy6wZ92hGI of someone eating and make observations about what happens to the cracker when it is in the mouth.

5. In the same “Make Observations About Eating Complex Carbohydrates” section of your science notebook, jot down your ideas in response to the following question:
   - What happens to the cracker when you slowly chew it in your mouth?
   - Be prepared to share these ideas with the whole class.

Connections to Previous Instruction

With your class

6. Think back to our unit on chemical reactions:
   - How did we describe chemical reactions?
   - How did we describe physical changes?
   - What kinds of changes do you think are happening in your mouth when you eat the cracker?
   - Be ready to share these ideas with the whole class.

Analyze Data from Eating a Graham Cracker

In your notebook

7. Obtain a copy of Analyze Data from Eating a Graham Cracker.

8. Analyze the data from the mouth of a healthy person eating a graham cracker. Record your analysis in your science notebook.
   - The light-colored bar shows the amount of the molecule in the previous location in a healthy person. The dark-colored bar shows the amount of the molecule in the new location in a healthy person.
   - Record whether amount of food molecules goes up (↑), goes down (↓), or stays the same (=) from the previous location to the new location.

9. Discuss patterns in the data with your class.

Read “What’s Spit?”

In your notebook

10. Obtain a copy of What’s Spit?. Read the article, “What’s spit?” and respond to the following questions in your science notebook under the heading, “What’s spit?”:
    - What kinds of evidence did the article provide to help you answer the question, “Do chemical reactions happen in the mouth?”
    - How might we use what we learned from the article to plan and conduct an investigation to help us answer the question, “Do chemical reactions happen in the mouth?”
Navigation

In our last class, we made observations about what happens when we eat a cracker, we analyzed data from a graham cracker in someone's mouth, and we read an article, "What's spit?"

**Turn and talk**

11. Turn and talk about the following questions with your partner:
   - What ideas did we generate so far related to this question, "When eating a graham cracker, why do complex carbohydrates decrease in the mouth while glucose increases?"
   - How could comparing molecular representations of these substances (showing the atoms that make them up) help us determine what might be happening?

Look for Patterns in Food Molecules

**With your class**

12. Obtain a copy of the complex carbohydrate and glucose cards from *Food Molecule Cards*.

13. Examine the cards to help answer the question, "How do these patterns help explain why the amount of one type of molecule (e.g., a complex carbohydrate) might be decreasing by the same amount that another type of molecule is increasing (e.g., glucose) in the graham cracker in the mouth?"

14. Share your ideas with the class.

Plan an Investigation to Test for Chemical Reactions in the Mouth

We think that there might be a chemical reaction happening in our mouths to break complex carbohydrates down into glucose molecules, but we don't have enough evidence yet to support this claim.

**Turn and talk**

15. Turn and talk with a partner to brainstorm ideas about the following question:
   - What kind of additional evidence could we collect to test our ideas about what is happening to the complex carbohydrates that we eat once we put them in our mouths?

16. Read the information about amylase, a chemical found in saliva.

17. Turn and talk with a partner to brainstorm ideas about the following question:
   - How could we use this substance to test our ideas about what is happening to a food that has complex carbohydrates in it when it is put in our mouths, without needing to actually put that food into our mouths?
18. Obtain a copy of Data Table for Chemical Reactions in the Mouth and Chemical Reactions in the Mouth Investigation.

19. Follow the steps on Chemical Reactions in the Mouth Investigation to plan how you will answer the question, “Do chemical reactions occur in the mouth?” Record your plans on Data Table for Chemical Reactions in the Mouth.

20. After you have planned your investigation, have your procedures approved by your teacher.

Conduct an Investigation to Test for Chemical Reactions in the Mouth

21. Follow the steps on Chemical Reactions in the Mouth Investigation to conduct an investigation to answer the question, “Do chemical reactions occur in the mouth?” Record your findings on Data Table for Chemical Reactions in the Mouth.

Building Understandings Discussion: Interpreting our Data

22. Bring your science notebook to the Scientists Circle.

23. With your class, have a Building Understandings Discussion, using evidence, to answer the question, “Do chemical reactions occur in the mouth?”

Navigation: Exit Ticket

24. Complete an exit ticket to answer the following questions:
   - Do you think that chemical reactions could occur in other places in the digestive system? Where do you think the chemical reactions would take place?
   - If so, what do you predict the “old stuff” and the “new stuff” in the chemical reaction would be?
   - How does what we figured out today help us figure out what might be going on with M’Kenna?

25. Update your table of contents and your Progress Tracker.
Analyze Data from Eating a Graham Cracker

Where is it happening?

What are the data for a healthy person?

Food Molecules

Legend:
- Mouth
- Graham Cracker

Relative Amount

- Fiber
- Carbohydrate
- Other Complex
- Glucose
- Fat
- Fatty Acids
- Protein
- Amino Acids
- Water
What’s Spit?

Pull a lollipop out of your mouth, and you'll see it. Wake up after drooling on your pillow, and you'll feel it. That's right. It's spit, which is also known as saliva (say: suh-LIE-vuh).

Saliva is a clear liquid that's made in your mouth 24 hours a day, every day. It's made up mostly of water, with a few other chemicals. The slippery stuff is produced by the salivary (say: SAL-uh-vair-ee) glands. These glands are found on the inside of each cheek, on the bottom of the mouth, and under the jaw at the very front of the mouth. They secrete (say: sih-KREET), or ooze, about 2 to 4 pints (or about 1 to 2 liters) of spit into your mouth every day!

Spit is super for a lot of reasons. Saliva wets food and makes it easier to swallow. Without saliva, a grilled cheese sandwich would be dry and difficult to gulp down. It also helps the tongue by allowing you to taste. A dry tongue can't tell how things taste—it needs saliva to keep it wet.

Spit helps begin the process of digestion (say: dy-JES-chun), too. Before food hits your stomach, saliva starts to break it down while the food's still in your mouth. It does this with the help of enzymes (say: EN-zimes), which are special chemicals found in the saliva. Amylase, which aids in the digestion of complex carbohydrates, is one kind of enzyme that can be found in your mouth. The combination of chewing food and coating it with saliva makes the tongue's job a bit easier—it can push wet, chewed food toward the throat more easily.

Saliva also cleans the inside of your mouth and rinses your teeth to help keep them clean. (But remember that spit isn't enough to keep teeth in tip-top shape; you still need to brush and floss!) The enzymes in saliva also help to fight off infections in the mouth.

Most school-age kids have just the right amount of saliva. Sometimes a person may not have enough saliva, but this is usually the result of certain medicines or treatments, some kinds of diseases, or old age.
Food Molecule Cards

two kinds of amino acid molecules

two kinds of glucose molecules

two kinds of fatty acid molecules

two kinds of carbohydrates

the tail end of one kind of protein molecule

the tail end of one kind of complex carbohydrate (starch) molecule

two kinds of fat molecules

KEY
Type of atom Symbol
sulfur S
nitrogen N
hydrogen H
oxygen O
carbon C
Chemical Reactions in the Mouth Investigation

Part 1: Plan the Investigation
Recall that the goal of this investigation is to figure out an answer to the question, “Do chemical reactions really occur in the mouth?” We decided to investigate whether a substance in saliva, amylase, could break complex carbohydrates down into glucose molecules. In previous investigations, we learned that we can use indicators to test for the presence of complex carbohydrates and glucose.

- Iodine is an indicator for starch (one type of complex carbohydrates)
  - If starch is not present, iodine stays brown
  - If starch is present, iodine turns black or dark purple
- Benedict’s solution is an indicator for glucose
  - If glucose is not present, Benedict’s stays blue
  - If glucose is present, Benedict’s turns orange or dark brown

You have the following substances available for your use in this investigation:
- Food samples soaked in water: crackers, taco shells, cooked rice
- Amylase solution
- Water
- Benedict’s solution
- Iodine

You have the following materials available for your use in this investigation:
- 4 microcentrifuge tubes
- Pipettes

Think about which substances you will need to add to each tube in order to figure out the answer to the question, “Do chemical reactions really occur in the mouth?” On Data Table for Chemical Reactions in the Mouth, Part 1, label each tube with the substances you plan to add. See the example to the right. Remember that scientists do controlled experiments, so you may want to include control groups.

Part 2: Plan your Procedures
Think about in which order you will need to add substances to your tubes. It may help to look ahead to the procedures in Part 3. Record the procedure titles you need in each box of Part 2 on Data Table for Chemical Reactions in the Mouth.

1. Food
2. Water
3. Iodine

Part 3: Make a Prediction
In Part 3 of Data Table for Chemical Reactions in the Mouth, make a prediction to answer the following question: What color do you predict the indicators will be after the investigation?
Part 4: Conduct the Investigation

Below, you will find the procedures for adding each substance to your tubes. Follow the order of procedures you created in Part 2 and the instructions below to add each substance to your tubes.

General Procedures to Follow

1. Gather your materials: four microcentrifuge tubes, distilled water, amylase solution, Benedict's solution, iodine solution, four eye droppers, and a coffee cup. Wear goggles throughout all of these steps.

2. Label all four microcentrifuge tubes to indicate what you decided to put in each tube.

Procedures to add FOOD to your tube

1. In a small cup, obtain a small amount of your food sample soaked in water.

2. Using a pipette, add approximately 0.5 mL of the food sample into the microcentrifuge tube (either 5 drops or approximately 1/3 of the microcentrifuge tube).
**Procedures to add WATER to your tube**

1. In a small cup, obtain a small sample of your distilled water.

2. Using a pipette, add approximately 0.5 mL of the distilled water to your tube (either 5 drops or approximately 1/3 of the microcentrifuge tube).

**Procedures to add AMYLASE to your tube**

1. In a small cup, obtain a small sample of amylase solution.
2. Using a pipette, add approximately 0.5 mL of the amylase solution to your tube (either 5 drops or approximately \( \frac{1}{3} \) of the microcentrifuge tube).

Procedures to add IODINE to your tube

1. In a small cup, obtain a small sample of iodine.

2. Using a pipette, add approximately 0.5 mL of the iodine to your tube (either 5 drops or approximately \( \frac{1}{3} \) of the microcentrifuge tube).
Procedures to add BENEDICT’S to your tube

1. In a small cup, obtain a small sample of Benedict’s.

2. Using a pipette, add approximately 0.5 mL of the Benedict’s to your tube (either 5 drops or approximately ⅓ of the microcentrifuge tube).

3. Pour boiling water into a cup or beaker. Add your tube to the cup or beaker and let it sit for approximately 10 minutes.

4. Using a spoon or tongs, remove the tube from the hot water.
Procedures to MIX your tube

Turn your tube upside down and right side up several times until all of the substances have been completely mixed.

Part 5: Record your Results

In Part 5 of Data Table for Chemical Reactions in the Mouth, record your results in response to the question: What color were the indicators after the investigation?

Part 6: Record your Interpretation

In Part 6 of Data Table for Chemical Reactions in the Mouth, record your interpretation of the results in response to the question: Which food molecules were detected in each tube?
## Data Table for Chemical Reactions in the Mouth

<table>
<thead>
<tr>
<th>Part 1: Diagram of Tube</th>
<th>Tube A</th>
<th>Tube B</th>
<th>Tube C</th>
<th>Tube D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Label each tube with the substances you plan to add.</td>
<td>[Diagram]</td>
<td>[Diagram]</td>
<td>[Diagram]</td>
<td>[Diagram]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part 2: Procedures</th>
<th>Tube A</th>
<th>Tube B</th>
<th>Tube C</th>
<th>Tube D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Record the order and title of procedures you will follow to set up your tubes in each box (remember to add your indicator last!).</td>
<td>[Diagram]</td>
<td>[Diagram]</td>
<td>[Diagram]</td>
<td>[Diagram]</td>
</tr>
<tr>
<td>Example:</td>
<td>[Diagram]</td>
<td>[Diagram]</td>
<td>[Diagram]</td>
<td>[Diagram]</td>
</tr>
<tr>
<td>1. RICE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. WATER</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. IODINE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. MIX</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part 3: Prediction</th>
<th>Tube A</th>
<th>Tube B</th>
<th>Tube C</th>
<th>Tube D</th>
</tr>
</thead>
<tbody>
<tr>
<td>What color do you predict the indicators will be after the investigation?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part 5: Results</th>
<th>Tube A</th>
<th>Tube B</th>
<th>Tube C</th>
<th>Tube D</th>
</tr>
</thead>
<tbody>
<tr>
<td>What color were the indicators after the investigation?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part 6: Interpretation</th>
<th>Tube A</th>
<th>Tube B</th>
<th>Tube C</th>
<th>Tube D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which food molecules were detected in each tube?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
LESSON 6: What happens to the different substances in food as it travels through the digestive system?

**PREVIOUS LESSON**
We made observations about what happens to some complex carbohydrates in the mouth, noting that the decrease in complex carbohydrates and increase in glucose seemed to be correlated. We planned and conducted an investigation to determine whether complex carbohydrates can undergo a chemical reaction when mixed with a substance in saliva to produce glucose. We argued that some complex carbohydrates are broken down into glucose molecules through chemical reactions occurring in the mouth.

**THIS LESSON INVESTIGATION**
We analyze more food data, starting from before the food enters the mouth and continuing through the large intestine, noting the food changes across different parts of a healthy digestive system. We notice patterns in which the quantity of some types of molecules decrease by the same amount that the quantity of other types of molecules increase. We argue that, similar to what we observed with complex carbohydrates in the mouth, this is a sign of a chemical reaction and that one substance can turn into another substance during digestion.

**NEXT LESSON**
We will review our Progress Trackers and develop a Gotta-Have-It Checklist to highlight the key ideas we have figured out. We will develop models to answer the questions, “How does a healthy digestive system work?” and “How is M’Kenna’s digestive system functioning differently than a healthy one?” We will examine conditions that might be causing M’Kenna’s symptoms.

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

**WHAT STUDENTS WILL DO**
Analyze and interpret data to identify patterns in the amount that certain food molecules (complex carbohydrates, proteins, and fats) decrease and other food molecules (glucose, amino acids, and fatty acids) increase as they move through different organs in the digestive system.

Analyze and interpret these data as evidence that the digestive system is a system of interacting subsystems composed of organs that each perform different functions.

**WHAT STUDENTS WILL FIGURE OUT**
Some new substances that were not there before start appearing in the stomach (amino acids and fatty acids).

When the amount of one substance increases in the mouth or stomach, a different substance decreases by the same amount. Chemical reactions in the mouth and stomach account for patterns in the data.
## Lesson 6 • Learning Plan Snapshot

<table>
<thead>
<tr>
<th>Part</th>
<th>Duration</th>
<th>Summary</th>
<th>Slide</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10 min</td>
<td>ADD TO OUR PROGRESS TRACKERS</td>
<td>A-C</td>
<td>Progress Tracker</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Facilitate a Building Understandings Discussion to update Progress Trackers to represent the idea that chemical reactions occur in our mouths, which helps explain why some molecules in our foods decrease by the same amount that other molecules increase during digestion.</td>
<td></td>
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</tr>
<tr>
<td>2</td>
<td>10 min</td>
<td>ANALYZE DATA TO DETERMINE IF CHEMICAL REACTIONS HAPPEN IN OTHER ORGANS</td>
<td>D-J</td>
<td>Data of Food Molecules for a Healthy Person, Food Molecule Data for a Healthy Person, ruler</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Support students as they analyze graphed data for following a graham cracker from the mouth to the large intestine in a healthy system. Focus students on identifying patterns in food molecules that increase and decrease as they travel through the digestive system.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>5 min</td>
<td>LOOK FOR PATTERNS IN FOOD MOLECULES</td>
<td>K</td>
<td>Food molecule card sets created from Food Molecule Cards</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provide students with food molecule cards of complex carbohydrates, proteins, fats, glucose, amino acids, and fatty acids to use to look for patterns in their structures. Ask students to use these models to explain whether chemical reactions could be happening in other parts of the digestive system beyond the mouth.</td>
<td></td>
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</tr>
<tr>
<td>4</td>
<td>17 min</td>
<td>BUILDING UNDERSTANDINGS DISCUSSION TO MAKE SENSE OF PATTERNS IN THE DATA</td>
<td>L</td>
<td>Food Molecule Data for a Healthy Person</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Engage students in a Building Understandings Discussion to make sense of patterns in graphed data for following a graham cracker from the mouth to the large intestine in a healthy system. Focus students on the role that the specialized structures in the digestive system play in the breakdown of large food molecules.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>3 min</td>
<td>NAVIGATION</td>
<td>M</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Support students in summarizing what they've figured out during this lesson and connecting their ideas back to M'Kenna's symptoms.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

End of day 1
Lesson 6 • 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>• food molecule card sets created from Food Molecule Cards</td>
</tr>
<tr>
<td>• Progress Tracker</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Data of Food Molecules for a Healthy Person</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Food Molecule Data for a Healthy Person</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• ruler</td>
<td></td>
<td></td>
<td></td>
</tr>
</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.

Gather food molecule cards made from Food Molecule Cards in Lesson 5.
Lesson 6 • Where We Are Going and NOT Going

Where We Are Going

Students will likely bring a few ideas about digestion to this lesson, including a familiarity with some of the molecules found in food and an understanding that digestion breaks down food to make it available to our bodies.

This lesson focuses students on realizing that each organ within the digestive system performs a slightly different function. Specifically, students identify organs that assist in breaking down and absorbing food molecules. This lesson is designed to engage students in the analysis and interpretation of graphed data on how molecules change or do not change as they move through digestion. Connecting the breakdown of some large food molecules into other food molecules will be new to 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.

Where We Are NOT Going

While students are becoming familiar with the organs of the digestive system, a detailed study of the mechanism of the body system is not necessary. Students also do not need to learn the details of the chemical reactions that are taking place in the digestive system to get to the main science ideas of metabolic reactions.
LEARNING PLAN for LESSON 6

1 · ADD TO OUR PROGRESS TRACKERS

MATERIALS: science notebook, Progress Tracker

Look back at what we figured out about chemical reactions in the mouth. Present slide A and remind students that last time we were working on figuring out whether chemical reactions happen in the mouth. Remind students that we decided to take a deeper dive into the digestive system of a healthy person because we think that it might help us figure out what is different about M’Kenna’s digestive system. Prompt students to turn and talk with a partner about the question, “What evidence did we use to support our claims about the question, ‘Do chemical reactions occur in the mouth?’” Provide students several minutes to gather their ideas with a partner, then prompt students to share their ideas with the class in a Building Understandings Discussion.

KEY IDEAS

Purpose of this discussion: This discussion serves as a way to pull together the progress that students made in Lesson 5. In this discussion, students work to represent the idea that chemical reactions occur in the mouth, which helps to explain why some food molecules increase and some decrease.

Listen for these ideas:
- Chemical reactions occur in the mouth.
- An enzyme called amylase helps break some types of complex carbohydrates down into glucose molecules.
- There is an increase in glucose because some types of complex carbohydrates are being broken down into glucose.

Suggested prompt

<table>
<thead>
<tr>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>What did we figure out in the last class? Do chemical reactions occur in the mouth?</td>
</tr>
<tr>
<td>Yes, we found out that big food molecules, like certain types of complex carbohydrates, are being broken down into smaller food molecules, like glucose. They are not just bigger chunks of complex carbohydrates being turned into little chunks of the same thing. The smaller food molecules really are different molecules with different properties.</td>
</tr>
<tr>
<td>What evidence do we have to support our claims?</td>
</tr>
<tr>
<td>When we made observations about eating a cracker, we noticed that our teeth seemed to break apart the cracker and that spit mixes with the cracker.</td>
</tr>
<tr>
<td>When we examined the data from a healthy person eating a graham cracker, we noticed that the amount of other complex carbohydrates in the mouth decreases and the amount of glucose increases.</td>
</tr>
<tr>
<td>We read an article that provided us with evidence that a special enzyme called amylase can break down substances in the mouth.</td>
</tr>
<tr>
<td>We conducted an investigation to determine if amylase breaks some types of complex carbohydrates down into glucose, and we discovered that it does!</td>
</tr>
</tbody>
</table>

✱ STRATEGIES FOR THIS BUILDING UNDERSTANDINGS DISCUSSION

It is important to use whatever representations the class agrees on to capture the essential ideas, rather than using the exact wording or pictures in this teacher guide. It is recommended that you include a simplified diagram that shows the smaller molecules of glucose or that shows there is a repeating chain of such subunits in macromolecules (like starch). For example, the class might decide they want to use different shapes for these subunits.
Add the word “digestion” to the word wall. Say, *When our bodies take big food molecules and break them down into smaller food molecules through chemical reactions, we call that “Digestion = a chemical reaction to break down food.”*

Say, *It sounds like we made a really important discovery about what is happening in the mouth! Let’s capture this on our Progress Trackers.*

Present slide B. Have students follow the directions on slide B to develop a 30-second argument using evidence and scientific reasoning with a partner that can support how we should add to our Progress Trackers and revise our model for what happens to food as it passes through the digestive system.

After spending some time working with their partner, have students update their 2-column Progress Trackers. Have students record the representation they agree upon in their Progress Tracker.*

Here is one suggested representation.

<table>
<thead>
<tr>
<th>Question</th>
<th>What I Figured Out in Words/Pictures</th>
</tr>
</thead>
</table>
| **Why do large food molecules, like certain types of complex carbohydrates, seem to disappear in the digestive system?** | • When we chew food, our teeth and tongue move the food around, and saliva is mixed with the food.  
• Saliva has a special enzyme in it called amylase. Amylase helps to break some types of complex carbohydrates down into glucose through a chemical reaction.  
• Because certain types of complex carbohydrates are broken down into glucose in the mouth, the amount of other complex carbohydrates in the mouth decreases and the amount of glucose increases. |

**ADDITIONAL GUIDANCE** Students work on this 3-column row of the Progress Tracker after important punchlines in the unit are figured out as a class—usually after the class has come to a consensus about something. These are rows we do not suggest skipping in the unit. If these pieces are missing, students may have trouble moving forward in their sensemaking. Remember that this is not a note-taking activity, and each groups’ Progress Tracker does not need to look exactly the same.
Consider using Progress Tracker as an opportunity for a formative assessment. Students should be able to argue from evidence, using patterns of change, that complex carbohydrates are broken down into glucose molecules through chemical reactions in a process called digestion. If students need additional support, consider spending more time interpreting the findings from Lesson 5 or revisiting the food molecule cards from Lesson 5.

After updating the Progress Trackers, help students navigate to the next activity. Ask students the following questions found on slide C.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you think that all of our food gets broken down in our mouths?</td>
<td>I'm not sure—probably no. The mouth seems to be breaking down only some types of complex carbohydrates. Don't we eat other things besides carbs? We eat protein, too.</td>
</tr>
<tr>
<td>Where do you think other food molecules we eat, like protein, get broken down?</td>
<td>Maybe in our stomachs? Could we check to see if this happens in other organs in our digestive system?</td>
</tr>
<tr>
<td>What could we do to figure that out?</td>
<td>Maybe we could try to find data similar to the data that we looked at from a person's mouth when they were eating a graham cracker.</td>
</tr>
</tbody>
</table>

Provide several moments for students to share their initial ideas about these questions. Tell students that you were able to access data that shows what happens to a graham cracker as it passes through the rest of the digestive system.

2 · ANALYZE DATA TO DETERMINE IF CHEMICAL REACTIONS HAPPEN IN OTHER ORGANS

**MATERIALS:** science notebook, Data of Food Molecules for a Healthy Person, Food Molecule Data for a Healthy Person, ruler

Say, Recall that we found one food molecule that doesn't seem to change (fiber), and we found that other types of complex carbohydrates decrease in the mouth while glucose increases. We wanted to look at what happens to food in other parts of the digestive system to see why certain food molecules are increasing while others are decreasing. We thought that if we can figure out what happens in a normal system, it may help us understand more about what's going wrong in M'Kenna's body. I pulled together graphs showing how food molecules change during healthy digestion from before it enters a person's body through multiple organs in the digestive system. Let's see if we can use these to figure out a typical pattern in what increases and decreases for a healthy person.

Arrange students in groups of three and orient them to their task. Remind students that the goal is to discover relationships between food molecule amounts that increase or decrease during digestion. Pass out a copy of Food Molecule Data for a Healthy Person and Data of Food Molecules for a Healthy Person to each student.

Present slide D to orient students as to how to record their data. These graphs show how food changes between two locations. As a reminder from Lesson 5, the light green (or light gray if printed in black and white) is the previous amount, while the dark green (or dark gray) is the new amount. In the first graph, the light bars represent what is in the graham cracker before it enters the mouth. Students already analyzed this in Lesson 5 but will do so again here so that they can track the food through the entire digestive system and have built-in support with the data analysis (by viewing a graph that they have already seen). On their handouts, students will record symbols to indicate the amounts that increase, decrease, or stay the same. Consider doing the first two locations together if you feel students need additional guidance. Note that students will attach the half-sheet data table from the Data of Food Molecules for a Healthy Person to their science notebooks after they have analyzed their data. Remind students to update their table of contents. See the example data sheet attached to the science notebook in the images below.*

* SUPPORTING STUDENTS IN DEVELOPING AND USING PATTERNS

The purpose of this data analysis and interpretation activity is to identify patterns in the rates of change of food molecules as they pass through different digestive organs.
Give groups 8–10 minutes to examine the data and record up, down, or stay the same trends on their data tables. Make rulers available for students. If students ask what the rulers are for, say that other students have asked for them before when looking at these data, and you wanted to make them available in case they thought they might be useful, too.

Then ask students to attach their data table handouts to their science notebooks, so they can write additional ideas around the table as they discuss what they notice. An example is provided.

Slides E–J contain the graphs in a colored version if you want to present them throughout the activity.

### 3 · LOOK FOR PATTERNS IN FOOD MOLECULES

**MATERIALS: science notebook, food molecule card sets created from Food Molecule Cards**

Connect food molecules in graphs to their structures on the food molecule cards. As students were examining the food graphs, they may have developed questions about what each of the molecules looks like and how they might be related to each other. Tell students that we can reference back to our Food Molecule Cards to see what these molecules actually look like.

Project slide K and use it to show the molecular representations of the various food molecules. Hand out the food molecule cards in your kit or that you prepared from Food Molecule Cards. Instruct students to compare and contrast the molecular structures for each of the food molecules. Prompt students to consider the question: How do these patterns help 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?

After several minutes, pull students together to report out some of the patterns they have noticed. Project slide J as you do this. Encourage students to come up to the projected image to show what they’ve noticed.

**ADDITIONAL GUIDANCE**

This activity, “Look for Patterns in Food Molecules,” follows the same activity structure as the food molecule activity in Lesson 5. In this lesson, however, students are presented with additional molecular representations beyond just complex carbohydrates and glucose. Use this as an opportunity to build on prior knowledge developed in Lesson 5.

Students should notice that, just as glucose looks like smaller bits of complex carbohydrates, amino acids look like smaller bits of proteins, and fatty acids look like smaller bits of fats.
Suggested prompt

Think about the graham cracker moving through the different organs of the digestive system.

How do these patterns help explain why the amount of one type of food molecule (e.g., a protein) might be decreasing by the same amount that another type of food molecule (e.g., amino acids) is increasing?

Sample student response

These models show that certain chemical reactions could be possible, where the same types of atoms would be in the reactant as are in the product.

It seems like breaking apart the bigger molecules into smaller pieces would get you certain smaller molecules (e.g., a protein molecule looks like it can be broken apart into amino acids).

Prepare students to engage in a Building Understandings Discussion in which they will make sense of patterns in the data on the food graphs.

4 · BUILDING UNDERSTANDINGS DISCUSSION TO MAKE SENSE OF PATTERNS IN THE DATA

MATERIALS: science notebook, Food Molecule Data for a Healthy Person

ADDITIONAL GUIDANCE

While helping students make sense of the data, students may begin to wonder about what is and what is not healthy. By examining the data of a healthy person, students will be able to see the following patterns emerging:

- It is healthy for the quantity of certain food molecules to decrease through digestion, going to zero by the time they reach the large intestine. This is true for macromolecules, such as fats, proteins, and carbohydrates.
- It is also healthy for the quantity of other molecules to increase during the start of digestion and then to decrease later in digestion. This is true for smaller molecules.
- 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.

Remember that slides E–J contain the graphs if you want to present them throughout the following discussion.

Make sense of patterns in the data that we can already explain. Bring the students together to share what they notice from the data. Focus first on patterns that confirm the model ideas already developed in the previous lessons, for example, the water pattern, the fiber pattern, the zeros at the end of the table, and the decrease in other complex carbohydrates and increase in glucose in the mouth. Prompt students to circle these patterns on their tables.

Make sense of new patterns in the data. Ask students to share patterns they’ve noticed about which food molecules increase and which decrease. As students share, ask the other groups if they observed the same patterns (e.g., when other complex carbohydrates go down in the stomach, the glucose goes up; both go down in the small intestine).

◆ SUPPORTING STUDENTS IN THREE-DIMENSIONAL LEARNING

Students should start to build towards identifying spatial relationships between changes in food molecule amounts and the organs in which they are occurring. These patterns of changing food molecule amounts support the disciplinary core idea that most of the food we eat is broken down during digestion.

◆ STRATEGIES FOR THIS BUILDING UNDERSTANDINGS DISCUSSION

This is a discussion in which students should come to key conclusions related to MS-LS1-3.

- First, students should analyze data to identify patterns in the functions of each of the organs in the digestive system.
- Second, students should interpret these data as evidence that the digestive system is a system of interacting subsystems that each perform different functions.
**KEY IDEAS**

**Purpose of this discussion:** Identify patterns in the food data.

**Listen for these ideas:**
- In the middle of the small intestine, all the substances in food start decreasing, except fiber and fatty acids.
- Some new substances that weren't there before start appearing in the stomach (amino acids and fatty acids), and more glucose appears in the mouth than at the beginning.

Use the following prompts to guide this discussion.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Which molecules only go down over time and never go up?</strong></td>
<td>Other complex carbohydrates, proteins, and fats only go down. This seems to happen mostly in the stomach and small intestine.</td>
</tr>
<tr>
<td><strong>Which molecules increase and decrease?</strong></td>
<td>Glucose, fatty acids, and amino acids go up in the stomach and the beginning of the small intestine and then go down.</td>
</tr>
<tr>
<td><strong>Do any types of molecules appear in the food at any point that weren’t in it before it was eaten?</strong></td>
<td>There were no amino acids and fatty acids in the graham cracker to begin with, but then they started appearing after they reached the stomach.</td>
</tr>
<tr>
<td><strong>Did anyone notice patterns in which one substance increased and another decreased in the same location?</strong></td>
<td>When complex carbohydrates go down, glucose goes up, except in the middle of the small intestine, where they both go down.</td>
</tr>
</tbody>
</table>

New patterns that students may identify include that some food molecules (complex carbohydrates, proteins, and fats) only go down, while other food molecules (glucose, amino acids, and fatty acids) go up, then down. It looks like when one food molecule goes up, another goes down, except in the middle of the small intestine, where most things just start to go down.

✅ If students attach their data tables to their science notebooks before the discussion of patterns, they can circle patterns on their data tables and write an observation about the pattern to the side of it. An example of one way to record these patterns is shown here. Record a class copy of these patterns to easily reference later in the unit.
ASSESSMENT OPPORTUNITY

Consider using Data of Food Molecules for a Healthy Person as an opportunity to provide formative assessment. Focus specifically on students’ abilities to analyze and interpret data to identify spatial relationships between food molecule digestion and absorption and the organs in which those processes occur. If students are struggling, consider providing additional support reading the graphs or making connections between large food molecules and small food molecules (e.g., protein and amino acids). It may also help to annotate one portion of the graph (e.g., fiber) together.

Interpret the data to make claims about the functions of each organ. After students have sufficiently analyzed the data, pose the second question on slide L.

Say, Based on the data, what claims can we make about the functions of each of the organs in the digestive system?

Facilitate a Building Understandings Discussion around this question. Recall that, in a Building Understandings Discussion, the teacher’s role is centered around pressing students to back up their ideas with evidence. During discussion, teachers also set and maintain focus around the discussion question, invite students to share claims and explanations, push for elaboration of evidence and reasoning, encourage critique and alternative explanations, and help the group come to tentative conclusions. The student’s role is to attempt to explain observations in the data, use data as evidence to support their claims, compare, contrast, and critique others claims, evidence, and explanations, agree and disagree respectfully, and ask questions to clarify.

KEY IDEAS

Purpose of this discussion: To make sense of the idea that each organ in the digestive system performs a different function and that the digestive system is composed of subsystems each performing different functions.

Listen for these ideas:

- Almost all of the food molecules change in the stomach and the beginning of the small intestine. This must mean that the function of the stomach and the small intestine is to help break down food.
- Nothing changes in the esophagus. This must mean that the function of the esophagus is not related to the breaking down of food.
- Most small food molecules decrease in the small intestine and parts of the large intestine. This must mean that the small intestine and the large intestine are involved in absorption.
- Each organ is a subsystem of the digestive system with a particular function.

Prior to beginning the discussion, give students several moments to gather their thoughts either through a Stop and Jot or through a partner talk. Then, begin the discussion by using the suggested prompts below.*

<table>
<thead>
<tr>
<th>Suggested prompts</th>
<th>Sample student responses</th>
<th>Follow-up questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can someone remind us of the question we are trying to answer?</td>
<td>The bigger question we are trying to answer is, “What happens to different substances in food as it travels through the digestive system?” We have this question because we wanted to know if chemical reactions occur in other places in the digestive system beyond the mouth.</td>
<td>Great, so our question is, “Based on the data, what claims can we make about the functions of each of the organs in the digestive system?” Let’s stay focused on this question and see what we think we have figured out.</td>
</tr>
<tr>
<td></td>
<td>Our question right now is, “Based on the data, what claims can we make about the functions of each of the organs in the digestive system?”</td>
<td></td>
</tr>
</tbody>
</table>

*openscied.org
<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are some of your claims?</td>
<td>Each organ in the digestive system (mouth, esophagus, stomach, small intestine, and large intestine) is performing a different function.</td>
</tr>
<tr>
<td></td>
<td>Large food molecules are mainly broken down in the stomach and the small intestine.</td>
</tr>
<tr>
<td></td>
<td>Small food molecules are mainly absorbed in the small intestine.</td>
</tr>
<tr>
<td></td>
<td>The function of the esophagus does not seem related to breaking down or absorbing large food molecules.</td>
</tr>
</tbody>
</table>

**Work as a class to represent findings.** Ask students for ideas of how we can represent what is happening to food molecules as they travel through the digestive system by showing the relationship between large food molecules and corresponding smaller food molecules.

<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>We need some way to represent this idea that certain types of complex carbohydrates break down into glucose, but the total amount of matter doesn't increase. Is there some way we can show this, without getting into the details of the specific number of atoms in each and how they are arranged?</td>
<td>Maybe we can show the smaller molecules as little shapes and the larger molecules as chains of those little shapes.</td>
</tr>
<tr>
<td>How can we show that the larger molecules appear to be made of similar clusters of atoms that make up the smaller molecules?</td>
<td>We can use squares (or other shapes) for smaller molecules and a &quot;necklace&quot; of those shapes chained together for the larger molecules.</td>
</tr>
</tbody>
</table>
Press students to back up their claims with evidence. Have students record the representation they agree upon for the breakdown of large food molecules to smaller food molecules. Students may wish to record their ideas in their Progress Trackers. Colored pencils may be useful in this representation, particularly for distinguishing that there are different types of food molecules and for representing that the arrow in the diagram isn’t just showing movement but it is showing a chemical reaction occurring. In the next lesson, students will work with these initial ideas to develop a revised model.

Here is one suggested representation.

**ADDITIONAL GUIDANCE**

It is important to use whatever representations the class agrees upon to capture the essential ideas, rather than using the exact wording or pictures in this teacher guide. It is recommended that you include a simplified diagram that shows the smaller molecules of glucose or that shows there is a repeating chain of such subunits in macromolecules (like starch). For example, the class may decide that they want to use different shapes for these subunits.
<table>
<thead>
<tr>
<th>Suggested prompt</th>
<th>Sample student response</th>
</tr>
</thead>
<tbody>
<tr>
<td>We said that each organ in the digestive system (mouth, esophagus, stomach, small intestine, and large intestine) is performing a different function.</td>
<td>We know that each organ is performing a different function because our data tables show us that some organs, like the esophagus, aren’t involved in breaking down or absorbing food molecules. Other organs, like the mouth, stomach, and small intestine, seem to play an important role in breaking down large food molecules into smaller food molecules. Other organs, like the small intestine and the large intestine, seem responsible for absorbing food molecules.</td>
</tr>
<tr>
<td>How did we arrive at that conclusion? What is our evidence?</td>
<td>We can conclude that each organ in the digestive system has its own function. Some of the functions are similar, and some are very different.</td>
</tr>
<tr>
<td>What seems to be true about all of our claims? What can we conclude?</td>
<td></td>
</tr>
</tbody>
</table>

After multiple students have shared the idea that each organ in the digestive system performs different functions and have supported their claims with evidence, suggest adding to our definition for “organ” on the word wall. Previously, our definition was that organs are “structures in the body.” Add the idea that each organ serves a particular function.

5 · NAVIGATION

MATERIALS: science notebook

Summarize what the class has figured out. Take a moment to summarize, or have a student summarize, what we’ve figured out during this lesson. You may wish to prompt students to complete their Progress Trackers for this lesson. They key idea that we figured out was that other organs besides the mouth seem to be breaking down food from big molecules into smaller molecules and that different organs have different functions. Each organ is a subsystem within a larger system that helps the body digest food.

Project slide M and give students just a few minutes to share out their ideas about how what we figured out relates to M’Kenna. Provide time for students to share out their ideas with the whole group. As students are sharing, note the large range of ideas that we have figured out.

Say, It sounds like we have figured out a lot! Maybe it will help us if we can pull all of these pieces together into an explanation for what is happening with a healthy person. That way we can look at all of these ideas in one place to help us figure out what is going on with M’Kenna.

Tell students that, in the next class, we are going to take some time to pull all of our ideas together into an explanation to help us better think about M’Kenna’s case.

Collect copies of Food Molecule Data for a Healthy Person to reuse between periods.
Navigation

Last time, we conducted a series of investigations to determine if chemical reactions happen in the mouth. We:

- Made observations about eating a cracker.
- Analyzed data from eating a graham cracker.
- Conducted an investigation to determine if chemical reactions occur in the mouth.

Turn and Talk

What evidence did we use to support our claims to answer the question, “Do chemical reactions occur in the mouth?”

Add to Our Progress Trackers

Work with a partner to construct a 30-second argument using evidence and scientific reasoning that can support how we should add to our Progress Trackers and revise our model for what happens to food as it passes through the digestive system.

After arguing from evidence with your class, add to your Progress Tracker.

How to Analyze the Data

1. The light-colored bar shows the amount of the molecule in the previous location in a healthy person. The dark-colored bar shows the amount of the molecule in the new location in a healthy person.

2. Record whether the food molecule increases (↑), decreases (↓), or stays the same (=) from the previous location to the new location.
Graham Cracker to Mouth

Mouth to Esophagus

Esophagus to Stomach

Stomach to Beginning of Small Intestine
Beginning of Small Intestine to Middle of Small Intestine

Middle of Small Intestine to Large Intestine

Look for Patterns in Food Molecules

Building Understandings Discussion

Think about the graham cracker moving through the different organs of the digestive system.

How do these patterns help explain why the amount of one type of molecule (e.g., a protein) might be decreasing by the same amount that another type of molecule (e.g., amino acids) is increasing?

Develop a whole-group record of what we agree on and where we have competing ideas.

- What patterns do we notice in the data?
- Based on the data, what claims can we make about the functions of each of the organs in the digestive system?
Discuss with a partner:
We just figured out a lot! How do all of our ideas help us explain what might be going on with M'Kenna? Take a moment to share your initial ideas with a partner.
Lesson 6: What happens to the different substances in food as it travels through the digestive system?

Navigation

Last time, we conducted a series of investigations to determine if chemical reactions happen in the mouth. We:
- Made observations about eating a cracker.
- Analyzed data from eating a graham cracker.
- Conducted an investigation to determine if chemical reactions happen in the mouth.

Turn and talk

1. Turn and talk with your partner about the following question:
   - What evidence did we use to support our claims to answer the question, “Do chemical reactions occur in the mouth?”

Adding to our Progress Trackers

2. Work with a partner to construct a 30-second argument using evidence and scientific reasoning that can support how we should add to our Progress Trackers and revise our model for what happens to food as it passes through the digestive system. You will spend two minutes with your partner finding evidence in your science notebooks and creating an argument to share with the whole group.
3. Share your ideas with the class.
4. After arguing from evidence with your class, add to your Progress Tracker using Progress Tracker.

Analyze Data to Determine if Chemical Reactions Happen Throughout the Digestive System

5. Obtain a copy of Food Molecule Data for a Healthy Person and Data of Food Molecules for a Healthy Person. Tape Data of Food Molecules for a Healthy Person into your science notebook.
6. Work in groups to examine data as a graham cracker moves through the digestive system of healthy person. The data include important food molecules.
   - The light-colored bar shows the amount of the molecule in the previous location. The dark-colored bar shows the amount of the molecule in the new location. Record whether the food molecule increases (↑), decreases (↓), or stays the same (=) from the previous location to the new location.
   - If the amount is zero in the new location (dark bar), record a zero (0).
Graham Cracker to Mouth

In your notebook

7. Work in groups to examine data as a graham cracker moves through the digestive system of a healthy person. The data include important food molecules.

- The light-colored bar shows the amount of the molecule in the previous location. The dark-colored bar shows the amount of the molecule in the new location. Record whether the food molecule increases (↑), decreases (↓), or stays the same (=) from the previous location to the new location.
- If the amount is zero in the new location (dark bar), record a zero (0).

Mouth to Esophagus

In your notebook

8. Work in groups to examine data as a graham cracker moves through the digestive system of healthy person. The data include important food molecules.

- The light-colored bar shows the amount of the molecule in the previous location. The dark-colored bar shows the amount of the molecule in the new location. Record whether the food molecule increases (↑), decreases (↓), or stays the same (=) from the previous location to the new location.

Esophagus to Stomach

In your notebook

9. Work in groups to examine data as a graham cracker moves through the digestive system of healthy person. The data include important food molecules.

- The light-colored bar shows the amount of the molecule in the previous location. The dark-colored bar shows the amount of the molecule in the new location. Record whether the food molecule increases (↑), decreases (↓), or stays the same (=) from the previous location to the new location.

Stomach to Beginning of Small Intestine

In your notebook

10. Work in groups to examine data as a graham cracker moves through the digestive system of healthy person. The data include important food molecules.

- The light-colored bar shows the amount of the molecule in the previous location. The dark-colored bar shows the amount of the molecule in the new location. Record whether the food molecule increases (↑), decreases (↓), or stays the same (=) from the previous location to the new location.
Beginning of Small Intestine to Middle of Small Intestine

11. Work in groups to examine data as a graham cracker moves through the digestive system of a healthy person. The data include important food molecules.
   - The light-colored bar shows the amount of the molecule in the previous location. The dark-colored bar shows the amount of the molecule in the new location. Record whether the food molecule increases (↑), decreases (↓), or stays the same (=) from the previous location to the new location.

Middle of Small Intestine to Large Intestine

12. Work in groups to examine data as a graham cracker moves through the digestive system of a healthy person. The data include important food molecules.
   - The light-colored bar shows the amount of the molecule in the previous location. The dark-colored bar shows the amount of the molecule in the new location. Record whether the food molecule increases (↑), decreases (↓), or stays the same (=) from the previous location to the new location.

Look for Patterns in Food Molecules

13. Examine the Food Molecule Cards. With your group, discuss your response to the question:
   - How do these patterns help us explain why the amount of one type of molecule (e.g., a protein) might be decreasing by the same amount that another type of molecule (e.g., amino acids) is increasing in the graham cracker in different parts of the digestive system?

14. Share your ideas with the class.

Building Understandings Discussion

15. Meet in a Scientists Circle with your class. Begin the discussion by focusing on the question:
   - What patterns do we notice in the data?

16. After identifying patterns in the data, focus on the question:
   - Based on the data, what claims can we make about the functions of each of the organs in the digestive system?

Navigation

17. Turn and talk with your partner about the following question:
   - How do all of our ideas help us explain what might be going on with M’Kenna?

18. Update your Progress Tracker and table of contents.
<table>
<thead>
<tr>
<th>Question</th>
<th>Source of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>What we figured out in words/pictures</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
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</tr>
</thead>
<tbody>
<tr>
<td>What we figured out in words/pictures</td>
<td></td>
</tr>
</tbody>
</table>
Food Molecule Data for a Healthy Person

With your group

1. Work in groups to examine data as a graham cracker moves through the digestive system of a healthy person. The data include important food molecules.

2. The light-colored bar shows the amount of the molecule in the previous location. The dark-colored bar shows the amount of the molecule in the new location. Record whether the food molecule increases (↑), decreases (↓), or stays the same (=) from the previous location to the new location.

3. If the amount is zero in the new location (dark bar), record a zero (0).

4. Here are helpful tips for interpreting the bars in the graph:
   - If both bars are equal, that means the amount of that type of molecule did not change.
   - If the light bar is less than the dark bar, that means the amount of that type of molecule increased.
   - If the dark bar is less than the light bar, that means the amount of that type of molecule decreased.
Food Molecules

Legend
- Esophagus
- Stomach

Water
Amino Acids
Protein
Fatty Acids
Fat
Glucose
Other Complex Carbohydrate
Fiber

Relative Amount

Food Molecules

Legend
- Stomach
- Beginning of Small Intestine

Water
Amino Acids
Protein
Fatty Acids
Fat
Glucose
Other Complex Carbohydrate
Fiber

Relative Amount
## Data of Food Molecules for a Healthy Person

**Food: Graham cracker**  
(*increases, decreases, or stays the same, and/or is zero*)

<table>
<thead>
<tr>
<th></th>
<th>Mouth</th>
<th>Esophagus</th>
<th>Stomach</th>
<th>Beginning: Small intestine</th>
<th>Middle: Small intestine</th>
<th>Large intestine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amino acids</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Protein</td>
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<tr>
<td>Fatty acids</td>
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<tr>
<td>Fat</td>
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<tr>
<td>Glucose</td>
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<tr>
<td>Other Complex Carbohydrate</td>
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<td></td>
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</tr>
<tr>
<td>Fiber</td>
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</tbody>
</table>