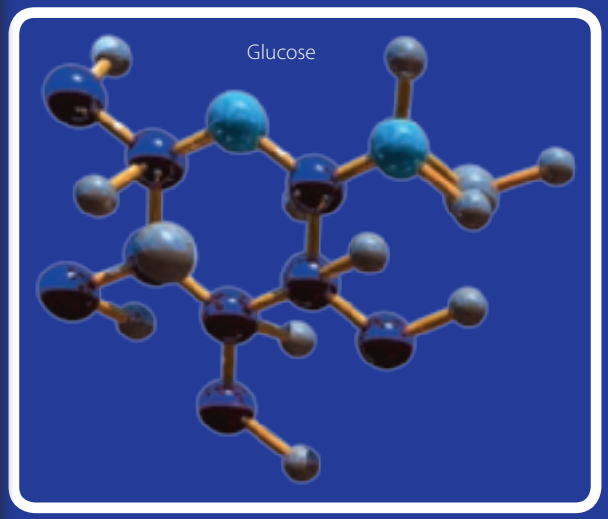
Metabolic Reactions:

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



Teacher Guide





GRADE 7 Core Knowledge Science®

Core Knowledge®

This unit is a modified version of a unit that has earned the NGSS Design Badge. The sole instructional modification is the addition of Core Knowledge Science Literacy content. The modification has not been reviewed.

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

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Core Knowledge®

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ISBN: 978-1-68380-809-1

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BEFORE YOU BEGIN

Before introducing the unit, please become fully acquainted with the program instructional model and classroom routines by reading the online resource **Teacher Handbook: Overview of the Core Knowledge Middle School Science Program**.

Online Resources



Use this link to download the **CKSci Online Resources Guide** for this unit, which includes specific links to:

- the unit's comprehensive materials list
- a full unit pacing snapshot
- lesson guidance slides
- all other recommended resources.

www.coreknowledge.org/cksci-online-resources

Student Work Pages



All student handouts and exercise pages are included in the consumable Student Work Pages book so that there is no need to print copies of these resources.

Student Books



All student handouts and exercise pages are included in the consumable Student Work Pages book so that there is no need to print copies of these resources. Students also will use the Student Procedure Guide and the Science Literacy Student Reader throughout the unit.

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 that 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 Disciplinary Core Ideas (DCIs): LS1.A, LS1.B, LS1.C, PS3.D

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.

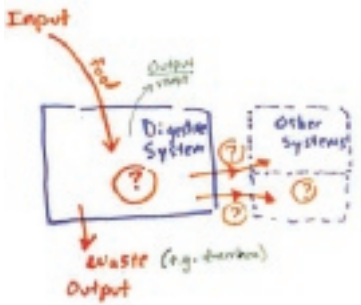
MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

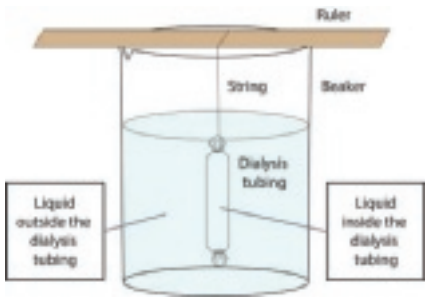
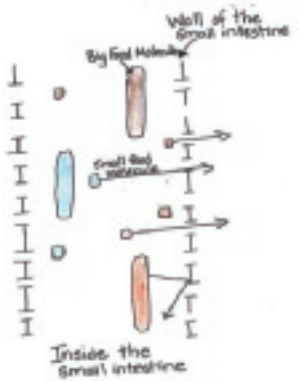
UNIT STORYLINE

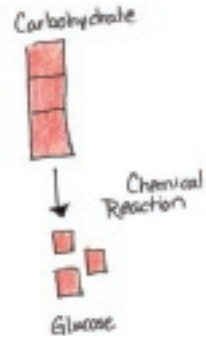
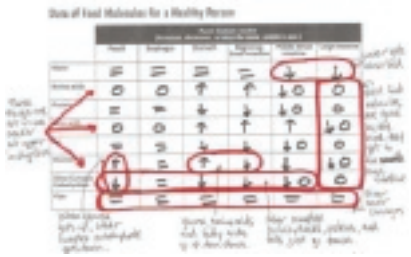
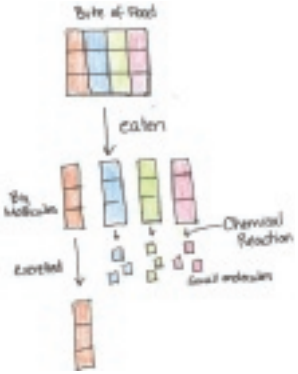
How students will engage with each of the phenomena

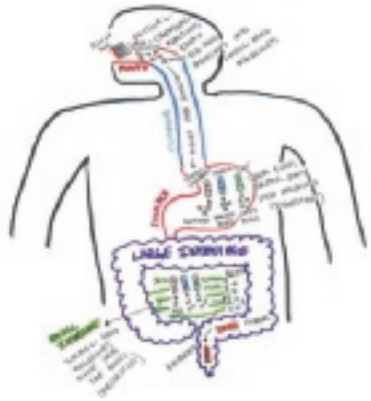
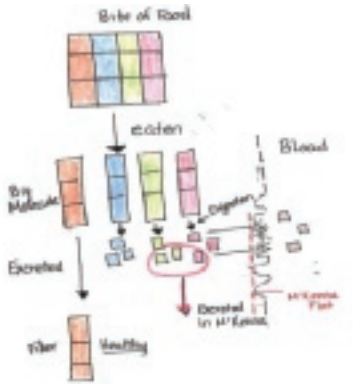
HANDS-ON/ LAB ACTIVITIES | VIDEOS OR IMAGES | DATA SETS | READINGS | COMPUTER INTERACTIVES

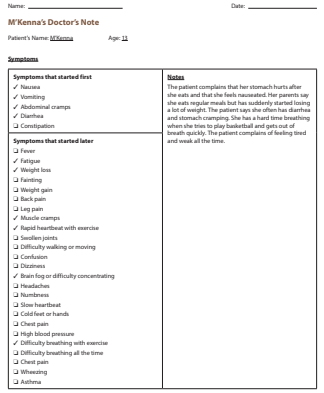
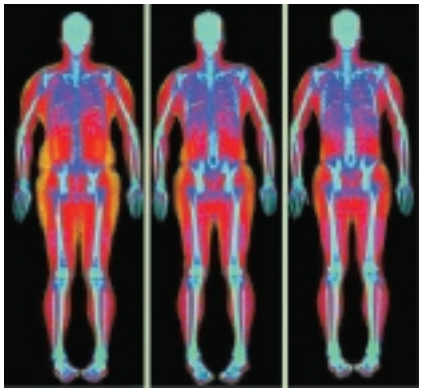
How do things inside our bodies work together to make us feel the way we do?

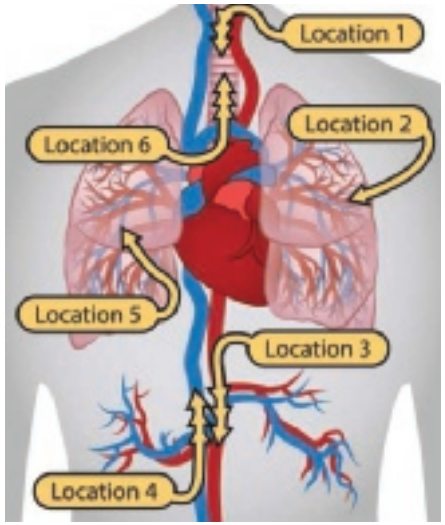
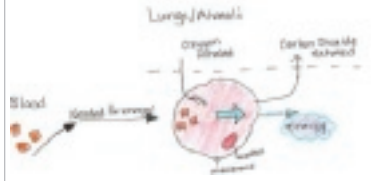
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 1 **3 days** **What is going on inside M'Kenna's body that is making her feel the way she does?** Anchoring Phenomenon	 *M'Kenna's Doctor's Note describes the symptoms in different parts of her body.*	M'Kenna, a 13-year-old girl, seems to be really sick and we aren't sure why. We notice she has symptoms in all different parts of her body and some symptoms started before others. We figure out: • We think that it has to do with her digestive system, but we have a lot of questions that we need to answer in order to figure out what is causing M'Kenna's symptoms. • We have some ideas for possible investigations we could pursue.	
⇩ **Navigation to Next Lesson:** We figured out that most of M'Kenna's symptoms were coming from her digestive system and that those symptoms started happening first. Also, we wondered if we could "see" inside M'Kenna's body in some way. So, we want to somehow see inside her digestive system next.			
LESSON 2 **2 days** **Can we see anything inside M'Kenna that looks different?** Investigation	 *There are differences between M'Kenna's small intestine and the small intestine from a healthy person.*	We examined M'Kenna's endoscopy report and some graphs that show what happens to food as it travels through M'Kenna's digestive system in comparison to a healthy one. We figure out: • The digestive system is made up of different parts called organs. The different organs have similarities and differences in their structures. • M'Kenna's small intestine doesn't look the same as a healthy one. • In a healthy person, many different substances in a graham cracker decrease as they travel through the small intestine. • Some substances in M'Kenna's small intestine decrease, but others do not decrease as much compared to a healthy person.	
⇩ **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?			

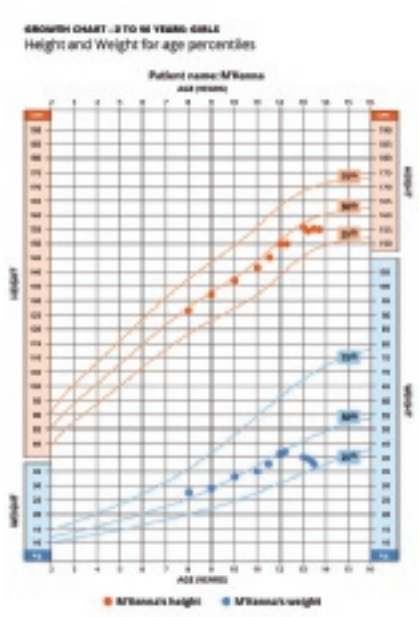
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 3 **2 days** **Why do molecules in the small intestine seem like they are disappearing?** Investigation	 *Dialysis tube system of the small intestine allows small but not large molecules to pass through its walls.*	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.*	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 Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 5 **2 days** **Why do large food molecules, like some complex carbohydrates, seem to disappear in the digestive system?** **Investigation**	 *In the mouth, some types of substances seem to decrease, and new substances increase.*	We make observations about what happens to complex carbohydrates, other than fiber, in the mouth. We analyze data from a graham cracker noting how the complex carbohydrates and glucose change in the mouth. We also notice that glucose molecules look like smaller pieces of complex carbohydrates. We plan and conduct an investigation to determine whether complex carbohydrates, other than fiber, undergo a chemical reaction when mixed with a substance in saliva to produce glucose. We figure out: • Some types of complex carbohydrates decrease in the mouth while glucose increases. • Chemical reactions that occur in the mouth break down some types of complex carbohydrates into glucose, and no matter disappears when this happens.	
⇩ **Navigation to Next Lesson:** We figured out that chemical reactions can occur in the mouth to break most complex carbohydrates down into glucose. Now we are wondering, Do chemical reactions occur anywhere else in the digestive system to break large food molecules down into smaller food molecules?			
LESSON 6 **1 day** **What happens to the different substances in food as it travels through the digestive system?** **Investigation**	 *The quantity of some types of molecules (complex carbohydrates, fats, and proteins) decreases by the same amount that the quantity of other types of molecules (glucose, fatty acids, and amino acids) increases.*	We analyzed food data, noting how the food changes in different parts of a healthy digestive system. We noticed patterns in which some molecules decreased by the same amount that other molecules increased. We argued that this is a sign of chemical reactions happening in the digestive system. We figured out: • Certain food molecules are broken down by different portions of the digestive system. • Different organs in the digestive system perform different functions.	
⇩ **Navigation to Next Lesson:** We think that we have figured out a lot! We can now account for one kind of molecule changing into another throughout the digestive system; in some places, like the small intestine, smaller food molecules are getting absorbed, and, in other places, like the large intestine, large food molecules are excreted. We think we should try to put all of these pieces together.			

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 7 **3 days** **What is the function of the digestive system, and how is M'Kenna's digestive system different?** Putting Pieces Together	 *All previous phenomena*	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.	
⇩ **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 **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.*	We zoom in on the small intestine to better understand its structure and function. First, we take stock of where we are in the body by mapping M'Kenna's system to the organization of the human body systems. We identify structures called "villi" that line the small intestine and use an interactive simulation to learn more about the villi. We figure out: • Body systems are organized by System > Subsystems > Tissues > Cells. • M'Kenna's intestinal wall surface is flat and a healthy person's is folded back and forth (forming villi). • Increased villi height results in more surface area that food molecules come into contact with as they flow through the small intestine; this results in a greater rate of absorption in a healthy small intestine than in M'Kenna's.	
⇩ **Navigation to Next Lesson:** We argued from evidence why M'Kenna is experiencing many of her digestive symptoms. Now we are ready to answer some questions on our Driving Question Board.			

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 9 **1 day** **How can a problem in one body system cause problems in other systems?** Problematizing	Name: _____ Date: _____ **M'Kenna's Doctor's Note** Patient's Name: M'Kenna Age: 13 **Symptoms** **Symptoms that started first** ✓ Nausea ✓ Vomiting ✓ Abdominal cramps ✓ Diarrhea ❑ Constipation **Symptoms that started later** ❑ Fever ✓ Fatigue ✓ Weight loss ❑ Fainting ❑ Weight gain ❑ Back pain ❑ Leg pain ✓ Muscle cramps ✓ Rapid heartbeat with exercise ❑ Swollen joints ❑ Difficulty walking or moving ❑ Confusion ❑ Dizziness ✓ Brain fog or difficulty concentrating ❑ Headaches ❑ Numbness ❑ Slow heartbeat ❑ Cold feet or hands ❑ Chest pain ❑ High blood pressure ✓ Difficulty breathing with exercise ❑ Difficulty breathing all the time ❑ Chest pain ❑ Wheezing ❑ Asthma **Notes** The patient complains that her stomach hurts after she eats and that she feels nauseated. Her parents say she eats regular meals but has suddenly started losing a lot of weight. The patient says she often has diarrhea and stomach cramping. She has a hard time breathing when she tries to play basketball and gets out of breath quickly. The patient complains of feeling tired and weak all the time. *M'Kenna's Doctor's Note shows symptoms in other body systems.*	We revisit the Driving Question Board (DQB) to see the progress we have made on our initial questions. We add new questions to the DQB and reorganize them in clusters related to the system to which they are connected. We revisit M'Kenna's Doctor's Note to look at her symptoms in other systems and realize that, although her symptoms started in the digestive system, there are still other systems having symptoms. We add two big questions to our DQB: "How can a problem in one body system cause problems in other systems?" and "How are these different systems connected?" We figure out: • Although our models can explain most of M'Kenna's digestive system symptoms, they can't fully explain her symptoms in other body systems. However, those symptoms are connected to what is happening in her digestive system.	
⇩ **Navigation to Next Lesson:** In this lesson, we think that problems in M'Kenna's digestive system are connected to her symptoms in other systems, such as brain fog, fatigue, and not gaining weight. This made us wonder if the fact that she is not able to get food molecules absorbed from her small intestine (digestive system) as quickly as a healthy person might be part of the reason she isn't gaining weight.			
LESSON 10 **2 days** **Why is M'Kenna losing so much weight?** Investigation	 *When you burn fat, the matter seems to vanish.*	We analyze trends in M'Kenna's weight and look at images of weight loss over time. It looks like the fat is disappearing, which makes us wonder, where is the fat going? We read an article that says that, when kids lose weight, the fat is being "burned." We wonder if this is the same "burning" as when we light something on fire. We do an experiment and light different types of fats on fire, weigh them, and compare their properties before and after they burn. We figure out: • When a person/animal loses weight, fat seems to go away. Some say when you lose weight you "burn" fat. • When we literally burn different types of fat, the mass seems to go down, just like when a person loses weight! • The properties of the vegetable oil and duck fat change before and after they are burned.	
⇩ **Navigation to Next Lesson:** We do an experiment and light different types of fats on fire and see that they seem to disappear, too, just like when a person loses weight! This makes us wonder, what is actually happening to fat when it burns?			

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 11 **2 days** **What happens to matter when it is burned?** Investigation	 *Food is burned in an open system, and the mass decreases. However, when food is burned in a closed system, the mass does not decrease, while carbon dioxide and water vapor increase.*	We conduct two investigations to trap the gases produced by burning food. First, we burn vegetable oil in a closed versus an open system and compare the masses of the systems. Second, we burn vegetable oil in a closed system and track carbon dioxide and water in the air within the system using a sensor. We figure out: • Food goes through a chemical reaction when it is burned. This reaction provides energy. • Foods require something from the air in order to make energy. • When food reacts with air to release energy, carbon dioxide gas and water vapor are its products.	
⇩ **Navigation to Next Lesson:** In this lesson, we figured out that a chemical reaction occurs when food is burned and that it uses air and produces carbon dioxide, water vapor, and gives off energy. This made us wonder—is this chemical reaction really happening in our bodies to provide us energy for the activities we do? Are we literally burning fat or other kinds of food inside our bodies?			
LESSON 12 **2 days** **Does this chemical reaction to burn food happen inside our bodies?** Investigation	 *Percent saturation of gasses in the blood changes throughout the body.*	We gather evidence showing that a chemical reaction happens in the cells of the body to provide them with energy. The reaction helps us explain why certain materials that we take into our bodies, like oxygen and food, are different from the materials that leave our bodies, like carbon dioxide and water. If our activity level increases, the chemical reaction happens faster to meet cells' needs. We figure out: • Oxygen is taken in (inhaled) through the lungs, and carbon dioxide is exhaled through them. These gases enter and exit the blood by passing through the lung membrane wall and are transported to and from the cells of the body. • Chemical reactions that happen within cells inside the body rearrange glucose and oxygen into carbon dioxide, water, and energy that the cells in the body can use. • This reaction, which we call cellular respiration, happens when we're resting, but it happens even more when we exercise.	
⇩ **Navigation to Next Lesson:** We figured out a lot about how our bodies get energy to do the things we need to do! We're ready to put all these pieces together and connect what we've figured out to explain some of M'Kenna's non-digestive symptoms.			

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
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	 Height and Weight for age percentiles *All previous phenomena*	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 Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 14 **1 day** **Do all animals do chemical reactions to get energy from food like humans?** Investigation	 *Readings about different animals show that they all seem to break down and burn food for energy using chemical reactions, even though they may have different structures inside of their bodies.*	We investigate an organism of our choice to see if it does metabolic reactions similar to the way humans do. We argue from evidence whether (1) our organism does chemical reactions to break down and burn food molecules the same way as humans and (2) it has the same structures inside its body that work together to do those processes. Then we come together to share our findings with other groups to give and receive feedback. We figure out: • Animals, aside from humans, rearrange matter in food through chemical reactions to release energy. • In animals, besides humans, oxygen reacts with food to produce carbon dioxide and provide energy. • Other living things, such as anaerobic bacteria, don't need oxygen for chemical reactions to get energy. • Animals might have different structures in their bodies that do the same functions.	
⇩ **Navigation to Next Lesson:** We've figured out so much! Now we are ready to revisit our DQB to show what we have learned by answering many of our questions.			
LESSON 15 **2 days** **What questions on our Driving Question Board can we now answer?** Putting Pieces Together	 *Animals, such as bears, can do the same chemical reactions as humans do to get energy from food to use now, to use for growth, or to store for later.*	We revisit the Driving Question Board and discuss all of our questions that we have now answered. Then we demonstrate our understanding by individually taking an assessment. Finally, we reflect on our experiences in the unit.	
LESSONS 1–15 **28 days total**			

Lab Safety Requirements for Science Investigations

It is important to adopt and follow appropriate safety practices within the context of hands-on investigations and demonstration, whether this is in a traditional science laboratory or in the field. In this way, teachers need to be aware of any school or district safety policies, legal safety standards, and better professional practices that are applicable to hands-on science activities being undertaken.

Science safety practices in laboratories or classrooms require engineering controls and personal protective equipment (e.g., safety goggles, nonlatex aprons and gloves, eyewash/shower station, fume hood, and fire extinguishers). Science investigations should always be directly supervised by qualified adults, and safety procedures should be reviewed annually prior to initiating any hands-on activities or demonstration. Prior to each investigation, students should also be reminded specifically of the safety procedures that need to be followed. Each of the lessons within the units includes teacher guidelines for applicable safety procedures for setting up and running an investigation, as well as taking down, disposing of, and storing materials.

Prior to the first science investigation of the year, a safety acknowledgement form for students and parents or guardians should be provided and signed. You can access a model safety acknowledgement form for middle school activities at the following location: (see the **Online Resources Guide** for a link to this item)

Disclaimer: The safety precautions of each activity are based in part on use of the specifically recommended materials and instructions, legal safety standards, and better professional safety practices. Be aware that the selection of alternative materials or procedures for these activities may jeopardize the level of safety and therefore is at the user's own risk.

Please follow these lab safety recommendations for any lesson with an investigation:

1. Wear safety goggles (specifically, indirectly vented chemical splash goggles), a nonlatex apron, and nonlatex gloves during the setup, hands-on investigation, and take down segments of the activity.
2. Immediately wipe up any spilled water and/or granules on the floor, as this is a slip and fall hazard.
3. Follow your *Teacher Guide* for instructions on disposing of waste materials and/or storage of materials.
4. Secure loose clothing, remove loose jewelry, wear closed-toe shoes, and tie back long hair.
5. Wash your hands with soap and water immediately after completing this activity.
6. Never eat any food items used in a lab activity.
7. Never taste any substance or chemical in the lab.



Specific safety precautions are called out within the lesson using this icon and a callout box.

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

Disciplinary core ideas are reproduced verbatim from *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. National Research Council; Division of Behavioral and Social Sciences and Education; Board on Science Education; Committee on a Conceptual Framework for New K-12 Science Education Standards. National Academies Press, Washington, DC. This material may be reproduced and used by other parties with this attribution. If the original material is altered in any way, the attribution must state that the material is adapted from the original.

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 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 Scope and Sequence, students will develop an understanding of genetic factors in Unit 8.5, how plants do chemical reactions to obtain and store energy in the subsequent Unit 7.4, and interactions with other organisms in the ecosystem dynamics in 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 Unit 7.3 and associated units within the 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 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 units.
- Supplemental teaching of the nature of matter, so that students see matter as made of particles.
- Supplemental teaching of the foundations for chemical reactions in PEs: (1) **MS-PS1-1** *Develop models to describe the atomic composition of simple molecules and extended structures* and (2) **MS-PS1-2** *Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred*. This unit is designed to come directly after two units involved in the foundations of chemical reactions and explicitly builds on those understandings. It is critical to note that students need the idea of chemical reactions and the idea that matter can be rearranged through these reactions yielding resultant materials with different properties to develop the explanations in this unit.
- Supplemental teaching of PEs: (1) **MS-LS1-1** *Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells* and (2) **MS-LS1-2** *Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function.* This unit does not introduce cells to students. It uses that prerequisite knowledge to build understanding that the organization of the body goes from cells, to tissues, to organs, to subsystems to multiple subsystems working together in one body system.

What are prerequisite math concepts necessary for the unit?

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

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

- **CCSS.MATH.CONTENT.7.SP.C.8.C:** Design and use a simulation to generate frequencies for compound events.

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

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

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

TEACHING SCIENCE LITERACY

How does the Core Knowledge Science Literacy routine integrate with the unit investigations?

The Core Knowledge Science Literacy Student Reader and the weekly Science Literacy routine layer varied reading opportunities into the science unit. In their lives after graduating from high school, most students will not become scientists. They will no longer routinely participate in guided investigations to figure out how phenomena work. They will, however, read text about science and scientific claims, day in and day out. The ability to learn and think about science through reading is a skill unto itself and is important in tandem with investigative learning. It is natural to primarily associate emerging literacy with reading and writing instruction at the elementary level, but middle school is an important time to hone literacy skills—specifically in science in the era of politicization of science topics, polarization among adults, and proliferation of misinformation on social media. Detection and construction of well-reasoned explanations are important not just in science, but throughout everyday life. Using claims and evidence in reasoning is the way that thoughtful people think about things; and writing is thinking in print. Students become voters as they emerge from high school, so it is important that they acquire skills for detection of faulty information and practice legitimate communication about scientific issues in the years leading up to that civic benchmark.

Throughout the course of the unit's investigative lessons, students write in their science notebooks in some fashion almost daily, and significant emphasis is placed on the speaking and listening communication threads of the CCSS. The instructional design of the investigations is deliberately light on having students access disciplinary core content through text. NGSS emphasis is on students investigating phenomena along the storyline, so students' interaction with text within lessons is minimal and in service to the unit's storyline. The Science Literacy routine is integrated to exercise students' ability to interact with text about science topics. The routine presents students with short reading selections in a variety of styles, all related to the unit in which students are engaged. Each reading selection is accompanied by a brief but thoughtful writing exercise.

The subject matter of the reading selections ties back to the unit, but the timing for the assigned readings is such that students do not read about specific facets of the subject before they have completed the lessons to investigate that content. In other words, the reading enhances and reinforces the knowledge that students have built in previous lessons; the reading does not reveal beforehand the key takeaways that students are intended to learn through lesson interactions.

When is it done within a unit?

The Core Knowledge Science Literacy Student Reader includes one reading collection per week for every week of the unit. A week's reading collection relates to the lessons completed in the previous week. The reading is assigned at the beginning of the week with the accompanying writing exercise due at the end of the week.

The reading and writing exercises are designed to be completed by students independently, with brief, supporting, teacher-facilitated discussions at the beginning, midpoint, and end of the week.

How do students typically represent their thinking as part of the routine?

Students generate a written product associated with each reading collection. The products are varied in form and include graphic organizers, concept maps, cartoons, memes, infographics, storyboards, outlines, and paragraphs. The complexity of the products increases from week to week, with the final product for the unit being a single, thoughtfully reasoned, and well-constructed paragraph.

Put Yourself in This Scene

Literacy Objectives

✓ Initiate thinking about the need to evaluate information in text and images.

Literacy Exercises

- Read a brief selection to pique interest, launch discussion, and begin to frame expectations.

Instructional Resources

Student Reader



Preface

Science Literacy Student Reader, Preface
"Put Yourself in This Scene"

No Prerequisite Investigation

The reading of the Preface is appropriate during the first week of unit instruction. The reading does not preemptively tell students facts about the topic that they are intended to learn throughout the course of their investigations.

Standards and Dimensions

NGSS

Disciplinary Core Idea MS-PS1-2: (Building toward) Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

Science and Engineering Practices: Asking Questions; Constructing an Explanation

Crosscutting Concept: Cause and Effect

CCSS

English Language Arts

RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

RST.6-8.6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.

RST.6-8.8: Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

Core Vocabulary

Core Vocabulary: Core Vocabulary terms are those that students should learn to use accurately in discussion and in written responses. During facilitation of learning, expose students repeatedly to these terms. No Core Vocabulary terms are highlighted in the Preface.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about any concepts in this exercise. Students will benefit from your modeling the use of these words without the expectation that students will use or explain the words themselves.

carbohydrate **cholesterol** **gluten**

A Glossary at the end of the Science Literacy Student Reader lists definitions for Core Vocabulary and selected Language of Instruction.

1. Plan ahead.

Determine your pacing to introduce the reading selections, check in with students on their progress, and discuss the reading content and writing exercise. If you are performing Science Literacy as a structured, weekly routine, you might implement a schedule like this:

- Monday: Designate a ten-minute period at the beginning of the week to introduce students to the Science Literacy Student Reader.
- Friday: Set aside time at the end of the week to facilitate a brief discussion about the reading.

You'll proceed with the in-class lesson investigations during this week.

2. Preview the assignment and set expectations. (Monday)

- Let students know that for the Science Literacy routine, they will read independently and then complete short writing assignments. The reading selections relate to topics they will be exploring in their Metabolic unit science investigations.
- The reading and writing will typically be completed outside of class (unless you have available class time to allocate).
- The first week's reading is a short introductory segment in the book, and there is no accompanying writing exercise as the unit is getting started.
- The class will discuss the reading together at the end of the week.

SUPPORT—The Preface is written at approximately Lexile 1000–1100, which leans toward the high end of the expected text complexity band for middle school. You may wish to introduce a word identification and comprehension convention into your routine to support struggling readers. Hang an envelope near the door with the label, "When we talk about the next reading selection, I could use a little more help understanding the word(s). . . " Encourage students, as they are reading, to jot words, phrases, or sentences that they are unclear about onto small scraps of paper and tuck them into the envelope at any time preceding the discussion of the reading. Whenever you facilitate class discussion about a reading selection, check the envelope first, and layer in added examples and repeat definitions to help students build comprehension and fluency for terms or complex sentences about which they have revealed they are uncertain.

3. Facilitate discussion.

(FRIDAY)

Facilitate a brief class discussion about the Science Literacy Student Reader Preface, entitled "Put Yourself in This Scene."

Pages 2–3 Suggested prompts	Sample student responses
How would you summarize the "scene" referred to in the title?	*An endless flow of information is what you get on TV, online, and among friends. Everyone has an idea about how to lose weight, gain weight, or maintain your weight.*
What do you know about the different pieces of information on these pages?	*I've heard of some of these diets, but it seems like a lot of work to figure out what to eat and what not to eat.*
Why do you think there is so much information about what food you should or shouldn't eat?	*So many people are worried about how they look. People think that eating or not eating certain foods will make them look or feel better.* *Some people have health issues and need to eat or avoid certain foods.* *Other people have allergies and cannot eat certain foods but can eat others.*
How do you know if diet information is good?	*If you look for the sources used to make the diet plan, it might give you some insight into the science behind the diet.*
How do you know if diet information is not good for you?	*If it makes you or someone you know sick or doesn't work, it's not good.* *Good science or medical data may be available to help you understand if diets are safe and effective.*

Student Reader



Preface

SUPPORT—If you are using the recommended word envelope convention, check the envelope to see if it contains any words, phrases, or sentences that students need help understanding. Read key sentences aloud, and provide concise explanation.

EXTEND—Make a class list of different diets and foods that students know of that they think are good and those that they think are bad. Review this list at the end of the unit to see if any of their ideas have changed.

Pages 2–3 Suggested prompt	Sample student responses
What symptoms are you aware of that are clues that the foods that someone is eating are not good for them?	*looking too fat or too thin* *having little energy* *developing problems with hair, skin, or nails* *looking pale* *feeling tired a lot* *getting stomachaches* *having allergic reactions*

KEY IDEA—Point out that, without an investigation into the sources of information in the claims made, there isn't really a way to make a good decision about which diets and foods you hear about are good for you. Both the investigations and the reading selections in the unit ahead will help students advance to a place where they have more knowledge to apply to the scenario, and they will circle back at the end of the unit to the topic of metabolic reactions inside our bodies and how things inside our bodies work together to make us feel the way we do.

LESSON 1

What is going on inside M'Kenna's body that is making her feel the way she does?

Previous Lesson

There is no previous lesson.

This Lesson

Anchoring Phenomenon

3 DAYS



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

Next Lesson

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

Building Toward NGSS

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

What Students Will Do

Develop models based on evidence to predict the relationships between components of a system (organs and body systems) to explain what is causing M'Kenna to feel the way she does (effect).

Ask questions that arise from careful observation of *M'Kenna's Doctor's Note* to clarify and seek additional information about what is going on inside the body of M'Kenna that is causing her symptoms (effect).

What Students Will Figure Out

- M'Kenna, a 13-year-old girl, seems to be really sick, and we aren't sure why.
- We think that it has to do with her digestive system but we have a lot of questions that we need to answer in order to figure out what is causing M'Kenna's symptoms. However, we have some ideas for possible investigations we could pursue.

Lesson 1 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**INTRODUCE AN INTERESTING PHENOMENON** Introduce students to M'Kenna's primary symptoms. Have students brainstorm other symptoms they might expect M'Kenna to have.	A	*Transcript of M'Kenna's symptoms*, (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**), speakers and computer to play the audio clip
2	7 min	**MAKE OBSERVATIONS OF THE DOCTOR'S NOTE** Engage students in a Notice-Think-Wonder routine around *M'Kenna's Doctor's Note*.	B	*M'Kenna's Doctor's Note*, *Map M'Kenna's Symptoms to Her Body Systems*, tape
3	8 min	**INITIAL IDEAS DISCUSSION ABOUT DOCTOR'S NOTE** Have students share their initial ideas about M'Kenna's symptoms in a whole-group discussion.	B	discussion norms poster
4	10 min	**DEVELOP INITIAL MODELS** Have students develop an initial model to explain what is going on with M'Kenna.	C	*Initial model*, tape
5	15 min	**SHARE INITIAL MODELS** Students share models with a partner then do a gallery walk to compare models.	D-E	
				End of day 1
6	20 min	**DEVELOP CONSENSUS MODEL IN SCIENTISTS CIRCLE** Students gather together in a Scientists Circle to share similarities and differences in their models and develop an initial consensus model.	F-G	chart paper, discussion norms poster, space for Scientists Circle
7	7 min	**PROGRESS TRACKER** Introduce the Progress Tracker.	H	
8	8 min	**SHARE RELATED PHENOMENA** Have students consider when they or someone they know experienced concurrent symptoms similar to M'Kenna's.	I	chart paper
9	10 min	**DEVELOP INITIAL QUESTIONS** Write down different questions students have about M'Kenna's case and related experiences.	J	index cards, tape, markers
				End of day 2

Part	Duration	Summary	Slide	Materials
10	20 min	**DRIVING QUESTION BOARD** Develop a Driving Question Board to create a shared space for student questions.	K	index cards, tape, markers, space for Driving Question Board
11	15 min	**IDEAS FOR INVESTIGATIONS** Have students generate ideas for investigations that the class could do to figure out what is going on inside of our bodies.	L-M	Driving Question Board, chart paper
12	8 min	**UPDATE THE TABLE OF CONTENTS**	N	
13	2 min	**NAVIGATION**		

End of day 3

Lesson 1 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• *Transcript of M'Kenna's symptoms* • *M'Kenna's Doctor's Note* • *Map M'Kenna's Symptoms to Her Body Systems* • *Initial model* • science notebook • tape • index cards • markers	• printout of the DQB questions	• M'Kenna Symptoms Interview (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) • speakers and computer to play the audio clip • tape • discussion norms poster • chart paper • space for Scientists Circle • space for Driving Question Board • Driving Question Board

Materials preparation (15 minutes)

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

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

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

Online Resources



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

Have tape available for students to attach handouts to their Science Notebooks.

Check that the video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) is loud enough for the whole class to hear.

Lesson 1 • Where We Are Going and NOT Going

Where We Are Going

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

Where We Are NOT Going

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

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

LEARNING PLAN FOR LESSON 1

1. Introduce an interesting phenomenon.

5 MIN

Materials: *Transcript of M'Kenna's symptoms*, speakers and computer to play the audio clip M'Kenna Symptoms Interview (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

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

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

*** Attending to Equity**

If you have any hearing impaired students, you can have them read the transcript of M'Kenna sharing her symptoms in *Transcript of M'Kenna's symptoms*.

Key Ideas

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

Listen for these ideas:

- Accept all student responses.

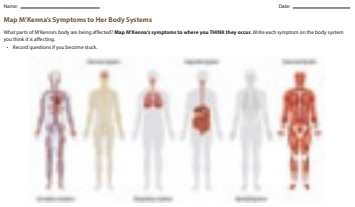
Play the audio clip. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

2. Make observations of the doctor's note.

7 MIN

Materials: *M'Kenna's Doctor's Note*, *Map M'Kenna's Symptoms to Her Body Systems*, tape

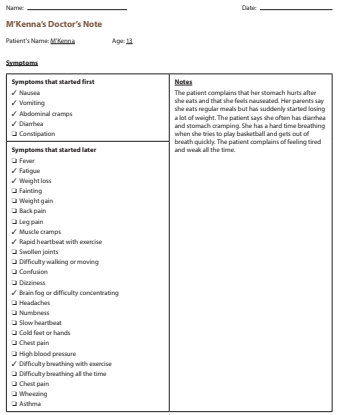
Introduce *M'Kenna's Doctor's Note*. Present **slide B**. Hand out a copy of *M'Kenna's Doctor's Note* and *Map M'Kenna's Symptoms to Her Body Systems*. A color copy of the body systems is also available in the References section of the Student Edition. Tell students to leave 14 pages (28 front-to-back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


Name: _____ Date: _____

Map M'Kenna's Symptoms to Her Body Systems

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

- Record questions if you become stuck.


Name: _____ Date: _____

M'Kenna's Doctor's Note

Patient's Name: M'Kenna Age: 13

Symptoms

Symptoms that started first	Notes
✓ Nausea ✓ Vomiting ✓ Abdominal cramps ✓ Diarrhea ❑ Constipation	The patient complains that her stomach hurts after she eats and that she feels nauseated. Her parents say she eats regular meals but has suddenly started losing a lot of weight. The patient says she often has diarrhea and stomach cramping. She has a hard time breathing when she tries to play basketball and gets out of breath quickly. The patient complains of feeling tired and weak all the time.

Symptoms that started later

❑ Fever
✓ Fatigue
✓ Weight loss
❑ Fainting
❑ Weight gain
❑ Back pain
❑ Leg pain
✓ Muscle cramps
✓ Rapid heartbeat with exercise
❑ Swollen joints
❑ Difficulty walking or moving
❑ Confusion
❑ Dizziness
✓ Brain fog or difficulty concentrating
❑ Headaches
❑ Numbness
❑ Slow heartbeat
❑ Cold feet or hands
❑ Chest pain
❑ High blood pressure
✓ Difficulty breathing with exercise
❑ Difficulty breathing all the time
❑ Chest pain
❑ Wheezing
❑ Asthma

Explain that when M'Kenna went to the doctor, the doctor documented all of her symptoms and that we are going to use *M'Kenna's Doctor's Note* to try to figure out what is going on. Tell students that in order to begin thinking more carefully about M'Kenna's case using *M'Kenna's*

Doctor's Note, they are going to engage in a Notice-Think-Wonder routine—first individually, then with a partner, and finally as a whole group. Prompt students to begin the Notice-Think-Wonder routine individually.* In their Science Notebooks, students should jot down responses to the following prompts:

- **NOTICE:** Make observations about *M'Kenna's Doctor's Note*. What do you **NOTICE**?
- **THINK:** Where do you **THINK** each symptom might occur in M'Kenna's body? Write each symptom on the body system you think it is affecting on *Map M'Kenna's Symptoms to Her Body Systems*.
- **WONDER:** What does this make you **WONDER** about M'Kenna and her symptoms?

Notice	Think	Wonder
I noticed that four of M'Kenna's symptoms seem to involve her digestive system.	Students write each symptom on the body system on which they THINK it's affecting on *Map M'Kenna's Symptoms to Her Body Systems*.	*This makes me wonder if something in her stomach started all of these symptoms.* *This makes me wonder if she has a food allergy.*
I noticed that many of the symptoms seemed to start first, then other symptoms started to happen later.		*This makes me wonder if all of M'Kenna's symptoms are related.*

Writing in Science



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

Additional Guidance

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

The focus of the unit is on figuring out how one issue could cause symptoms in so many other places in the body. We want students to figure out how M'Kenna's body is being affected—what's the underlying cause?—and that the body systems must be interacting or connected somehow. The class should wonder how these different systems are interacting. Here is more information about celiac disease if you are interested. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**).

After giving students several minutes to jot down their ideas, prompt them to share their ideas with a partner. Pairs of students should determine two or three Notice-Think-Wonder groupings to share with the whole class.

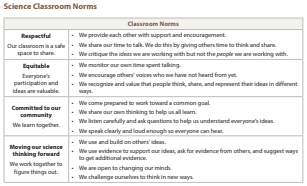
*** Attending to Equity**
Initial Ideas Discussions allow all students to share their initial thinking on a topic, which supports a classroom culture that values students' prior knowledge and experiences.

3. Initial Ideas Discussion about Doctor's Note

8 MIN

Materials: discussion norms poster

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



Science Classroom Norms

Classroom Norms	
Respectful Our classroom is a safe space to share.	• We provide each other with support and encouragement. • We share our time to talk. We do this by giving others time to think and share. • We critique the *ideas* we are working with but not the *people* we are working with.
Equitable Everyone's participation and ideas are valuable.	• We monitor our own time spent talking. • We encourage others' voices who we have not heard from yet. • We recognize and value that people think, share, and represent their ideas in different ways.
Committed to our community We learn together.	• We come prepared to work toward a common goal. • We share our own thinking to help us all learn. • We listen carefully and ask questions to help us understand everyone's ideas. • We speak clearly and loud enough so everyone can hear.
Moving our science thinking forward We work together to figure things out.	• We use and build on others' ideas. • We use evidence to support our ideas, ask for evidence from others, and suggest ways to get additional evidence. • We are open to changing our minds. • We challenge ourselves to think in new ways.

Choose a norm to work on today. Direct students to look over their classroom norms. Ask them to silently choose a norm to intentionally work on and monitor in themselves during class to help the learning community grow stronger and more productive for everyone.

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

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

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

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

* Strategies for This Initial Ideas Discussion

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

You may wish to have students help you create the norms or you may wish to create the norms yourself and then share them with students. If you create the norms yourself, consider spending some time thinking with students about why the norm is important, what it might look and sound like when students are "demonstrating" the norm, and how not following the norm could affect how others feel and interact with the learning community.

Key Ideas

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

Listen for these ideas:

- Accept all student answers and be careful to not evaluate them as right or wrong.
- There is likely something wrong with M'Kenna's digestive system (and that could mean more than just the stomach).
- There also seem to be other systems involved (e.g., circulatory and respiratory).
- We probably can't explain all of M'Kenna's symptoms with a simple "stomach bug" or virus.

- It is weird that most of her symptoms seem to be in the digestive system, but she is also experiencing symptoms in other systems (e.g., circulatory and respiratory).
- The weight loss seems odd—we can hypothesize why M'Kenna isn't gaining weight, but it is more difficult to figure out why she is losing weight.

Using the prompts below, encourage all students to go public with their ideas and support students as they begin to connect their thinking to the thinking of their peers:

- *Can you say more about that? What do you mean by that?*
- *So let me see if I get what you are saying. Are you saying that . . .? (Leave space for the original student to agree, disagree, or say more.) Who can repeat that idea or put it in their own words?*
- *What makes you think that?*
- *Did any other groups say something similar? What did you say?*
- *Did any groups say something different? What did you say?*
- *Do you agree/disagree with that? Why?*
- *Who can add on to the idea that we are building?*
- *Where on* M'Kenna's Doctor's Note *does it say that?*

Wrap up the discussion only after many students have had a chance to go public with their ideas and after the key ideas above have emerged.

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

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

*** Attending to Equity**
This is an important opportunity to emphasize that each individual has contributions to make to their community of learners. It is through differences in thinking that the class will grow their knowledge together. Throughout this unit, students will be asked to be open to sharing knowledge products that depict their current thinking and to be open to learning from classmates who share their knowledge too.

4. Develop initial models.

10 MIN

Materials: *Initial model*, Science Notebook, tape

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

Develop initial models. Hand out *Initial model* and have students tape it into their Science Notebooks. Have students individually sketch their initial models.*



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

*** Supporting Students in Engaging in Developing and Using Models**
When engaging in modeling, the key should be on explaining the "how" and the "why" of a phenomenon, not just the "what." To help students focus on the "how" and the "why" for M'Kenna's

Additional guidance to help students in their modeling:

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

Tell students to record questions if they become stuck.

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

Assessment Opportunity

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

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

case, remind students to explain what might be *causing* M'Kenna to have symptoms in all these different parts of her body rather than trying to "diagnose" her condition.

*** Supporting Students in Developing and Using Cause and Effect**

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

5. Share initial models.

15 MIN

Materials: Science Notebook

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

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

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

Safety Precautions

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



Tell students, *Next class we will share our similarities and differences out with the whole class to find areas we have in common and identify where we have differences.*

End of day 1

6. Develop consensus model in Scientists Circle.

20 MIN

Materials: Science Notebook, chart paper, discussion norms poster, space for Scientists Circle

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

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

Additional Guidance

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

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

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

*** Attending to Equity**
You will form a Scientists Circle in many future lessons as well. Setting up the norms and logistics

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

Key Ideas

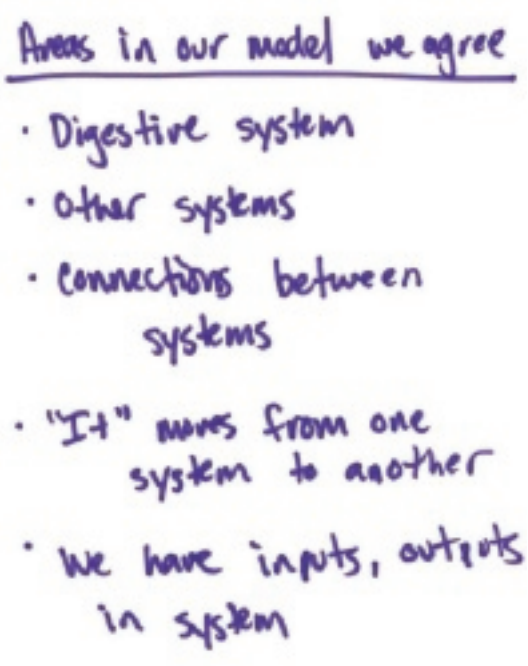
Purpose of this discussion: There are two goals of this discussion: (1) to continue to help students build the habit of sharing their ideas publicly and (2) to generate a variety of initial ideas about what is going on in M'Kenna's case. As such, it is again important to accept all student responses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

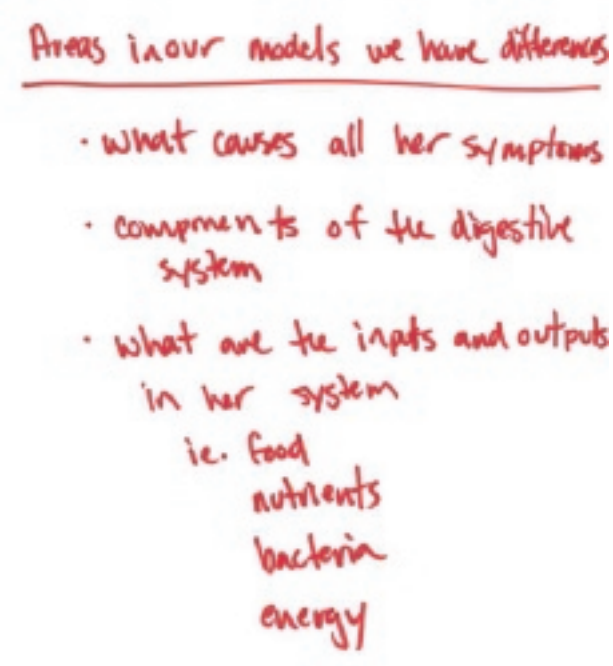
Listen for these ideas:

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

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

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





for forming, equitably participating in, and breaking down that space is important to do if this is your first time forming such a space.

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

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

*** Attending to Equity**
Add the word "interaction" to the Word Wall, which will become a useful space for recording a shared meaning of these new words as students develop a deeper meaning of them.

A helpful distinction for determining if a word should be added to the Word Wall is to decide if it's a "word we earn" versus a "word we find out." A "word we earn" is one we work together to understand

Represent areas of agreement and disagreement in a systems model. Most groups of students will only agree on two things in this model: (1) there is something going on in M'Kenna's digestive system that is affecting other systems in her body and (2) this may have something to do with what is going into her digestive system or moving from this system to her other systems. Build an abstract representation of this using boxes, arrows, and question marks.

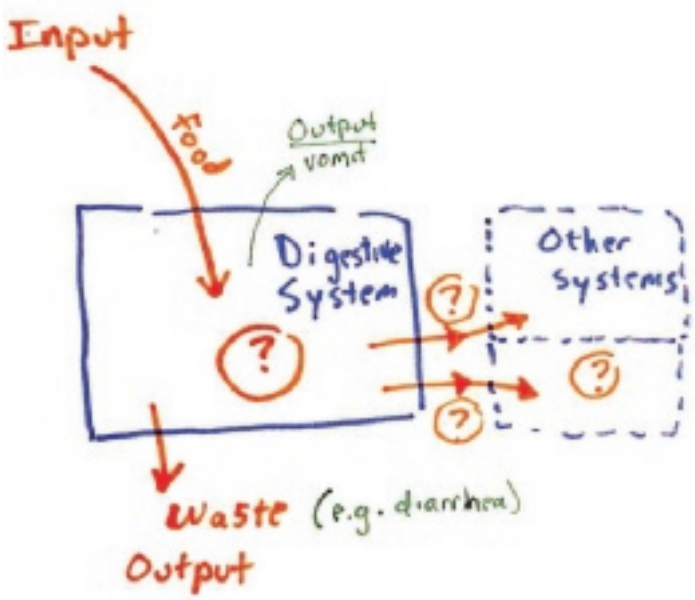
Say, *It looks like many of us have the digestive system somehow affecting or connecting with other body systems in some way. Maybe there is an interaction there. Anytime there is a connection or relationship between two things, we call that an "interaction."*

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

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

Conclude the discussion after many students have had the opportunity to share their ideas and after several competing models have emerged and have clearly been explicated in the consensus model you develop as a class.

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



7. Progress Tracker

7 MIN

Materials: Science Notebook

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

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

through investigation and collaborative sense-making, so we should celebrate our growing understanding of the word by adding it to the word wall. A "word we find out" may be encountered through text or media and is defined for us. These words are less important to add to our Word Wall, though they may become a "word we earn" if our understanding of the word grows and changes.

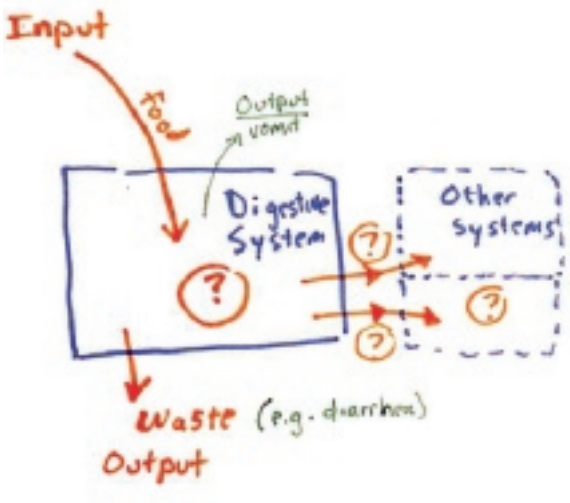
Throughout this lesson we will help students develop a deeper meaning for this word as we have students discuss different types of interactions going on inside our bodies. By the end of the lesson, this will have become a "word we earned," even though its initial definition was presented to us by the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

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

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

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

In the example Progress Tracker row for this lesson, each of the columns has been completed with ***possible*** student ideas.

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

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

*** Supporting Students in Three-Dimensional Learning**

Here, students are practicing modeling with the Crosscutting Concept lens of systems and systems thinking and integrating small pieces of evidence they will use to build disciplinary core ideas over time. Some classes may suggest labeling other known outputs of the model they've seen as evidence, such as vomit and diarrhea. Include these details only if your students bring them up.

*** Attending to Equity**

This Tracker serves as teacher guidance for what students might say at various points throughout the unit. However, some students may say more and others may say less. It is important that what the students write in the two-column tracker reflects their own thinking at that particular moment in time.

8. Share related phenomena.

8 MIN

Materials: chart paper

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

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

Have students turn and talk with a partner about their ideas before sharing out with the whole group (**slide I**). Accept all student responses. Try to draw out a wide variety of related phenomena. Encourage students to consider how the related phenomena are similar to or different from M'Kenna's case. Keep a public record of the related phenomena (you will revisit this poster in Lesson 8). You may also want to prompt students to keep a record of the related phenomena in their Science Notebooks. Some related phenomena may include these things:

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

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

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

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

*** Attending to Equity**
A key element of the Anchoring Phenomenon routine is letting students share their experiences with related phenomena. By doing this, students can connect their diverse experiences with the shared phenomenon that is the focus of the unit.

9. Develop initial questions.

10 MIN

Materials: index cards, tape, markers, Science Notebook

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

Prompt students to take out and review the following resources (in their Science Notebooks) as you show **slide J**:

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

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

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

End of day 2

*** Attending to Equity**
A DQB provides a public representation of the class's joint mission. Students can share their questions and wonderings with one another, and the visual representation offers another modality for students to access science in the classroom. It should be centrally located in the classroom so that it can be referenced and added to throughout the unit.

*** Attending to Equity**
Asking questions in everyday language allows students to share their thinking or experiences, even if they do not have the appropriate scientific vocabulary yet. This is helpful for emergent multilingual students because by not requiring scientific words at the onset you do not limit their participation in classroom discourse.

10. Driving Question Board

20 MIN

Materials: index cards, tape, markers, Science Notebook, space for Driving Question Board

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

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

*** Attending to Equity**
First and foremost during the formation of the DQB is reinforcing a classroom community wherein all ideas are valued and everyone has a question up on the board. Use your judgement on how to press students to form "how" and "why" questions. If a student

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

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

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



struggles with sharing, encourage them to go public with questions rather than focusing specifically on forming a "how" or "why" question.

Assessment Opportunity

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

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

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

Here is one example of the kinds of questions students might come up with.



11. Ideas for Investigations

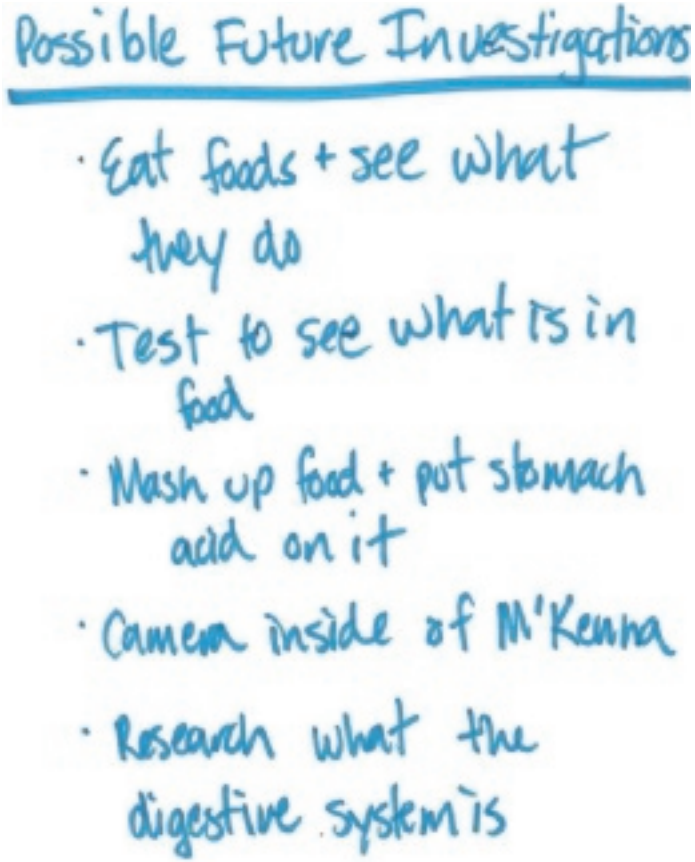
15 MIN

Materials: Science Notebook, Driving Question Board, chart paper

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

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

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



12. Update the table of contents.

8 MIN

Materials: Science Notebook

Update the table of contents with students. Say, *Before we start on one our investigation ideas, let's organize the work we have done so far.*

Show **slide N**. Remind students to reserve at least 4 pages (8 pages front-to-back) for the table of contents for a single unit. After the table of contents, they should reserve the next 10 pages (20 pages front-to-back) for their Progress Tracker for the unit. This is the place where students will individually reflect on their progress and also add key consensus modeling work completed by the class.

Science Notebook

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



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

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

*** Supporting Students in Engaging in Asking Questions and Defining Problems**

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

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

Science Notebook

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



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

13. Navigation

2 MIN

Materials: None

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

Suggested prompts	Sample student responses
Where did most of M'Kenna's symptoms sound like they were coming from?	*inside of her body* *her digestive system*
What symptoms started happening first?	*Her digestive symptoms started before the others.*
Where do you think it makes sense to start our investigations?	*Maybe we can look inside her body in some way?* *Maybe we should start with her digestive system?*

Summarize for the class, *We were also thinking it would be useful to be able to "see" inside M'Kenna's digestive system. Doctors have tools to do that these days. They can put small cameras into patients' bodies to see what is going on inside of them. If doctors used one of these cameras and put it down through M'Kenna's digestive system, I wonder what we would see? Let's start here tomorrow.*

ADDITIONAL LESSON 1 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

Collaborative discussions (one-on-one, in groups, and teacher-led) are embedded in nearly every lesson of this unit. There are many opportunities to connect with **CCSS.ELA-LITERACY. SL.6-8.1: "Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6-8 topics, texts, and issues, building on others' ideas and expressing their own clearly."**

LESSON 2

Can we see anything inside M'Kenna that looks different?

Previous Lesson

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

This Lesson

Investigation

2 DAYS



We examine M'Kenna's endoscopy report and look at some graphs that show what happens to food as it travels through M'Kenna's digestive system in comparison to a healthy one. We figure out that some of the food that M'Kenna eats is not leaving her small intestine. We add our new ideas to our initial models and our Driving Question Board. We decide we want to know more about what is going on in M'Kenna's small intestine and what could be happening to the food that seems to be going away.

Next Lesson

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

Building Toward NGSS

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

What Students Will Do

Analyze and interpret data to identify patterns in how the structures of the digestive system and relative amounts of substances in a food sample appear in a healthy person as compared to in M'Kenna.

What Students Will Figure Out

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

Lesson 2 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Students review some of the artifacts that the class created and notice that we seem to zero in on the digestive system as a key player for what might be going on with M'Kenna. The class decides that they need to know a little more about the digestive system.	A	Students' completed *Initial model*, consensus model
2	10 min	**LOOK AT STRUCTURES OF THE DIGESTIVE SYSTEM**	B-C	*Analyzing Endoscopy Images*
3	15 min	**ANALYZE ENDOSCOPY IMAGES USING THE COMPUTER INTERACTIVE** Students engage with the interactive to compare organs in a healthy person's digestive system and M'Kenna's digestive system.	D-E	*Analyzing Endoscopy Images*, Students will need access to the computers that are connected to the internet in order to view and use the interactive, A Look Inside the Digestive System (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)
4	15 min	**BUILDING UNDERSTANDINGS DISCUSSION** Build some agreement that there seems to be something wrong with M'Kenna's small intestine. Motivate the next investigation, which is to follow the food through the small intestine.	F	
				End of day 1
5	5 min	**NAVIGATION** Help students focus on the question, "What happens to food in the small intestine?"	G	
6	22 min	**INTERPRET GRAPHS OF FOOD IN THE SMALL INTESTINE** Students examine data showing what happens when food passes through the digestive system of a healthy person as compared to that of M'Kenna. They realize that some food isn't leaving M'Kenna's small intestine.	H-J	*What happens in the small intestine?*
7	8 min	**ADD TO THE PROGRESS TRACKER** Update the two-column Progress Tracker with students to summarize what they have figured out in this lesson.	K	Progress Tracker

Part	Duration	Summary	Slide	Materials
8	10 min	**INITIAL IDEAS AND NEXT STEPS** Students share initial ideas about what is happening to the molecules that seem to be disappearing in the small intestine and how they might go about investigating them.	L	
				End of day 2
		SCIENCE LITERACY ROUTINE Upon completion of Lesson 2, students are ready to read Student Reader Collection 1 and then respond to the writing exercise.		Student Reader Collection 1: *Changing Body Weight*

Lesson 2 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• *Analyzing Endoscopy Images* • Science Notebook • *What happens in the small intestine?* • Progress Tracker	• Students' completed *Initial model* • consensus model • Students will need access to the computers that are connected to the internet in order to view and use the interactive	• A Look Inside the Digestive System interactive (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Materials preparation (30 minutes)

Online Resources



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

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

Make sure that there is a stable internet connection or that you have downloaded the interactive to computers before class begins. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

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

Clear a space to display individual group models and the consensus model for use during class discussion.

Lesson 2 • Where We Are Going and NOT Going

Where We Are Going

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

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

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

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

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

Where We Are NOT Going

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

LEARNING PLAN FOR LESSON 2

1. Navigation

5 MIN

Materials: Students' completed *Initial model*, consensus model

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

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

Say, *We have some suspicions that M'Kenna's symptoms seem to be somehow related to the digestive system. We wondered if we could "see" inside M'Kenna's body in some way. So, we want to somehow see inside her digestive system next.*

2. Look at structures of the digestive system.

10 MIN

Materials: *Analyzing Endoscopy Images*, Science Notebook

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

Suggested prompt	Sample student response
What structures inside our bodies come to mind when you think of the digestive system?	*Accept all answers. Students might know many of the following: mouth, throat, stomach, small intestine, large intestine, rectum, salivary glands, pharynx (this term is less likely to surface), teeth, and tongue.*

Distribute copies of *Analyzing Endoscopy Images*. Present **slide C**.

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

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



*** Attending to Equity**
Introduce new science concepts using everyday language at first. Students are more likely to have some initial thinking or experiences with a phenomenon if they encounter it with everyday language. Science terminology can be introduced later in the lesson when students have experienced the phenomenon and have started to investigate it. In this case, you have introduced the word "organ" after they have seen it used in context.

Assessment Opportunity

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

Key Ideas

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

Listen for these ideas:

- All of the structures along the digestive tract seem to be hollow and tube-like.
- Accept all responses.

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

Additional Guidance

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

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

Suggested prompt	Sample student responses
Do you think that the diagrams you saw look the same way that organs do in the body?	*No, these are simple drawings, and the body is more complicated.* *The body isn't perfect like in these drawings.* *They are also in black and white, and that's not what our actual body looks like in color.*

Suggested prompt	Sample student responses
What do you think doctors do when they want to get a better look at real organs inside of a healthy person?	*They cut people open during surgery and look inside.* *Doctors use x-rays to look inside the body.* *Doctors use cameras to look inside the body and take pictures.*

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

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

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

We are going to look at two sets of images of the organs that we just studied. One set belongs to a healthy person and the other belongs to M'Kenna. You will compare each set of organs and see if you notice any differences between the healthy person's organs and M'Kenna's.

Use the suggested prompts to help students recall the ideas they had for figuring out what's wrong with M'Kenna's digestive system in particular.

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

3. Analyze endoscopy images using the computer interactive.

15 MIN

Materials: *Analyzing Endoscopy Images*, Students will need access to the computers that are connected to the internet in order to view and use the interactive, A Look Inside the Digestive System. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

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

Arrange students in groups of 2-3 to engage with the interactive endoscopy report.* Allow time for students to open the interactive and keep track of their noticings on the graphic organizer. Present **slide E** and and have students

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

return to *Analyzing Endoscopy Images* where they will record their observations from the endoscopy report. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

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

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

Have students follow the instructions in order to look at images of five locations in the digestive system. In step 3 of the interactive, students can ignore the instruction "Review the food molecule data you collected about a healthy system and about M'Kenna's system." They will do this step after the interactive, not before.

Additional Guidance

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

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

Support students in their analysis by providing the following steps:

1. Have students examine the pictures closely one at a time, paying attention to color, shape, size, and anything that strikes them as notable.
2. After a couple minutes, invite students to independently write down what they observed without making any interpretations.
3. Ask students, "what questions do you have about these images?" and have them ask as many questions as they can come up with.
4. Lead students in a discussion of their questions, guiding them to write down any ideas that they think are important.

4. Building Understandings Discussion

15 MIN

Materials: None

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

Key Ideas

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

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

Listen for these ideas:

- The coloring of both are similar, and the lining of some of the organs looks similar. There were ridges in some structures.
- M'Kenna's small intestine looks smooth compared to the healthy person's.

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

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

Additional Guidance

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

Motivate needing more information about what the small intestine does.

Suggested prompts	Sample student responses
Where does the food go after it is in the small intestine?	*It looks like it goes to the large intestine after the small intestine.*
What's the purpose of the small intestine?	*I am not completely sure what the small intestine does, but I see that food changes in the small intestine of a healthy person.*
Does the structure of the tube have anything to do with its function?	*The tube is like a path for food as it goes through the body.*

*** Supporting Students in Developing and Using Structure and Function**

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

*** Supporting Students in Engaging in Analyzing and Interpreting Data**

When attempting to determine if a cause and effect relationship exists, students need to realize that phenomena may have more than one cause and the fact that two events are happening at the same time doesn't necessarily imply causation. After examining the endoscopy images, students will examine a second set of data *What happens in the small intestine?*

Suggested prompts	Sample student responses
Just because the structures look different, do you think that's the cause of M'Kenna feeling sick? Or could it just be a coincidence?	*Yeah, it could be the cause. It's kind of like a clue.* *I'm not really sure; it could just be random differences between different people, too.*
Do you think we have enough evidence to say that this is the cause of M'Kenna's issues?	*No, this probably isn't enough evidence.* *We can't claim that the different looking structures are the cause just yet. We need something else to really say we have the cause of her symptoms.*

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

End of day 1

5. Navigation

5 MIN

Materials: None

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

Suggested prompts	Sample student responses
What did we figure out last class?	*We figured out that it looks like there is something off with M'Kenna's small intestine.*
Do we know what is wrong or how it could be impacting M'Kenna?	*Sort of. It looks smooth and the healthy small intestine looks bumpy.* *It's probably impacting her digestion.*
What do you think happens to M'Kenna's food when it gets to her small intestine?	*We aren't sure. I wonder if we could figure out what happens. Is there any way to see what happens to her food compared to that of a healthy person?*

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

6. Interpret graphs of food in the small intestine.

22 MIN

Materials: *What happens in the small intestine?*, Science Notebook

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

Additional Guidance

The food data was based on an average percentage of breakdown of macromolecules during digestion using estimates from the research literature. Actual numbers vary from person to person, health of their digestive systems, and with different variations of foods (e.g., not all milk is equal).

So we began with a basic nutrition label for the foods and then applied the percentage of breakdown that occurs in different organs to get estimate decreases and increases. There was also other research on what molecules tend to remain in poop after healthy digestion versus in those with celiac disease so the proportions of food molecules in the large intestine and poop are estimates of what is within normal ranges and out of normal ranges.

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

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

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

Interpret observations using "What it means" statements. Present **slide I** and have students write "What it means" statements next to each of their "What I see" statements. These statements are students' initial explanations of what

*** Supporting Students in Engaging in Analyzing and Interpreting Data**

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

*** Supporting Students in Developing and Using Patterns**

Be sure to emphasize the portions of the questions in which students are asked, ". . . and how did you explain it?" This discussion should extend beyond simply reporting what students saw in the data. Students should use the patterns they have identified in the data and images to begin to identify cause and effect relationships in order to explain the differences

they think is happening to cause the change in data. Give groups four minutes to work on their interpretations then have several groups share their interpretations aloud. Probe deeper into a few of the interpretations, specifically about the disappearance of many of the bars in the healthy system but not in M'Kenna's.

Make sense of the patterns in the data. Facilitate a discussion by following the graham cracker through the small intestine. This discussion can piggyback off of the sharing of "What it means" statements but with the intention of steering the students toward noticing certain patterns if they have not yet emerged during discussion. Project **slide J** so that the class can see the graphs for the beginning of the small intestine and the middle of the small intestine as they discuss.

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

between the healthy digestive system and M'Kenna's. At this point in the unit, students will likely struggle to explain what they are seeing, but it is helpful to continually push them to try to explain why something might be happening.

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

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

7. Add to the Progress Tracker. 8 MIN

Materials: Progress Tracker

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

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



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

Question	What I figured out in words/pictures
How is M'Kenna's digestive system different from a healthy person's?	The digestive system is made up of different parts called organs. The different organs have similarities and differences in their structures. M'Kenna's small intestine doesn't look like a healthy one. It has bumps and is smoother than a healthy one (which has more ridges). In a healthy person, all the substances in a graham cracker seem to disappear as they travel through the small intestine, but these substances don't decrease as much in M'Kenna.

*** Supporting Students in Three-Dimensional Learning**
Students should use observations of data and images in the lesson to identify patterns based on similarities and differences in both structures (endoscopy images) and functions (food data) to compare how a healthy person's digestive system is functioning differently from M'Kenna's.

Additional Guidance

This is a time for students to individually think about what is happening inside the digestive system. It is important that students describe their initial understanding of what is happening within M'Kenna's digestive system. Students should also be encouraged to use both words and pictures to describe their thinking.

8. Initial Ideas and Next Steps 10 MIN

Materials: None

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

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

Project **slide L** and ask students to turn and talk with a partner to brainstorm ways we might investigate that question further.



Suggested prompts	Sample student responses
We know that matter can't just disappear. What ideas do we have about what is happening to the molecules that are disappearing in the small intestine?	*No, maybe something else is happening to it.* *They might be moving somewhere else, maybe traveling on through the digestive system to Location E (large intestine).* *It is moving somewhere else, maybe going through the walls of the intestine out of the digestive system. Maybe it's traveling into the blood vessels we saw under the surface?* *It is changing into something else?* *It is vanishing completely?*
What questions are you wondering about now?	*Accept all answers.*

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

Update the table of contents. Have students update the table of contents in their Science Notebook.

Assessment Opportunity

Have students record their ideas from the Turn and Talk as an optional exit ticket. Though the prompt and anticipated responses are geared toward helping students brainstorm initial ideas, looking at students' responses can be helpful for you in gauging how to adjust the navigation routine at the start of the next lesson. This can help you determine if you will need to add prompts for Lesson 3 to help students articulate and reason out why simulating the small intestine would make sense to pursue as a next investigation based on where we left off in our thinking last time. If some students are struggling with the data analysis, provide additional support by gathering them in a small group to facilitate a more structured analysis of the endoscopy images as a navigation into the next lesson.

SCIENCE LITERACY: READING COLLECTION 1

Changing Body Weight

1 "Healthy" Body Weight
2 What Gets Lost in Weight Loss?
3 Weight Loss Bunk and Junk
4 Clues About Weight Change

Literacy Objectives

- ✓ Organize related details about metabolic reactions inside our bodies.
- ✓ Argue a position on the issue of healthy diet choices.
- ✓ Support a position on healthy diet choices with evidence.
- ✓ Differentiate fact, reasoned judgment, speculation, and opinion.

Literacy Exercises

- Read varied text selections related to the topics explored in Lessons 1–2.
- Evaluate the reading selections according to provided prompts and criteria.
- Compare and contrast information gained from reading text with information gained from class investigation.
- Prepare a persuasive poster in response to the reading.

Instructional Resources

Student Reader



Collection 1

Science Literacy Student Reader, Collection 1
"Changing Body Weight"

Exercise Page



EP 1

Science Literacy Exercise Page
EP 1

Prerequisite Investigations

Assign the Science Literacy reading and writing exercise *after* class completion of this lesson group:

- Lesson 1: What is going on inside M'Kenna's body that is making her feel the way she does?
- Lesson 2: Can we see anything inside M'Kenna that looks different?

Standards and Dimensions

NGSS

Disciplinary Core Idea MS-PS1-2: (Building toward) Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

Science and Engineering Practices: Asking Questions; Constructing an Explanation

Crosscutting Concepts: Cause and Effect; Structure and Function

CCSS

English Language Arts

RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

RST.6-8.6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.

RST.6-8.8: Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

Core Vocabulary

Core Vocabulary: Core Vocabulary terms are those that students should learn to use accurately in discussion and in written responses. During facilitation of learning, expose students repeatedly to these terms. However, these terms are not intended for isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about any concepts in this exercise. Students will benefit from your modeling the use of these words without the expectation that students will use or explain the words themselves.

body mass index (BMI) **calipers**

colonoscopy **endoscopy** **net**

A Glossary at the end of the Science Literacy Student Reader lists definitions for Core Vocabulary and selected Language of Instruction.

1. Plan ahead.

Determine your pacing to introduce the reading selections, check in with students on their progress, and discuss the reading content and writing exercise. If you are performing Science Literacy as a structured, weekly routine, you might implement a schedule like this:

- Monday: Designate a ten-minute period at the beginning of the week to introduce students to the assignment.
- Wednesday: Plan to touch base briefly with students in the middle of the week to answer questions about the reading, to clarify expectations about the writing exercise, and to help students stay on track.
- Friday: Set aside time at the end of the week to facilitate a discussion about the reading and the writing exercise.

You'll proceed with the in-class lesson investigations during this week.

Exercise Page



EP 1

2. Preview the assignment and set expectations. (Monday)

- Let students know they will read independently and then complete a short writing assignment. The reading selection relates to topics they are presently exploring in their Metabolic Reactions unit science investigations.
- The reading and writing will be completed outside of class (unless you have available class time to allocate.
- Preview the reading. Share a short summary of what students can expect.
  - *In "'Healthy' Body Weight," you will read about how body weights are determined for different body types, such as tall and short people.*
  - *You'll read about the differences among losing water weight, fat, and muscle mass.*

- *In "Weight Loss Bunk and Junk," you'll read about things that don't help people lose weight or get healthy.*
- *In "Clues About Weight Change," you'll find out how doctors use procedures to find out why changes in weight are occurring and if it's a problem.*

- Distribute Exercise Page 1. Preview the writing exercise. Share a summary of what students will be expected to deliver. Emphasize that Science Literacy exercises are brief. The focus is on thoughtful quality of a small product, not on the assignment being big and complex.
  - *For this assignment you will be expected to generate a poster that "advertises" a healthy diet choice.*
- Remind students of helpful strategies they can employ during independent reading. Offer the following advice:
  - *The reading should take approximately 30 minutes to complete.* (Encourage students to break reading into smaller sections over multiple short sittings if their attention wanders.)
  - *A good reading strategy is to scan through the collection first to see the titles, section headers, graphics, and images to see what the selections are going to be about before fully reading.*
  - *Next, "cold read" the selections without yet thinking about the writing assignment that will follow.*
  - *Then, carefully read the Exercise Page to understand the expectations for the writing part of the assignment.*
  - *Revisit the reading selections to complete the writing exercise.*
  - *Jot down any questions for the midweek progress check in class.* (Be sure students know, though, that they are not limited to that time to ask you for clarification or answers to questions.)

3. Touch base to provide clarification and address questions. (Wednesday)

Touch base midweek with students to make sure they are on track while working independently. You may choose to administer a midweek minute-quiz to give students a concrete reason not to postpone completing the reading until the last minute. Ask questions such as these, and have students jot answers on a half sheet of paper:

Suggested prompts	Sample student responses
What is the BMI, Body Mass Index?	*The BMI is a chart that uses height and weight to aid in determination of a person's health.*
Compare losing water weight, muscle mass, and body fat.	*All cause weight to change. Losing water weight is temporary. Losing muscle mass can be harmful. Losing extra body fat can add to muscle mass.*
Why might exercising one part of the body not help burn body fat there?	*Stored fat is broken down throughout the body, not just in one area.*
What is the difference between endoscopy and colonoscopy?	*An endoscopy looks at the upper digestive tract, including the esophagus, stomach, pancreas, and upper part of the small intestine. A colonoscopy looks at the large intestine, colon, and other organs in the lower digestive tract.*

Ask a few brief discussion questions related to the reading that will help students tie the text content to students' classroom investigations.

Suggested prompts	Sample student responses
Why did M'Kenna have an endoscopy?	*The doctors were concerned that there was something wrong with her upper digestive tract.*
What did M'Kenna's endoscopy show?	*There were differences between M'Kenna's small intestine and the small intestine of a healthy person.*

- Refer students to the Exercise Page 1. Provide more specific guidance about expectations for students' deliverables due at the end of the week.
  - *The writing expectation for this assignment is to create a poster that "advertises" a healthy diet choice.*
  - *In the Preface you read and every day you see all kinds of fads and misinformation about diet and exercise. In this assignment, you will counter this bad information by persuading people your age to make healthy choices.*
  - *Do some research to make sure that your claims are credible and endorsed by people who know what they are talking about.*
  - *The important criteria for your work are that the choice you are advertising is a healthy choice and there are good reasons to make a habit of it.*
  - *Make your poster engaging, like a good advertisement, so that people your age will be persuaded.*
- Explain that a great poster will have a clear message and engaging graphics.
- Answer any questions students may have relative to the reading content or the exercise expectations.

Exercise Page



EP 1

4. Facilitate discussion.

(Friday)

Facilitate class discussion about the reading collection and writing exercise.

The four reading selections address issues that bombard students everyday, including healthy weight, diet, and exercise. The selections introduce students to the idea that there is a lot of misinformation about these topics, information that can be scientifically investigated by studying metabolic reactions inside our bodies to confirm or deny claims.

Student Reader



Collection 1

Pages 4–5 Suggested prompts	Sample student responses
What is the general purpose of the first selection, "'Healthy' Body Weight"?	*It establishes that there are guidelines, such as the BMI, to help determine a person's health.*
What is a body fat percentage?	*A body fat percentage tells how much of a person's body is fat in proportion to lean tissue including muscle and bone.*

SUPPORT—If you are using the recommended word envelope convention, check the envelope to see if it contains any words, phrases, or sentences that students need help understanding. Read key sentences aloud, and provide concise explanation.

Pages 4–5 Suggested prompt	Sample student response
What are different ways to determine if a person is a healthy weight?	*using a bathroom scale, determining BMI, calculating body fat percentage*

Pages 6–9 Suggested prompts	Sample student responses
How does the second selection help you build knowledge on top of what you learned in the first selection?	*The first article reveals how to tell if a person is at an unhealthy weight. The second article explains that weight loss and gain are the result of different causes.*
Compare losing water weight, losing muscle mass, and losing body fat.	*Losing water weight is quickest, by sweating or going to the bathroom. Losing body fat takes more time as fat is burned as energy and transforms to muscle mass. It is the result of changing food habits and exercising. Losing muscle mass takes the longest time. It is the result of changing diet and exercise habits so that muscles shrink and waste away.*
Is losing weight always a good thing?	*No, if a person loses weight because they are not eating or moving, they might be really sick.*

Pages 10–11 Suggested prompts	Sample student responses
What is the general purpose of the third article, "Weight Loss Bunk and Junk?"	*This article cautions people about weight loss fads, even if they sound as if they will work.*
What is the best way for people to tone their stomach muscles?	*losing body fat throughout the body by making diet changes and exercising*

Pages 12–13 Suggested prompt	Sample student response
What is the general purpose of the fourth article, "Clues About Weight Change?"	*This article describes medical procedures that use cameras to look at the upper and lower digestive tracts.*

SUPPORT—Some students may not be familiar with the scientific and mathematical terms *mass* and *percentage*. Explain that mass is the amount of matter in an object. It is different from weight, which is the measure of gravity on an object. Discuss the meaning of *percentage*, a part of a whole.

CHALLENGE—Have interested students research one of the popular diets (keto, paleo, Mediterranean) or some other diet or diet fad. Ask them to report on one of these diets and explain why it is healthy or not, why it is practical or not, and its expected effect on the body. Alternatively, break the class up into groups, and have each group research one of these popular diets and create a presentation on it.

EXTEND—Have students watch a video about what happens during a colonoscopy. Follow up with a discussion about the procedure.

Pages 12–13 Suggested prompt	Sample student response
Why would someone need an endoscopy or colonoscopy?	*If a person were having digestive problems such as stomachaches, vomiting, or diarrhea over time, without any reason, one of these procedures could help figure out the problem. These procedures are also helpful in detecting digestive disease before there are symptoms.*

5. Check for understanding.

Evaluate and Provide Feedback

For Exercise 1, students should create a poster that "advertises" a healthy diet habit. They should conduct research to make sure their posters are advocating healthy habits. The poster should include the reasons the choice is a healthy one. They should use graphics and images to support their argument.

Use the rubric provided on the Exercise Page to supply feedback to each student.

LESSON 3

Why do molecules in the small intestine seem like they are disappearing?

Previous Lesson

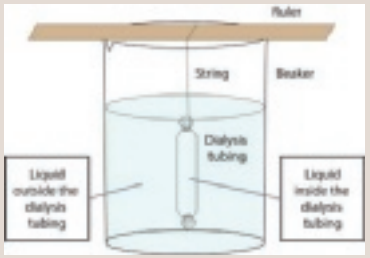
We examined M'Kenna's endoscopy report and some graphs that show what happens to food as it travels through M'Kenna's digestive system in comparison to a healthy one. We figured out that some of the food in M'Kenna's small intestine seems to be remaining in her small intestine. We added our new ideas to our Progress Trackers and our Driving Question Board.

This Lesson

Investigation

2 DAYS





We plan and conduct an investigation to determine whether food molecules can pass through or travel across a surface with a structure similar to the small intestine. We argue for how our results and molecular representations of the substances we used might help explain how small food molecules, but not large ones, could be absorbed into the body by passing through openings in the wall of the small intestine. We are left wondering, "What happens to molecules that don't travel across the walls of the small intestine?"

Next Lesson

We will 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, like complex carbohydrates, glucose, and fatty acids. We will examine poop data to confirm that water and fiber are typical to find in poop, but other substances are not.

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

Plan and conduct an investigation in order to produce data to determine whether food molecules can travel from one side of a system to the other side separated by a solid structure with properties similar to the walls of the small intestine.

Argue from evidence to revise a model to show how the results of this investigation and graphs of different types of food molecules traveling through the small intestine explain how the structure of the walls impacts the function of the small intestine.

What Students Will 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).

Lesson 3 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Review ideas and related questions from the previous lesson for what might be happening to the food molecules that go missing in the small intestine.	A	
2	10 min	**PLAN THE DIALYSIS TUBE REPRESENTATION OF THE SMALL INTESTINE INVESTIGATION** Introduce the materials that students can use to investigate this lesson's question. Ask students to work in groups to draw their representations in their Science Notebooks.	B-D	chart paper, markers
3	5 min	**EVALUATE THE LIMITATIONS OF OUR DIALYSIS TUBE MODEL SYSTEM** Students examine the qualities of their models as a representation of the small intestine and discuss limitations.	E	chart paper, markers
4	15 min	**CONDUCT THE DIALYSIS TUBE SYSTEM INVESTIGATION** Students complete Part 1 of the investigation in small groups by setting up the dialysis tube system with starch and glucose liquid inside of the dialysis tube.	F	*Dialysis Tube Investigation*, *Day 1 Dialysis Tube Investigation Instructions*, chart paper, markers, Dialysis Tube System Investigation Lab Set Up Demonstration of Sealing & Filling Dialysis Tubing video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)
5	5 min	**MAKE A PREDICTION ABOUT DIALYSIS TUBE RESULTS** Have students record a prediction of what kind of molecules they will find on the inside and outside of the dialysis tubing when they sample their lab systems in Parts 4 and 5 of their *Dialysis Tube Investigation*.	G	*Dialysis Tube Investigation*, *Day 1 Dialysis Tube Investigation Instructions*, tape

End of day 1

Part	Duration	Summary	Slide	Materials
6	3 min	**NAVIGATION** Instruct students to turn and talk about their predictions with a member of another group.	H	
7	10 min	**COLLECT DATA FROM DIALYSIS TUBE SYSTEM** Monitor students working in small groups in the lab as they collect samples from inside and outside of their dialysis tube system in Parts 4 and 5.	I	*Dialysis Tube Investigation*, *Day 2 Dialysis Tube Investigation Instructions*, Dialysis Tube System Data Collection
8	5 min	**ANALYZE AND INTERPRET DATA FROM DIALYSIS TUBE SYSTEM** Direct students to return from the lab to complete "Making Sense" questions with groups in Part 6.	J	*Dialysis Tube Investigation*, *Day 2 Dialysis Tube Investigation Instructions*, chart paper, markers
9	12 min	**BUILDING UNDERSTANDINGS DISCUSSION ABOUT OUR RESULTS FROM DIALYSIS TUBE SYSTEM** Pull students together to share findings across groups about the structure of the dialysis tubing and differences between large and small food molecules.	K	*Dialysis Tube Investigation*
10	8 min	**COMPARE MOLECULAR REPRESENTATIONS OF GLUCOSE AND STARCH** Show the molecular structures of starch versus glucose and have students compare the differences in the size and shape of the molecules (and similarities in the types of atoms that make them up) to inform the revision (or validation) of their initial models about the structure of the surface of the dialysis tubing.	L	*Dialysis Tube Investigation*, *Starch and Glucose Molecules*
11	8 min	**ADDING TO OUR PROGRESS TRACKERS** Ask students to argue from evidence with a partner for how these results help explain why some kinds of food molecules could be absorbed across the wall of the small intestine and why others cannot.	M-N	*Progress Tracker*, *Starch and Glucose Molecules*, tape
12	3 min	**NAVIGATION** Ask students to brainstorm what happens to food molecules that aren't absorbed in the small intestine. Record this in the form of a new question to investigate next time.	O	

End of day 2

Lesson 3 • Materials List

	per student	per group	per class
Dialysis Tube System Investigation materials	• safety goggles	• 1 (6-inch) dialysis tubing section • 2 (8-12-inch) dental floss sections • 20 mL glucose solution (in a 3 oz plastic cup) with a pipette • 20 mL starch solution (in a 3 oz plastic cup) with a pipette • empty 20 oz plastic cup or 500 mL beaker • permanent marker • coffee cup with lid • near boiling water • 500 mL distilled water • ruler • tape	• electric tea kettle or access to a (near) boiling water dispenser
Dialysis Tube System Data Collection materials	• safety goggles	• dialysis tube setup from day 1 • 20 mL of iodine solution (in a 3 oz plastic cup) with a pipette • 20 mL of Benedict's solution (in a 3 oz plastic cup) with a pipette • three plastic pipettes • a permanent marker • scissors • spoon • six microcentrifuge tubes • a coffee cup with lid • near boiling water	• tea kettle or access to (near) boiling water dispenser
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• Science Notebook • *Dialysis Tube Investigation* • *Day 1 Dialysis Tube Investigation Instructions* • *Day 2 Dialysis Tube Investigation Instructions* • *Progress Tracker*	• tape • *Starch and Glucose Molecules*	• chart paper • markers • Lab Set Up Demonstration of Sealing & Filling Dialysis Tubing video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Online Resources



Materials preparation (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.

Make sure students can easily access *Starch and Glucose Molecules* on day 2 of the lesson. Laminate or put in sheet protectors so students can use dry erase markers to show their thinking.

Day 1: Dialysis Tube System Investigation

- **Group size:** Split your class into groups of 3-4 students.
- **Setup:**
  - **Preparing the dialysis tubing:** Cut a 6-in. section of dialysis tubing (1 per group of 3 students). Soak these for at least an hour in a tub of distilled water.
  - **Preparing the sections of dental floss:** Cut 6 in. sections of dental floss (2 per group of 3-4 students). Place these on a plate or bin for students to get during the lab.
  - **Preparing the glucose solution:** Pour 250 mL of distilled water into a 500-mL beaker. Measure 50 g of powdered glucose and add it to the beaker. Add more distilled water to bring the total volume up to 500 mL. You have enough powder left to repeat this recipe to make an additional batch (1 liter total of glucose solution). Pour about 20 mL of this solution into a small 3 oz plastic cup for each lab group. You can use this for multiple classes.
  - **Preparing the starch solution:** Add 5 g of starch (either corn or potato) to 50 mL of distilled water, shake well, and pour into 450 mL of boiling, distilled water. Stir thoroughly for 1 minute. Leave to cool down. You have enough powder left to repeat this recipe to make an additional batch (1 liter total of starch solution). Pour about 20 mL of this solution into a small 3 oz plastic cup for each lab group. You can use this for multiple classes.
  - **Distilled water:** Each group will need about 500 mL of room temperature distilled water to set up their dialysis tube model system.
- **Notes for during the lab:**
  - You will need access to hot water before the lab to prepare the starch solution. An electric kettle works well if you do not have instant hot tap water. Water needs to be close to boiling**.**
  - Save the coffee cups and spoons to reuse in each class.
- **Watch the videos** for guidance on both Day 1 and Day 2 investigations (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**).

Day 2: Dialysis Tube System Investigation

- **Setup:**
  - **Iodine:** Each group will need a 3 oz plastic cup with about 20 mL of iodine and a pipette. You can use this for multiple classes.
  - **Benedict's:** Each group will need a 3 oz plastic cup with about 20 mL of Benedict's and a pipette. You can use this for multiple classes.

- **Tea kettle:** Set up one (or more) tea kettles around the room. It helps to get the water to boiling before class and then to run the tea kettle again in class right before students need the hot water.

- **Safety:**
  - 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 poured 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:**
  - Iodine should be kept in its brown bottle in a dark cabinet (as it is light sensitive).
- **Notes for during the lab:**
  - Each group will need access to hot water during the lab. An electric kettle works well if you do not have instant hot tap water. Water needs to be close to boiling**.**

Lesson 3 • Where We Are Going and NOT Going

Where We Are Going

This lesson addresses the question of whether or not substances can move across the surface of an organ system based on their structure. This investigation will help students deepen their understanding for why some, but not all, molecules can cross that surface.

This lesson introduces differences in molecular structure between different food molecules. This will lay the groundwork for a key Disciplinary Core Idea that food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth or to release energy. These ideas are further developed in Lesson 5. But in this lesson, students are introduced to the molecular structure of one large food molecule (starch) and one simple sugar (glucose) molecule. Students will notice that starch is a much larger molecule than glucose. They may also start to notice that the types of atoms that make up both are the same and that there is some similarity in the arrangement of those atoms in both molecules. If students do not notice the similarities, do not bring them up, as they will have the opportunity to make this connection in Lesson 5.

Though students may still have lingering ideas that matter can disappear, this lesson will provide evidence that matter may simply be moving from one system to another, rather than disappearing.

By the end of this lesson, students should develop the idea that small food molecules are absorbed into the body when they pass through doors in the walls of the small intestine. Students often think that, when we use the word "absorb," we are talking about it like a paper towel soaking up a liquid (so maybe the food is going into the dialysis tubing). So when the molecules go through the dialysis tubing, it does not make sense as to why we call it "absorption." The food is being absorbed into the bloodstream, but the students do not know that yet, which is why calling this process absorption in the beginning of the lesson does not make sense.

Where We Are NOT Going

In this lesson, students will be using indicators as a sign to show food molecule movement, but they will not be figuring out the effects of concentration gradients on this system (as has often been done using a similar lab setup to this investigation).

In this lesson, students will not figure out where the matter that isn't absorbed goes. Don't worry about this because that will be the focus of the next lesson.

In this lesson students will not figure out how the openings in M'Kenna's small intestine are different than a healthy individual; however, in Lesson 8, students will uncover how structural differences in the villi of M'Kenna's small intestine can account for differences in the amount of food she absorbs.

Students are introduced to complex carbohydrates. While they may be interested in the similarities and differences between starch, glucose, and other food molecules, this lesson will only focus on the starch molecule being much larger than the glucose molecule and similarity in atomic makeup. Students are not responsible for identifying numbers of atoms or bond arrangements. At this point, the analysis of the molecular nature of carbohydrates focuses on visualizing how a large molecule could be broken down into a smaller molecule.

LEARNING PLAN FOR LESSON 3

1. Navigation

5 MIN

Materials: Science Notebook

Help students recall their ideas. Ask them, "What caused the patterns in the food data from the last lesson." Project **slide A**. Summarize how last time we compared the amounts of substances in foods in M'Kenna's and a healthy person's small intestines. Ask students to turn and talk to their partners about what they thought might be happening to the food molecules as they traveled through the small intestine of a healthy person.

Say, *We know that matter can't just disappear, so we think that the food molecules from the graham cracker must be going somewhere in a healthy person. This might help us understand what is NOT working properly for M'Kenna.*

Additional Guidance

Encourage students to look back in their Science Notebooks to review some of the explanations the class came up with at the end of the last lesson.

Listen to students' partner discussions. Listen for students to share that the food was moving on to the large intestine, changing into something else, or going through the walls of the small intestine to other places in the body. After a couple minutes, ask students to share their ideas with the whole group.

Suggested prompt	Sample student responses
What were some ideas we had for what might be happening to the food molecules as they traveled through the small intestine of a healthy person?	*We thought maybe some food was moving somewhere else, maybe traveling on to the large intestine.* *We thought maybe it was going into the walls of the small intestine.* *We wondered if the food molecules from the graham cracker go THROUGH the walls into someplace else (like air through a screen).* *We thought maybe the food molecules are changing into something else.* *We think that there might be something different about the two food molecules.*

Additional Guidance

Some students will quickly jump to using the word "absorption," but the class has not yet developed a representation for what this means to them. This will be a "word we earn" by the end of this lesson. If students use this word, ask another student if they can restate what absorption means to them when used by another student. Then check to see if that is what the first student meant. You can add the word "absorption" to your word wall with a question mark, and ask students if we can first gather evidence before we earn this word as something we can use without explaining it (each time) in class.

Tell students, *Let's work together to figure out a way to investigate our ideas. Let's start with the one related to the question about whether or not food molecules might be going through the wall of the small intestine.*

2. Plan the dialysis tube representation of the small intestine investigation.

10 MIN

Materials: Science Notebook, chart paper, markers

Introduce the materials available for this investigation. Suggest to students that testing an actual sample of a small intestine would be a really effective way to investigate our question but might be somewhat difficult. Present **slide B** to the class and summarize that we could take a sample of a real small intestine, a graham cracker or food molecules, and see if the molecules travel across the small intestine wall.

*** Supporting Students in Engaging in Developing and Using Models**

In middle school, a model is a representation of a phenomenon that is used as a tool to represent our thinking of how or why something in the world works the way it does. In early grade bands, the practice of modeling centered

Suggested prompts	Sample student responses
Why might it be difficult for us to do this investigation using a real small intestine?	*We can't see inside the small intestine.* *How will we know if what we think is happening is actually happening with the food molecules?* *It might not be safe to use humans or animals to do investigations on because we would have to hurt them!*
What hopes would we have if we were to design our own representation of this system?	*We would need to have the walls of the small intestine, the inside of the small intestine, the food, etc.*

Introduce the dialysis tubing as a material we could use to investigate our question. Present **slide C**. Introduce the idea that when scientists or engineers don't have a sample of the materials they want to test, they often use other materials that have similar structures and functions to conduct their tests. We call this a representation of a system.*

Tell students that you have a supply of specialized medical equipment that we can use in place of an actual piece of small intestine. Show students a cut-up piece of dialysis tubing that you have soaking in a tub of water. Let them know that they can use a piece of this material to help investigate our question.

Map the components of the dialysis tube system to our body. Present **slide D.** Say, *Let's draw our dialysis tube system in our notebooks. If we are going to use this tubing to represent our small intestine, we need to make sure we are all on the same page about not only how we are going to use it but also about what each part of our system represents in the human body.*

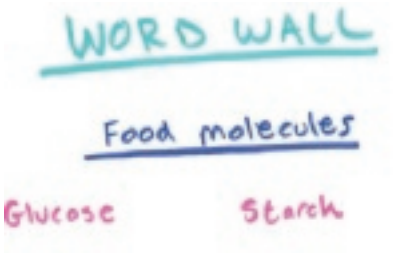
Suggested prompts	Sample student responses
What does the dialysis tube represent?	*The dialysis tube is the small intestine.*
What should the outside of the tube represent?	*The outside of the tube is the rest of the body outside of the small intestine.*

Start by drawing the dialysis tube on a piece of chart paper and have students draw the tube on a new page in their notebooks. Then have students do a Turn and Talk about what each part of the dialysis tube system represents and what they should add to their representations.

Tell students, *I have some of the food molecules—glucose and starch—that we can use to find out about what was going on in the small intestine.**

around developing physical replica that represents concrete events, objects, and systems. However, in middle school we are pushing students to develop representations of phenomena at scales we can't directly observe and the mechanisms that cause them are also unobservable. For this reason, we talk about dialysis tubing as a physical representation, rather than a model, of the small intestine. This representation helps students gather data in order to then engage in the practice of modeling to explain interactions within the digestive system.

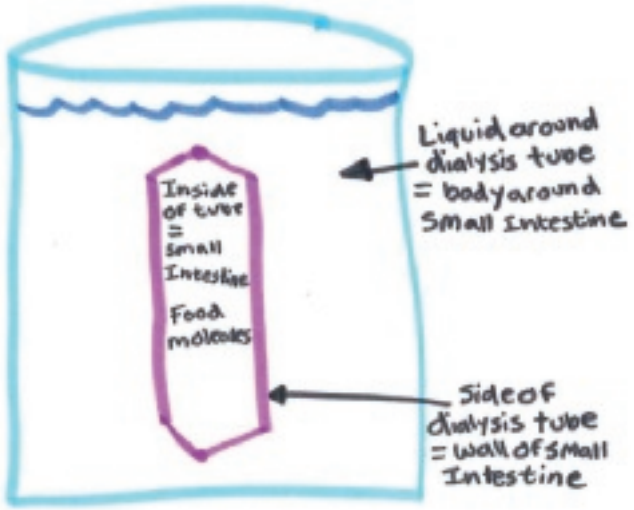
*** Attending to Equity**
When new scientific words, like glucose or starch, are introduced, it can be helpful for emergent multilingual students to see a reference to those words added to a word wall. Add these words to the word wall as they emerge in the discussion, rather than before.



After initially drawing the tube system, ask students, *So, where would we put the food molecules in our dialysis tube system to represent what is happening in the small intestine?*

Have students individually write in their notebooks below their representation of the small intestine to explain where they think we should put the food molecules in the dialysis tube system and their reasoning for why we should put them there.

Suggested prompt	Sample student response
Where should we put the food (molecules)?	*We should put the food molecules inside the tube because we know from last lesson that food moves from our mouths down to our stomachs and then into our small intestine; so that's where the food starts—inside the small intestine.*



Assessment Opportunity

Walk around the room while students are individually writing in their notebooks about where to put the food molecules in their dialysis tube system. It is important that students understand that the dialysis tube is a representation of the small intestine so that they can map the results from the investigation back to what is happening differently in M'Kenna's body and revise their model to show how the structure of the small intestine impacts the function of the molecules within the system. If students are struggling with where to put the food molecules, ask them to look back at their data analysis from Lesson 2 and to explain what each part of their representation would be in the human body.

Additional Guidance

At this point, the drawing of the tube should be open on both ends which is representative of the small intestine. In the next activity, students will help you revise the representation to better fit the needs of the investigation.

3. Evaluate the limitations of our dialysis tube model system.

5 MIN

Materials: Science Notebook, chart paper, markers

Evaluate the qualities and limitations of the dialysis tube model system. Present **slide E**.

Tell students, *We decided to put the food molecules inside the dialysis tubing because, as we saw in Lesson 2, the amount of food molecules changed inside of the small intestine. So, let's take a deeper look at our dialysis tube model to see how well it represents the small intestine and identify any limitations this model might have.*

Turn and talk about how to make our model more similar to an actual human body. Walk around the room listening to partners talk as students are comparing their dialysis tube models to the human body.

*** Supporting Students in Engaging in Developing and Using Models**
In this lesson, students work in partners and as a whole class to define the limitations of the dialysis tube model of the small intestine.

Suggested prompts	Sample student responses	Follow-up questions
How could we make our model more similar to an actual human body?	*So, the tubing isn't really our small intestine, and it isn't really in our body. The sides of the tubing equal the walls/sides of the small intestine.*	*Can you label that in your models?*
What's different about our model system compared to the small intestine in a real human body?	*In our body, the small intestine is like a long tube. Our model is only a small piece.* *Our body is more complex than just a container with liquid on the outside of the dialysis tubing representing our body. There are way more parts and things going on. This is a really simple version of what's going on.*	*Why does it matter that we make our model more simple than a real body system?*
How does that connect to what you mean when you say something is going through or down the small intestine?	*When we say something is going down the small intestine, we mean it is going from one end and out the other, and when we say through the small intestine, we mean through the walls.*	*Can you say more about that?*
How could we improve our model to be more like the small intestine?	*In order to be more like the small intestine, we should leave the ends of the dialysis tubing open.*	*But what would happen if we left the tubing open in our model system?*
So what do we have to do with the tubing?	*We would need to close off the ends to simulate the beginning (where it connects to the stomach) and end of the small intestine (where it connects to the large intestine); that way we would know if the molecules are going through the walls and not just out of the top or the bottom.*	*Let's add that to our models.*

For students to see the limitations of their model, it is important that they not only understand the materials that they will be using but can also map the model back to the real small intestine.

Revise our dialysis tube model system. As you are discussing the small intestine, have students label the start and end of the small intestine. Walk around as students are revising their models to demonstrate how their setup aligns with the small intestine in the human body. Bring students back together to add the closed ends of the dialysis tube to their model.

Identify limitations to the model system. Summarize for students, *We have to close off our dialysis tubing in our system even though it's not the way our digestive system works. This is a limitation or downside of our model, but sometimes we have to have limitations in order to investigate what we really want to find out.**

Suggested prompt	Sample student response
How might these limitations be necessary for us to do our investigation?	*Our real small intestine isn't cut off with knots—it's open at either end because stuff goes through to the next organ, but we want to only look at what happens in the small intestine and need a way to keep the food molecules from floating out of the top or bottom.*

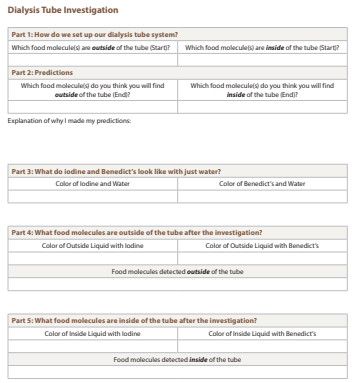
Demonstrate how to work the dialysis tubing. Show the video. (see the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Alternate Activity

Alternatively, you could do a live demonstration, by having students gather around a central lab table and asking for a student volunteer to help hold the tubing while you demonstrate how to tie and fill it. This could give you an opportunity to orient students to the other equipment they will use in this investigation and where it is located in the room.

4. Conduct the dialysis tube system investigation. 15 MIN

Materials: Dialysis Tube System Investigation, Science Notebook, *Dialysis Tube Investigation*, *Day 1 Dialysis Tube Investigation Instructions*, chart paper, markers, Lab Set Up Demonstration of Sealing & Filling Dialysis Tubing video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)


Dialysis Tube Investigation

Part 1: How do we set up our dialysis tube system?	
Which food molecule(s) are ***outside*** of the tube (Start)?	Which food molecule(s) are ***inside*** of the tube (Start)?
Part 2: Predictions	
Which food molecule(s) do you think you will find ***outside*** of the tube (End)?	Which food molecule(s) do you think you will find ***inside*** of the tube (End)?

Explanation of why I made my predictions:

Part 3: What do iodine and Benedict's look like with just water?	
Color of Iodine and Water	Color of Benedict's and Water

Part 4: What food molecules are outside of the tube after the investigation?	
Color of Outside Liquid with Iodine	Color of Outside Liquid with Benedict's
Food molecules detected ***outside*** of the tube	

Part 5: What food molecules are inside of the tube after the investigation?	
Color of Inside Liquid with Iodine	Color of Inside Liquid with Benedict's
Food molecules detected ***inside*** of the tube	

Give instructions for conducting the investigation. Present **slide F**. Pass out a copy of *Day 1 Dialysis Tube Investigation Instructions* and a copy of *Dialysis Tube Investigation* to each student. Summarize that students will read page one of *Day 1 Dialysis Tube Investigation Instructions*, write on the *Dialysis Tube Investigation*, and complete Parts 1 and 2 in this class.

Then tell students that the two different liquids available for them to use are in the lab area. Tell students that the liquids include starch, which is a type of complex carbohydrate, and sugar, which is made of glucose. Iodine is an indicator for starch, and Benedict's solution is an indicator for glucose. If starch is not present, iodine stays brown. If starch is present, iodine turns black or dark purple. If glucose is not present, Benedict's stays blue. If glucose is present, Benedict's turns orange. If you are unable to show your students positive results for starch and glucose, display the optional slide.

Assign students to their lab groups (recommended size of three).

Alternate Activity

Students may want to put an actual graham cracker inside of the tube with the glucose and starch solutions. To do so, they can crush a small piece of graham cracker in a little cup using the end of a pen. Once there are no longer any large chunks (it will look like large grains of sand), pour enough water into the cup to cover the graham cracker. Students can use a pipette to put 5 squirts of graham cracker into the dialysis tube. The sugar in the graham cracker might not be small enough to pass through the dialysis tubing; however, it would be a visual for students to remember that food starts inside the small intestine, and we are looking to see where it goes from there.

Alternate Activity

For an alternative activity, you can mass the dialysis system before and after the experiment. Students should find that the mass of the system doesn't change. If you mass the system before and after, you might want to do the experiment in a closed system by placing a clear plastic bag over it. This would help prevent any loss of mass due to evaporation overnight.

5. Make a prediction about dialysis tube results.

5 MIN

Materials: Science Notebook, *Dialysis Tube Investigation*, *Day 1 Dialysis Tube Investigation Instructions*, tape

Make predictions. Figure out how the class is going to tell if there were any changes in our model system. Present **slide G**. Bring students back together and remind them to complete Part A with their predictions. Students should base these predictions on their hypothesis from Lesson 2 about what they thought was going to happen to the food molecules in the small intestine.

Writing in Science



Considering possible outcomes directly connects to the reasoning students will do based on data from this investigation. So, thinking through the possible outcomes is time well spent to prepare students for reasoning later on. If students need more support in writing their predictions, give them this sentence starter: I think that starch will be found _____ because _____, and I think that glucose will be found _____ because _____.

Determine how we will detect if changes in the dialysis tube system occur.

Tell students, *We put glucose and starch inside of the tube and want to see where they go because we are curious about what is happening differently in M'Kenna's small intestine and that of a healthy person with no symptoms!*

Remind students that we hypothesized in our last lesson that we will see an output of food molecules that have moved, but we have differences of opinion for where those outputs will go. Ask students to remind you where they thought the molecules would go.

*** Supporting Students in Engaging in Developing and Using Models**

Students will have wanted to conduct this test in an actual small intestine. However, this is a great opportunity to have students use their representation of a natural system to represent inputs and outputs of the system at unobservable scales.

Students will use the dialysis tube and indicators to show that matter can flow through a system, even though we can't see it, such as microscopic openings in the small intestine/dialysis tube and the movement of glucose molecules. Scientists often use representations and tools to help them to observe the unobservable.

Listen for ideas about food molecules either going out of one end of the tube or possibly passing through the walls of the tube (like air through a screen). But we usually can't see the air go through the screen or the molecules go through the tube because they are at too small of a scale for us to see.

Suggested prompt	Sample student response
How will we know what is going through the tube?	*We need something to show us that a change is happening because all the molecules are clear, and we can't tell from just looking at the model system.*

We realize that we need to somehow "see" if those molecules are there, so we use some indicators that our teacher has to help us see since we are working at an unobservable scale.*

Remind students that their *Dialysis Tube Investigation* should now be taped into their Science Notebooks and to update their table of contents.

To support them in this, explain how indicators can be used to show the presence of something when there is very little material there or it is too small to see with their own eyes.

Additional Guidance

If you are running short on time, students may take the *Dialysis Tube Investigation* home to complete their predictions before the second half of the lesson.

Collect *Starch and Glucose Molecules* to reuse for your next class.

End of day 1

6. Navigation

3 MIN

Materials: Science Notebook

Orient students to the predictions they made from the last class in Part 2. Present **slide H**. Give students time to talk with someone from another group about their setups from Part 1 and their predictions from Part 2 about what they anticipate they will find when they sample liquid from inside and outside of the dialysis tubing.

Additional Guidance

Encourage students to look back at their *Dialysis Tube Investigation* to review their setups and predictions.

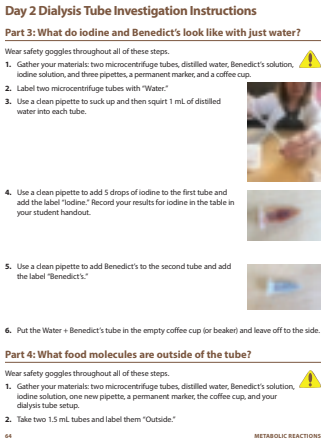
7. Collect data from dialysis tube system. 10 MIN

Materials: Dialysis Tube System Data Collection, Science Notebook, *Dialysis Tube Investigation*, *Day 2 Dialysis Tube Investigation Instructions*

Provide an overview of lab procedures. Present **slide I** and pass out *Day 2 Dialysis Tube Investigation Instructions*. Tell students that Parts 3, 4, and 5 will be completed in the lab, and Part 6 should be completed outside of the lab area, back at their class tables. **Monitor students in the lab area as they carry out the investigation.***

Alternate Activity

If students brought in samples from home to test, tell them that they should do this between Parts 3 and 4 and how much time they will have for this.



Day 2 Dialysis Tube Investigation Instructions

Part 3: What do iodine and Benedict's look like with just water?

Wear safety goggles throughout all of these steps.

1. Gather your materials: two microcentrifuge tubes, distilled water, Benedict's solution, iodine solution, and three pipettes, a permanent marker, and a coffee cup.
2. Label two microcentrifuge tubes with "Water."
3. Use a clean pipette to suck up and then squirt 1 mL of distilled water into each tube.
4. Use a clean pipette to add 5 drops of iodine to the first tube and add the label "Iodine." Record your results for iodine in the table in your student handout.
5. Use a clean pipette to add Benedict's to the second tube and add the label "Benedict's."
6. Put the Water + Benedict's tube in the empty coffee cup (or beaker) and leave off to the side.

Part 4: What food molecules are outside of the tube?

Wear safety goggles throughout all of these steps.

1. Gather your materials: two microcentrifuge tubes, distilled water, Benedict's solution, iodine solution, one new pipette, a permanent marker, the coffee cup, and your dialysis tube setup.
2. Take two 1.5 mL tubes and label them "Outside."

64 METABOLIC REACTIONS

*** Supporting Students in Engaging in Planning and Carrying Out Investigations**
Student data produced from this portion of the investigation will be used as evidence to explain how the structure of food molecules influences their ability to pass through the openings in the walls of the small intestine.

8. Analyze and interpret data from dialysis tube system. 5 MIN

Materials: Science Notebook, *Dialysis Tube Investigation*, *Day 2 Dialysis Tube Investigation Instructions*, chart paper, markers

Let students know when there are at least five minutes left, so they have time to start on the "Making Sense" questions in Part 6. Present **slide J**. Have students write their groups' results on chart paper or whiteboard for the whole class to see.



Remind students to give you the *Day 2 Dialysis Tube Investigation Instructions* to reuse for your next class as they finish the lab work.

9. Building Understandings Discussion About Our Results from Dialysis Tube System 12 MIN

Materials: Science Notebook, *Dialysis Tube Investigation*

Facilitate a Building Understandings Discussion in a Scientists Circle. Have students bring their Science Notebooks with them to the Scientists Circle.

Present **slide K** and ask students to contribute their ideas to the questions below with the whole class, while revising and updating the class model of the dialysis tube system with evidence from our investigation. Be sure to include where the starch and sugar food molecules were at the beginning and end of the investigation.

Key Ideas

Purpose of this discussion: To press toward a class-wide explanation that (1.) there must be openings in the dialysis tube model of the small intestine because we saw glucose on the outside of the tube (that was not there before), and (2.) there are differences between the structure of starch and glucose. Also, resolve (if possible) and disagreements, different perspectives, or partial understandings we have at this point around the interpretation of data collected and what it means.

Listen for these ideas:

- We removed the bag the next day, tested the liquid inside and outside of the bag, and found that
  - sugar was both inside and outside of the bag, but starch was still only inside of it.
- The structure of the walls of the dialysis tube model of the small intestine must have little gates or openings for some food molecules to pass through.
- There must be something different in the structure of starch and glucose food molecules that made the system function differently, which kept the starch from passing through the walls of the dialysis tubing.

Suggested prompts	Sample student responses
Did any of the food molecules end up on the other side of the dialysis tubing?	*The sugar we put inside the dialysis tubing ended up outside of it.*
How do you know? What's your evidence?	*When we tested the outside of the tube with Benedict's, it turned orange.*
Did any food molecules stay inside of the dialysis tubing?	*The starch we put inside the dialysis tubing ended up staying inside of it.*
How do you know? What's your evidence?	*When we tested the outside of the tube with iodine, the color did not change to black. It stayed brown.*
What do our results tell us about the structure of the dialysis tubing?	*There must be small openings/gates in the surface of the dialysis tubing.*
What structure in our bodies was the dialysis tubing similar to again?	*our small intestine*

Additional Guidance

As a reminder, during a Building Understandings Discussion, the role of the teacher is to press students to use evidence to back up their ideas. When revising the dialysis tube model of the small intestine, it is really important to view the openings of the dialysis tubing as little gates, rather than holes, if possible. This will help them later in Lesson 8 when the class makes the connection that more cells allow for more food molecules to be absorbed into the body.

If students think that the only way to get food into the body is to have holes or gaps in the small intestine, it might be tough to see how *more* cells leads to *more* absorption later on. Analogies that help students to understand this idea might be: if a yard was surrounded by a fence with no gates, there would be no way to get inside the yard; however, a yard with a gate would allow stuff to go through.

Turn and talk to connect back to the small intestine. Ask students to turn and talk to their neighbor for one minute about the following question:

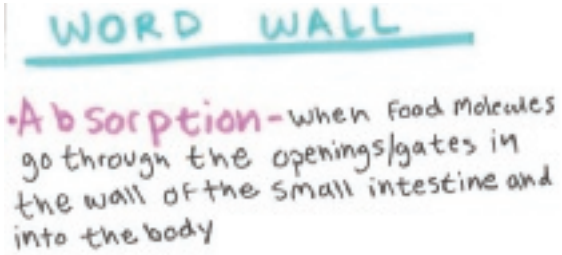
If there are small openings or gates in the dialysis tubing, and we said that the dialysis tubing was similar to our small intestine, then what should our small intestine have too?

Question why glucose could pass through the dialysis tubing but starch couldn't. Since starch doesn't cross the surface of the dialysis tubing at all, the class should wonder if there was something different about the shape or size of the starch molecule that might prevent it from getting through the doors in the tube system. This makes the class want to look closer at what is different about the starch and sugar food molecules.

Suggested prompts	Sample student responses
How is it possible that some molecules can get through a structure like the dialysis tubing but not others?	*The shape or size of the molecule of a complex carbohydrate must be different from a sugar molecule.*
What do our results tell us about what might be different about the structure of starch versus sugar molecules?	*Maybe they are bigger or have a different shape that doesn't fit through the holes/pores/gates in the surface.*

Additional Guidance

This is the time when students may again bring up the idea of absorption. Ask students to clarify what they mean when they use the term "absorption," and then ask other students if they agree or can restate what that student meant when they said the word "absorption." Come to a consensus (using student language from your class) that from now on when we use the word "absorption," we mean that molecules are moving from one place to another through something and into another place. In this case, we are talking about glucose being absorbed into the body by moving through the walls of the small intestine. Add the word "absorption" and the class explanation for it to your class word wall.

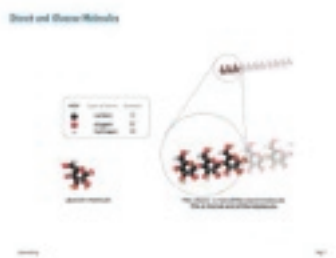


10. Compare molecular representations of glucose and starch.

8 MIN

Materials: Science Notebook, *Dialysis Tube Investigation*, *Starch and Glucose Molecules*

Return to seats to look at molecular representations of starch and glucose. Tell students that you have a diagram that shows a representation of the structure of a starch molecule and the structure of a glucose molecule, which might help us confirm



*** Attending to Equity**
Students may bring up scientific words (such as atoms or molecules) from prior instruction related to

or revise the ideas we have developed so far. Project an image of the molecular representations of starch and glucose (a sugar) (**slide L**) and/or pass out a copy of *Starch and Glucose Molecules*.

Ask students to look for and share any patterns they notice in the molecular structure models of starch versus glucose in a Turn and Talk. Encourage students to come up to show what they notice.

Additional Guidance

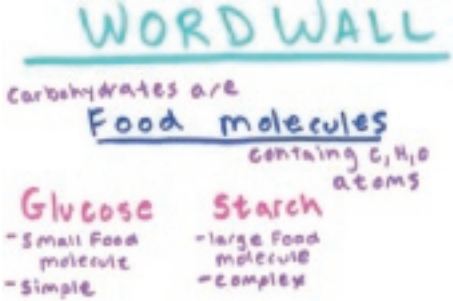
Encourage students to come to the front of the room to present a noticing around the molecular models that everyone has analyzed. This provides a concrete reference point for other students to add their ideas to a discussion. It also grows a culture in which students see that for the class to make progress on figuring things out together, students need to have space to present their ideas for their classmates to work with.

Suggested prompts	Sample student responses
Where is the glucose molecule in this model?	*Have a student come up to the board to point to the smaller glucose molecule.*
Where is the starch molecule in this model?	*Have a student come up to the board to point to the larger starch molecule.*
How do the molecules compare?	*The starch molecule is much, much bigger than the sugar molecule.*
What is different about them?	*The starch molecule is like a long string; the sugar molecule is a small clump.*
Are there any similarities between the two food molecules?	*They both appear to be made of the same types of atoms (C, H, and O).* *However, starch appears to be made of many more of these types of atoms than sugar.*
How does this help us confirm or revise the ideas we have developed so far about why glucose (sugar) can go through the surface of the dialysis tubing but starch cannot?	*The starch molecules are too big to fit through the gates in the surface of the dialysis tubing.*
If the surface of the small intestine has a similar structure, what can we say about the size of the molecules that can pass through/across its surface?	*The molecules that pass through the walls must be smaller than the wall's gates/openings.*

chemical reactions. If they come up, make sure all students can use those words and refer to your word wall from a previous unit. As the words come up, ask students to explain in their own words what they mean when they use them and if the class agrees with that explanation.

*** Strategies for This Consensus Discussion**

At this point, revise the word wall to include more detailed descriptions of starch and glucose, agreed upon by the class. Students should now be able to describe that starch is one type of a complex carbohydrate. Complex carbohydrates are large food molecules. Glucose is a simple carbohydrate, which are small food molecules.



Revise the class definitions for glucose and starch. Ask, *So now that we have compared the molecular structures of two food molecules, starch and glucose, how can we revise our word wall to better represent our current thinking?***

Say, *Some of the surfaces of the organs in the digestive system, like the small intestine, appear to be allowing some smaller materials to move across what appears to be solid surfaces. I think we've figured out the function of this particular organ!**

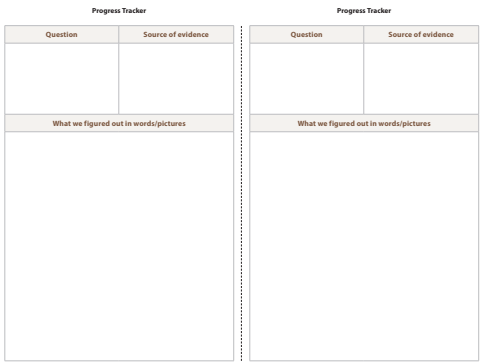
11. Adding to Our Progress Tracker

8 MIN

Materials: Science Notebook, *Progress Tracker*, *Starch and Glucose Molecules*, tape

Argue from evidence with a partner. Project **slide M.** Tell students, *Argue from evidence with your partner for how our results help explain why some kinds of food molecules can be absorbed across the wall of the small intestine and others cannot. Decide on how you want to represent this in words and pictures in your individual Progress Trackers.*

Update Progress Trackers with a partner. Project **slide N**. Have students work with a partner to add what the class has just figured out to their Progress Trackers. Hand out one half of *Progress Tracker* and have students tape it into their Science Notebooks in the Progress Tracker section.



Writing in Science

To support all students Writing in Science, you may hand out an index card to each group to help students engage in a productive dialogue. You can write the following sentence starters on the index card:

My argument is that we should add _____ to our Progress Tracker.

My evidence to support my argument is: _____.

Project **slide N**. Have students add these ideas to their Progress Trackers along with the lesson question and source of evidence that led to these findings as you record them as well.

Additional Guidance

Students work on this 3-column row of the Progress Tracker after the class figures out important punchlines in the unit (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.

* Supporting Students in Developing and Using Structure and Function

This is a great place to help students begin to see that the structures of organs help give them particular functions. We will continue to build on this idea, and by the end of Lesson 7, we will be able to generalize out that all organs have a particular structure and function. Students should also begin to make connections between food data from the previous lesson and the molecular structure of those molecules in this lesson. They should draw conclusions that the structures of those molecules can affect their ability to move through different organs in the digestive system.

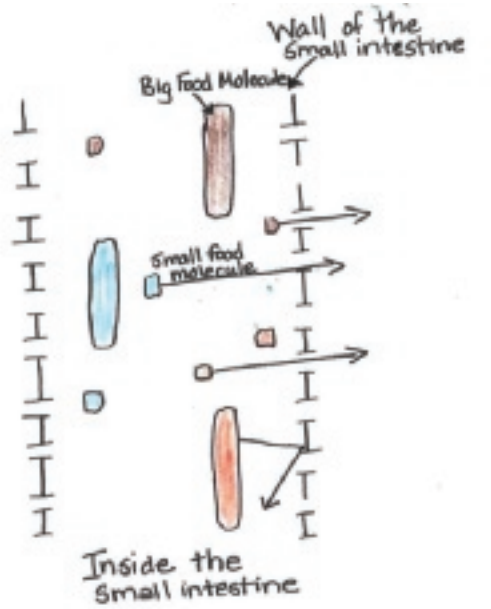
To support students in doing so, refer to evidence from the investigation about how only certain molecules can move through the dialysis tube and how that relates to what we learned about the large structure of starch (versus small structure of glucose). In future lessons, students will continue to examine the relationship between organ structure and function as a determining factor in how food molecules move through the digestive system.

Below is one suggested representation.

Question	Source of evidence
3. Why do molecules in the small intestine seem like they are disappearing?	• Dialysis tubing investigation • Molecular representations of starch (complex carbohydrate) versus sugar (glucose, which is a small carbohydrate)

What I figured out in words/pictures

- The food molecules are not disappearing. Some of them are moving through the walls of the small intestine and being absorbed into the body. When we say "absorption," we mean that molecules are moving out of the small intestine and into the body *or* moving from one place to another through something.
- Dialysis tubing is kind of like our small intestine—it's a big tube with openings/gates. When we put big food molecules, like starch, in the dialysis tubes, they are too big to fit through the holes, but smaller food molecules, like glucose, can fit through. We know this because the color changed on the outside, which detected the small food molecules, but not the big ones.



*** Supporting Students in Three-Dimensional Learning**

In this lesson, students work with a partner to revise their models of the small intestine, using evidence from their investigations, to include openings or gates in the small intestine to show different inputs and outputs of the digestive system. Students should indicate that while some food molecules were able to move out of the small intestine, other food molecules like starch, a large food molecule, did not move through the dialysis tubing.

Give students a chance to review their evidence with a partner before committing their ideas to their Science Notebook. If students are struggling to revise their models, have them think back to the unit's driving question and then ask them to think about the structure of the dialysis tubing and the molecules that did and did not pass through.

12. Navigation

3 MIN

Materials: Science Notebook

Have students brainstorm questions and next steps with a partner. Present **slide O** and ask students to brainstorm what happens to food molecules that aren't absorbed in the small intestine. Have students record this in their "New Ideas" section in their Science Notebooks.

Say, *So we know what happens to some of the food molecules in M'Kenna's small intestine. But what could be going on with the rest of the food molecules? What new questions are we wondering about now?*

As time permits, have them share out their ideas. If time is short, use these prompts at the start of the next class, before launching Lesson 4, as part of the navigation routine for that lesson. Tell students, *Let's take what we have figured out and bring it back to our driving question about M'Kenna, How do things inside our bodies work together to make us feel the way we do? Let's think back to what was different with the food molecules in M'Kenna compared to a healthy small intestine. We realize that M'Kenna's small intestine is somehow not letting the small molecules through the wall.*

Suggested prompts	Sample student responses	Follow-up questions
What might be going on inside M'Kenna as compared to in a healthy person that is causing the different amounts of food molecules?	*Could M'Kenna's issue be that she can't get the small molecules to wherever they are supposed to go next?* *Or could M'Kenna's issue be later on in her digestive system—like maybe those small molecules are interfering with what is happening next?* *Where are the molecules that don't get absorbed going next?*	*What else are you wondering about now?*
What do you think might happen to food molecules that aren't absorbed in the small intestine?	*They might leave the body as poop.* *They might break down further in the large intestine.*	*Are there any questions on our Driving Question Board that we are wondering about now?*
What sort of data would we would need to investigate these ideas?	*See what food molecules leave the body in the poop.* *See what food molecules are present in the large intestine.*	*Are there any ideas from our ideas for investigation that you want to investigate next?*

Have students record questions they want to investigate in their Science Notebooks.

Students wonder

- *If a large molecule, like starch, can't pass through the small intestine, what happens to it next?*
- *When it gets to the large intestine, does it get through or no? And if not, then what? We wondered if it might ended up in poop.*
- *Next steps: We wanted to look at what food substances are found in the large intestine and poop.*

Collect the *Starch and Glucose Molecules* to use with the next class.

ADDITIONAL LESSON 3 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

CCSS.ELA-LITERACY.RST.6-8.3: "Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks." Remember that, when we have a scientific text, we should look for key elements such as a multi-step procedure. When we read procedures, it's important to read all of the steps through to the end before we try to carry out the instructions.

LESSON 4

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

Previous Lesson

We conducted an investigation to determine how molecules could be absorbed into the body from the small intestine. We found that really small molecules could cross membranes, but large molecules could not. This made us wonder, "What happens to molecules that don't get absorbed by the small intestine?"

This Lesson

Investigation

1 DAY



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 that water and fiber are expected in a healthy person, but other molecules are likely not healthy. We figure out that fiber appears to have a more complex structure in that it has a lot of atoms connected in more ways. We think this makes it harder to break apart than glucose. We wonder about the ups and downs of all the food molecules during digestion and if this is different for M'Kenna.

Next Lesson

We will make observations about what happens to some complex carbohydrates in the mouth, noting that the decrease in complex carbohydrates and increase in glucose seem to be correlated. We will plan and conduct an investigation to determine whether some complex carbohydrates can undergo a chemical reaction when mixed with a substance in saliva to produce glucose. We will argue that some complex carbohydrates are broken down into glucose molecules through chemical reactions occurring in the mouth.

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 determine patterns and limitations of the relative amounts of different molecules in food as it moves through the digestive system of a healthy person versus M'Kenna.

What Students Will 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.

Lesson 4 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	4 min	**NAVIGATION** Prompt students to turn and talk to discuss the big discoveries and questions they had from the previous lesson. Students wondered about what happens to the molecules that are not absorbed in the small intestine.	A	
2	15 min	**FOLLOW THE GRAHAM CRACKER USING DIGESTIVE SYSTEM DATA** Support students in using the I^2 sensemaking strategy to analyze graphed data for following starch from the mouth to the large intestine. Discuss what molecules remain in the large intestine in a healthy person and in M'Kenna, and confirm what is normal as poop leaves a healthy person's system. Students look for patterns in the rates of change of the relative amounts of different food molecules in different parts of the digestive system.	B	tape, student notebook, *Graham Cracker Data*, *Analysis Strategy for Graham Cracker Data*
3	5 min	**BUILDING UNDERSTANDINGS DISCUSSION ABOUT GRAHAM CRACKER DATA** Guide students to examine specific patterns in the complex carbohydrate data and help them connect that to what they know about systems.	C-D	*Analysis Strategy for Graham Cracker Data*
4	5 min	**EXAMINE POOP DATA** As a whole class, have students look at poop data to see what we expect to see in a healthy person versus M'Kenna.	E	
5	5 min	**COMPARE FIBER AND STARCH MOLECULES** Take a closer look at fiber and starch to generate ideas to explain why some molecules are changing and others aren't.	F	
6	10 min	**ADD TO OUR PROGRESS TRACKER** With a partner, students record what they have figured out about what happens in the large intestine based on the data analysis.	G	*Science Classroom Norms*

Part	Duration	Summary	Slide	Materials
7	5 min	**NAVIGATION** Ask students to jot down ideas to add to the Progress Tracker in their Science Notebook. They should also brainstorm new questions they have about patterns in the food data.	H	

End of day 1

Lesson 4 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• tape • student notebook • *Graham Cracker Data* • *Analysis Strategy for Graham Cracker Data* • *Science Classroom Norms*		

Materials preparation (25 minutes)

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

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

Review the Identify and Interpret (I^2) sensemaking strategy to prepare for data analysis and interpretation.

Online Resources



Lesson 4 • Where We Are Going and NOT Going

Where We Are Going

Food is made of complex molecules that contain mostly carbon, hydrogen, and oxygen. Some complex food molecules, such as fiber, are made of these same atoms but, interestingly, cannot break down like similar-looking molecules, such as starch. 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. By the end of this lesson, students notice the pattern that some of the large food molecules, like complex carbohydrates, seem to be going away in a healthy person but not in M'Kenna.

Where We Are NOT Going

Do not go into depth with the discussion about the molecular structure of fiber and starch. Students need only understand that fiber has multiple connections that make it more difficult to break down. Students do not need to know that food molecules like starch are being broken down in the digestive system, as they will figure this out in Lessons 5 and 6. They also do not need to know the intricacies of why fiber does not break down. Students navigate to the next lesson by hypothesizing about what might be happening to the starch molecules that makes them disappear.

Students may enter this lesson with the belief that poop contains more than fiber and water. By analyzing data from the large intestine and a graph of what is in poop, students learn that, in a healthy person, poop contains only fiber and water.

LEARNING PLAN FOR LESSON 4

1. Navigation

4 MIN

Materials: None

Review discoveries and questions from the dialysis tubing lab. Present **slide A**. Use the suggested prompts below to facilitate student discussion of the main discoveries made during the lab and the questions they generated at the end of the investigation.

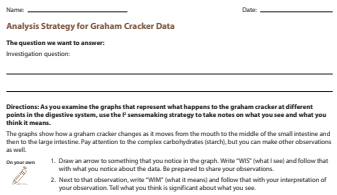
Suggested prompts	Sample student responses
What are some discoveries we made?	*We figured out that small molecules can cross membranes, and we called this "absorption." We figured out that large molecules cannot cross membranes.*
What were the big questions we came up with?	*If a large molecule, like a complex carbohydrate, can't get absorbed by surrounding tissue, what happens to it next?* *When it gets to the large intestine, does it break down there and get absorbed or not? And if not, then what? Maybe it ended up in poop?*
What data did we decide would be useful for answering these questions?	*We wanted to look at data from the large intestine and from poop.*

Introduce the lesson question to students, drawing on the discussion. Say to students, *So, it seems like we're trying to figure out the answer to the question, What happens to molecules that don't get absorbed in the small intestine?*

2. Follow the graham cracker using digestive system data.

15 MIN

Materials: tape, student notebook, *Graham Cracker Data*, *Analysis Strategy for Graham Cracker Data*


Name: _____ Date: _____

Analysis Strategy for Graham Cracker Data

The question we want to answer:

Investigation question:

_____

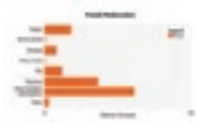
_____

Directions: As you examine the graphs that represent what happens to the graham cracker at different points in the digestive system, use the I² sensemaking strategy to take notes on what you see and what you think it means.

The graphs show how a graham cracker changes as it moves from the mouth to the middle of the small intestine and then to the large intestine. Pay attention to the complex carbohydrates (starch), but you can make other observations as well.

On your own

1. Draw an arrow to something that you notice in the graph. Write "WIS" (what I see) and follow that with what you notice about the data. Be prepared to share your observations.
2. Next to that observation, write "WIM" (what it means) and follow that with your interpretation of your observation. Tell what you think is significant about what you see.





Tell students, We wanted to look at what happens to large molecules if they can't get out of the small intestine. We know that a complex carbohydrate is a large molecule. I have some graphs that show what is in food when it enters the body, and what that same food looks like when it is in the large intestine before it exits the body as waste. We can look at these graphs to help us figure out what happens to big molecules like starch.

Introduce and prepare for the I² sensemaking strategy. Present **slide B** to students and remind them how to use the I² strategy to analyze and interpret data.* Arrange students in groups of three. Refer students to *Analysis Strategy for Graham Cracker Data*. Students can tape the handout in their Science Notebook.

Additional Guidance

When handing out the graphs, explain to students that we want to know what happens to a graham cracker when we put it in our mouths. These graphs represent the types of molecules that make up that graham cracker. We can't see the molecules. They are unobservable, but the data analysis allows us to visualize what we cannot see—how the graham cracker changes as it moves through the digestive system in a healthy person and in M'Kenna.

Evaluate limitations of the data. Use the following prompts to support students in considering whether or not the evidence in the graphs is sufficient for drawing conclusions about what happens to the food molecules in the digestive system.*

Suggested prompt	Sample student response
What do you notice about the x- and y-axes of these graphs?	*It just says, "relative amounts" and there are no numbers or values.*

*** Supporting Students in Engaging in Analyzing and Interpreting Data**

Students will use the Identify and Interpret (I²) sensemaking strategy to analyze the graph. Consider modeling one observation (WIS) and one interpretation (WIM) with your students before they begin small-group work. This strategy helps students break down an information-rich graph into smaller pieces to interpret, which will allow them to use the data to provide evidence for a phenomenon.

*** Supporting Students in Engaging in Analyzing and Interpreting Data**

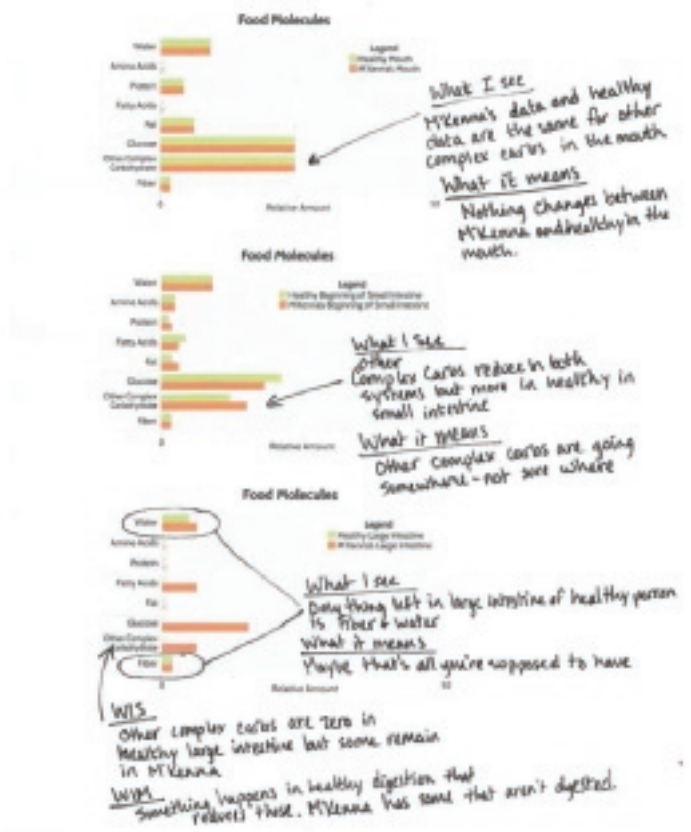
In the last lesson, students took time to consider the limitations of the dialysis tube model system, concluding that it did not exactly imitate the way a real digestive system works. Here, students must take time to consider the limitations of their data analysis. In this case, we are given relative amounts of the presence of each type of food molecule in various structures. We do not know absolute numbers or units of the food molecules. The method of how the data were collected may matter, for example if it were collected from the beginning or the end of the large intestine, and we do not

Suggested prompts	Sample student responses
What information do we have in the graphs? What information seems to be missing?	*We can see a comparison of the contents of a healthy structure versus the contents of M'Kenna's structure.* *We don't know exactly how much of anything there is because there are no exact values assigned.*
If there aren't any numerical values assigned to these graphs, will we still be able to use them to draw conclusions?	*Yes. We can see clearly that the values are changing, we just don't know how much.* *The precise amounts might not matter at this point.*

have that information. Guide students to the understanding that the visualization of the data in the bar graph is sufficient to draw conclusions in this situation but that exact numerical values and extra information assigned to the bar graphs would make their analysis more precise and accurate. Sometimes scientists are limited to the information to which they have access.

Make observations of the graph using "What I see" statements. Prompt students to write "What I see" (WIS) statements in their small groups. Remind students to write directly on the graphs, drawing arrows to their observations. After about 4–5 minutes, bring students together to discuss their observations of the graphs (e.g., What patterns did you notice? Did anybody else notice something similar?). Focus the discussion on complex carbohydrates initially, then broaden to other observations students made. Students can mention observations about the healthy data, M'Kenna's data, and/or comparisons between the two.

Interpret observations using "What it means" statements. Have students write "What it means" (WIM) statements next to each of their "What I see" statements. These statements are students' initial explanations of what they think is happening to cause the change in data. Give groups 4–5 minutes to work on their interpretations, then have several groups share some of their interpretations aloud. Probe deeper into a few of the interpretations, specifically about complex carbohydrates and fiber.



Writing in Science

Take into account the diverse learning needs of your students with regard to their analysis and writing skills when forming student groups. If there are some students who would benefit from additional support in their data analysis, gather that group of students for a facilitated small group. Examine the first graph, asking students to state out loud what they notice about the data. Model how students should annotate their graphs by writing students' ideas on your copy. Circulate and provide feedback as students continue in partner pairs, supporting them in articulating their ideas in writing.

Additional Guidance

As students annotate *Analysis Strategy for Graham Cracker Data*, circulate and use the following prompts to ensure that they notice key aspects of the graphs.

- *What do you notice about the amounts of each food molecule as they move through a healthy system? Through M'Kenna's system?*
- *How is what's happening in a healthy system similar and different to what is happening in M'Kenna's system?*
- *In which locations in the digestive system do you see the most changes in the amounts of food molecules? What do you think that means?*

3. Building Understandings Discussion About Graham Cracker Data

5 MIN

Materials: *Analysis Strategy for Graham Cracker Data*

Make sense of the patterns in the data. Facilitate a Building Understandings Discussion in which students share their interpretations of the graham cracker data and make claims about what might be happening inside a healthy digestive system and in M'Kenna's digestive system based on evidence from the graphs.* This discussion can piggyback off the sharing of "What it means" statements but with the intention of steering the students toward noticing certain patterns if they have not yet emerged during discussion.

Key Ideas

Purpose of this discussion: to help students make claims about what is happening to food molecules as they move through different structures of the digestive system.

Listen for these ideas:

- In a healthy person, the relative amount of complex carbohydrates reduces to nothing as it moves through the different structures of the digestive system. Maybe it is breaking down and getting absorbed.
- The complex carbohydrate in M'Kenna's digestive system reduces as it moves through each structure, but it doesn't seem to disappear the way it does in a healthy digestive system.
- Fiber stays constant in all of the structures in both a healthy person and M'Kenna.
- In a healthy large intestine there is only fiber and water. M'Kenna's digestive system has fiber and water but also other molecules.

Use **slide C** to focus the discussion on changes in the graham cracker by the time it reaches the small intestine and on the changes that occur as it moves from the small intestine to the large intestine. First, focus on the complex carbohydrate as a large molecule. Then present **slide D** to draw out patterns students noticed about fiber. This time, organize the conversation more specifically on healthy patterns and M'Kenna's patterns (pointing students to green bars for healthy data and orange bars for M'Kenna's data). Also, prompt students to reflect on the interactions of these

*** Supporting Students in Developing and Using Systems and System Models**
By guiding students to think about the difference between what is happening in the small and large intestines, you are also beginning to help them understand the concept of subsystems. Students have been examining the digestive system, but have not considered organs as a subsystem. Students should begin to think about each organ as a subsystem of the digestive system, just as the digestive system is a subsystem of the body system.

*** Supporting Students in Developing and Using Patterns**
Students examine patterns in the rates of change of several food molecules. As they identify differences between the rates of change in a healthy digestive system and M'Kenna's, students

organs and how those interactions relate to what they already know about systems.* Use the suggested prompts below.

should begin to identify differences in the function of organs in the digestive system.

Suggested prompts	Sample student responses
What's happening to the complex carbohydrate in a healthy body (green bars) over time, and how did you explain it?	*It got less and less and was zero in the large intestine. We think it is disappearing or maybe breaking down.*
How was the rate of change in complex carbohydrates (orange bars) different in M'Kenna? How did you explain it?	*M'Kenna's decreased, too, but didn't go down as much as the healthy data. She still had some in her large intestine. We think her body isn't breaking it down small enough.*
Did the same things happen to food in the small intestine and the large intestine?	*No. In the small intestine we see a lot of different molecules, but in the large intestine we just see fiber and water in a healthy person.*
Does this make you think that the small and large intestines have similar or different functions? Why or why not?	*I think they might do different things because something different must be happening in the small intestine if all that stuff goes away by the time it gets to the large intestine.*
What substance seems to remain constant (unchanged) as it travels through the digestive system?	*Fiber.*

Predict what should be normal in solid waste (poop). Based on students' noticing of the data from the large intestine in a healthy system, have students predict which of these types of molecule that are in the graphs are likely to be found in poop.

Suggested prompt	Sample student responses
How could these graphs help us predict what we would expect to see in solid waste that leaves the body as poop in a healthy system?	*The healthy data show that only water and fiber are left, so that seems like what we should typically expect. M'Kenna has water and fiber but also some fatty acids, glucose, and complex carbohydrates left. Her food isn't digesting how it should if she were healthy.* *It seems like poop should be made of mostly water and fiber.*

Say, *We're thinking it's typical of healthy people to have fiber and water in poop but maybe not these other substances. I actually have a graph that shows what our poop is mostly made from. The graph just shows the main stuff that's left from the food we eat. Let's check it out.*

4. Examine poop data.

5 MIN

Materials: None

Analyze poop data. Present **slide E** to students. Explain to students that these data represent an average break down of the things that can be found in poop that come from food. Direct students to turn and talk to discuss how the poop data compare with the healthy large intestine data and M'Kenna's large intestine data.

Engage students in a Building Understandings Discussion by asking, *What's usually found in poop? What might not be typical to find in poop?*

Key Ideas

Purpose of this discussion: The discussion around the typical makeup of poop is critical for helping students to figure out that most of what we eat is absorbed, with only fiber and a few trace molecules remaining in our digestive system after digestion and absorption. Excretion is one pathway for food molecules in the body, but this pathway is actually quite small in comparison to the absorption pathway.

Listen for these ideas:

- Fiber is normal in poop, and we see that in M'Kenna and in a healthy person.
- Water is normal in poop, and we see that in M'Kenna and in a healthy person; but M'Kenna has more water in her large intestine than a healthy person.
- M'Kenna has other stuff in her poop, like fatty acids, glucose, and complex carbohydrates. In a healthy person, no complex carbohydrates, fatty acids, or glucose leave as poop. They are gone once they reach the large intestine.

Return to data analysis to consider other food molecules. Transition to figuring out why some food molecules are changing in different parts of the digestive system but others are not.

Say, *So, we saw that fiber is staying the same throughout both a healthy system and M'Kenna's and complex carbohydrates are decreasing in both, though less in M'Kenna. Why are some molecules staying the same while others are changing? Let's take a closer look at fiber and starch to see if we can figure out why. I have some diagrams that represent a fiber and a starch molecule.*

5. Compare fiber and starch molecules.

5 MIN

Materials: None

Compare fiber and starch molecules in an Initial Ideas Discussion. Project **slide F** and have students figure out what is similar and what is different about the structure of fiber versus starch molecules. Remind students that starch is one example of a complex carbohydrate. This comparison could help us understand the pattern in the way starch changes during digestion but fiber does not change. Discuss the structural similarities and differences.

*** Attending to Equity**
Add the term "fiber" to your word wall as a "word we earned." Summarize for students that glucose, starch, and fiber are types of carbohydrates. Glucose is a simple carbohydrate. Starch and

Key Ideas

Purpose of this discussion: After completing data analysis and examining the molecular structure of fiber and starch, students share initial thoughts about what they think happens to these molecules as they move through the digestive system.

Listen for these ideas:

- Glucose, starch, and fiber are all made up of C, H, Os.
- Starch is more complex than glucose, and fiber is even more complex than starch.
- Fiber molecules are large and difficult to break down due to extra connections between chains.
- Starch molecules look like they *might* be breaking down during digestion.

Suggested prompts	Sample student responses
What's similar about the two molecules?	*They are both made of carbon, hydrogen, and oxygen.*
What's different about the two molecules?	*They look like they are made up of chains of glucose molecules.* *They're really big molecules.* *The fiber molecule is a lot bigger and looks like a giant blob. It has extra connections between the different chains.**

Ask students to share ideas about how the structure of the molecule might be related to the patterns of how much food molecules changed that they observed in the graham cracker and poop data.*

Suggested prompts	Sample student responses
How might the structure of a food molecule relate to whether or not it will decrease to zero?	*Fiber may be harder to absorb (or break apart) because it's so big. Starch (other complex carbohydrate) is big, but there are fewer connections between the chains so it might be easier to break down.*
Starch (other complex carbohydrate) is still way bigger than glucose. If starch molecules are so big, how they are all disappearing in the healthy person? Where did the starch go?	*We're not sure, but maybe it gets broken apart into smaller pieces?* *Maybe it's getting absorbed somewhere?* *Maybe there's some kind of chemical reaction happening?*

fiber are complex carbohydrates. Fiber is really complex, which is why our bodies don't break it down, but we can break down other complex carbohydrates like starch.

Here is one possible representation.



*** Supporting Students in Three-Dimensional Learning**
Prompt students to use evidence from their data analysis to support their ideas by citing patterns about changes in the amounts of food molecules from data comparing the healthy person in order to identify atypical patterns in M'Kenna's data.

6. Add to our Progress Tracker.

10 MIN

Materials: *Science Classroom Norms*

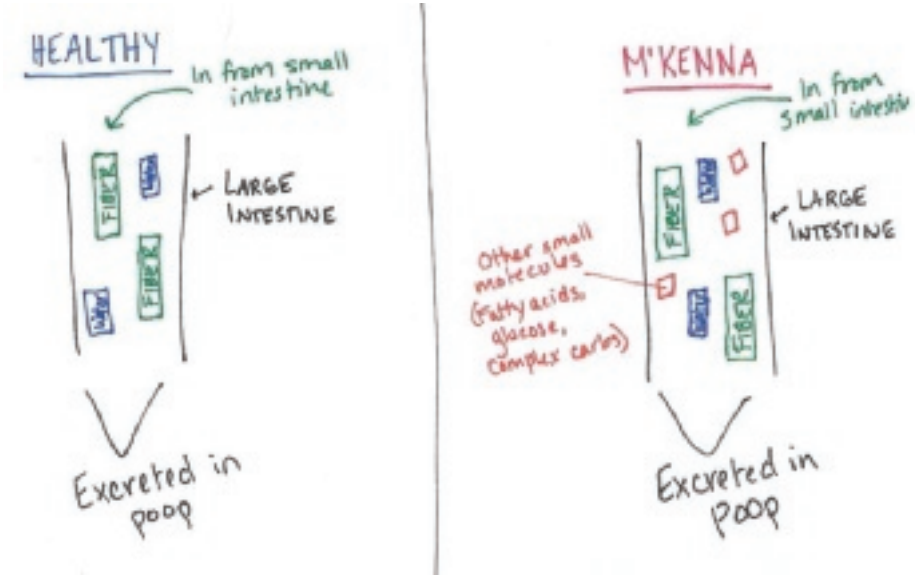
Share ideas for the Progress Tracker. Present **slide G**. Have students work with a partner to use what they have gleaned from their data analysis to represent what is happening in the large intestine in a healthy person and M'Kenna.

Say, *Think about what the data tells you about what is happening in the large intestine and work with a partner to represent that thinking in words and pictures in your Progress Tracker.** Below is one suggested representation.

Question	Source of evidence
4. What happens to food molecules as they move through the small intestine and large intestine?	• Graham Cracker Data • Poop Data

What I figured out in words/pictures

- 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.



Assessment Opportunity

Examine students' *Science Classroom Norms* for evidence of data analysis. For example, they should include fiber moving into the large intestine of both a healthy person and M'Kenna, but the representation of M'Kenna's large intestine should also include other molecules. Students' models should demonstrate the understanding from the data analysis that, in a healthy system, the rate of change of the relative amounts of food molecules causes the amount of other food molecules to reduce to zero. The rate of change in M'Kenna's system results in food molecules remaining in the large intestine.

If you do not see evidence of these patterns in students' models, refer to the graphs of relative amounts of food molecules in a healthy digestive system and M'Kenna's digestive system. Encourage students to represent the rate of change for each system in their models. Students do not need to know that food molecules like starch are being broken down in the digestive system. They will figure this out in Lessons 5 and 6.

7. Navigation

5 MIN

Materials: None

Transition to thinking about the size of all the food molecules in the graph. Recap by saying, *So, we think bigger molecules like fiber can't pass through membranes. We can see in the graphs that fiber is an input and an output. It doesn't appear to be changing at all. But other complex carbohydrates are a little confusing. In the graphs, the other complex carbohydrate seems to be an input, but we don't see the other complex carbohydrate as an output. We know complex carbohydrates are much bigger than some of the other food molecules and can't pass through a membrane, yet it still seems to end up disappearing in a healthy person by the time it reaches the large intestine. What's up with that?*

Turn and talk about the other food molecules. Present **slide H** and ask students to talk with a partner about the following questions. If time permits, have them record their ideas in their Science Notebooks and/or assign some of these questions as home learning.

Suggested prompts	Sample student responses
If big food molecules can't get absorbed in the small intestine, why aren't there other big molecules besides fiber, like other complex carbohydrates, coming out in the poop of healthy people?	*We're really not sure! Maybe they are getting absorbed somewhere else? Could they be breaking down into something else?*
What's happening to the other big food molecules like complex carbohydrates? How can we explain why the amount of some complex carbohydrates are changing but others are not?	*Maybe the matter is disappearing or getting used up?* *Maybe it is getting absorbed somewhere else in the digestive system?* *Maybe a chemical reaction is happening, and it's breaking down into something else?*

Consider how to figure out what is happening to other complex carbohydrates in the digestive system. Guide students to the idea of investigating how other complex carbohydrates are processed from the very start of the digestive system: the mouth. Students may have already voiced some initial ideas that the other complex carbohydrate is being absorbed in a different part of the digestive system or that the other complex carbohydrate is being broken down into smaller molecules through a chemical reaction. In order to figure out what is happening to the other complex carbohydrate, it might help to track it from the very beginning of the digestive system. If students struggle to recall the first part of the digestive system, prompt them to think about what happens when they eat.

Say to students, *How can we figure out if anything is happening to the complex carbohydrate? Is the complex carbohydrate changing somehow? Sometimes when we're not sure about what's going on in a system, we have to go back to the beginning.*

Suggested prompt	Sample student response	Follow-up questions
Where does the digestive system begin?	*the mouth*	*Maybe we could start at the beginning of the digestive system to see what's going on?* *Could we put something in our mouths and see if we notice what happens?*

Continue, *We want to find out if there is a change to that starch that we can use to help us understand what we saw in the graphs. Maybe we can slowly eat a piece of food that contains a lot of complex carbohydrates, like starch, and try to pay attention to what's happening. I'll bring in some food with starch in it so that we can try this tomorrow.*

Additional Guidance

The next two lessons will provide evidence that the food matter is not actually disappearing. This reaffirms an important idea developed in prior instruction about matter—namely that it doesn't appear or disappear (PS1.A: The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish). The next two lessons will provide evidence that it is changing from one substance into another through chemical reactions.

Collect copies of *Graham Cracker Data* to reuse with other classes.

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

2 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.

Lesson 5 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	7 min	**NAVIGATION** 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.	A-B	
2	9 min	**MAKE OBSERVATIONS ABOUT EATING COMPLEX CARBOHYDRATES** Make predictions followed by observations about what happens when we eat a cracker, which has complex carbohydrates in it.	C-D	1-2 crackers, Animation of a Person Chewing - 7.3 Metabolic Reactions Lesson 5 video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)
3	7 min	**CONNECT OBSERVATIONS TO CHEMICAL REACTIONS UNIT** 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.	E	
4	12 min	**ANALYZE DATA FROM EATING A GRAHAM CRACKER** 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.	F-G	ruler, *Analyze Data from Eating a Graham Cracker*
5	10 min	**READ "WHAT'S SPIT?"** 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.	H	*What's Spit?*

End of day 1

Part	Duration	Summary	Slide	Materials
6	7 min	**LOOK FOR PATTERNS IN FOOD MOLECULES** 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.	I-J	Food molecule card sets (only complex carbohydrates and glucose cards) created from *Food Molecule Cards*
7	10 min	**PLAN AN INVESTIGATION TO TEST FOR CHEMICAL REACTIONS IN THE MOUTH** 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.	K-N	tape, *Chemical Reactions in the Mouth Investigation*, *Data Table for Chemical Reactions in the Mouth*
8	15 min	**CONDUCT AN INVESTIGATION TO TEST FOR CHEMICAL REACTIONS IN THE MOUTH** Monitor students as they work in small groups in lab to complete Parts 3-6 of the investigation.	N	*Chemical Reactions in the Mouth Investigation*, Chemical Reactions in the Mouth lab
9	10 min	**BUILDING UNDERSTANDINGS DISCUSSION—INTERPRETING OUR DATA** Pull students together in a Scientists Circle. Ask students to make claims, supported by evidence, about whether chemical reactions occur in the mouth.	O	
10	3 min	**NAVIGATION** Students complete an exit ticket to help them think about where else in the digestive system chemical reactions occur.	P	
				End of day 2
		SCIENCE LITERACY ROUTINE Upon completion of Lesson 5, students are ready to read Student Reader Collection 2 and then respond to the writing exercise.		Student Reader Collection 2: *Gut Reactions*

Lesson 5 • Materials List

	per student	per group	per class
Chemical Reactions in the Mouth lab materials	• safety goggles	• 4 pipettes • 4 microcentrifuge tubes • a beaker or coffee cup • 30 mL of iodine in a 3 oz plastic cup • 30 mL of Benedict's solution in a 3 oz plastic cup • a spoon • fine tip permanent marker	• hot water (it is recommended that you boil the water in an electric kettle) • 1 cup taco shells in a 20 oz cup • 1 cup cooked rice in a 20 oz cup • 1 cup crackers in a 20 oz cup • 1 gram dextrose-free amylase enzyme • 200 mL distilled water
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• Science Notebook • 1-2 crackers ruler • *Analyze Data from Eating a Graham Cracker* • *What's Spit?* • tape • *Chemical Reactions in the Mouth Investigation* • *Data Table for Chemical Reactions in the Mouth*	• Food molecule card sets (only complex carbohydrates and glucose cards) created from *Food Molecule Cards*	Animation of a Person Chewing - 7.3 Metabolic Reactions Lesson 5 video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Materials preparation (Overnight time needed plus 60 minutes)

Online Resources



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 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**).

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 20 oz 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 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

7 MIN

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.

Suggested prompts	Sample student responses
What were some discoveries we made about what might be different about M'Kenna's digestive system?	*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.*
What are some discoveries we made about what happens to large and small food molecules as they pass through the digestive system?	*Very large food molecules, like fiber, stay the same in the digestive system and leave the body as poop.* *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.*

Suggested prompt	Sample student response
If the large food molecules, like complex carbohydrates, are gone when they reach the large intestine, what do you think happens to them?	*We don't know what will happen to them! But we have two ideas about what could be happening to them: (1) complex carbohydrates could be getting absorbed somewhere other than the small intestine, or (2) complex carbohydrates could be breaking down, through chemical reactions, into something else. We want to figure out what is happening to the complex carbohydrates in the digestive system.*

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.

Suggested prompt	Sample student response
How would figuring this out help us to explain what is going on with M'Kenna?	*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.*

Suggested prompts	Sample student responses
	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.
Do we have any ideas on our Ideas for Investigations board that may help us with our investigation today?	*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.*

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. 9 MIN

Materials: 1-2 crackers, Science Notebook, Animation of a Person Chewing - 7.3 Metabolic Reactions Lesson 5 video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

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 a video of a person chewing (See the online resources guide for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

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

Suggested prompt	Sample student responses
What observations did you make about what happens to the cracker in your mouth?	*I crunched up the cracker with my teeth. As I chomped down with my teeth, the cracker broke down into smaller pieces.*

Suggested prompt	Sample student responses
	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.*

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	Sample student responses
What kinds of physical changes do you observe happening with the cracker?	*The cracker is being broken into smaller pieces.* *The cracker is mixing with spit.*

3. Connect observations to chemical reactions unit.

7 MIN

Materials: Science Notebook

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 prompts	Sample student responses
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?	*The molecules of the substances we start with break apart and the atoms that make them form new arrangements (new molecules).*
How do the properties of the substances we start with in a chemical reaction and end with in a chemical reaction compare?	*The properties of the substances we start with in a chemical reaction are different from the properties of the substances that we end with.*
In our previous unit on chemical reactions, how did we describe physical changes?	*When a process like smashing it, melting it, freezing it, boiling it, etc., occurs.*
How do the properties of the stuff we start with compare to the stuff we end with in a physical change?	*The substances before the processes have the same properties as those after the processes.*

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.



Suggested prompts	Sample student responses
What kinds of changes do you think are happening to the substances in the cracker in our mouths?	*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.*
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?	*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.*

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!*

4. Analyze data from eating a graham cracker.

12 MIN

Materials: ruler, Science Notebook, *Analyze Data from Eating a Graham Cracker*

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.



Additional Guidance

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.

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.

*** Supporting Students in Developing and Using Patterns**
Students should use patterns of changes in the data to identify that a chemical reaction is occurring in the mouth.

*** Supporting Students in Engaging in Analyzing and Interpreting Data**
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.

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



Suggested prompts	Sample student responses
What patterns did you notice in the data?	*Everything except for complex carbohydrates and glucose stayed the same.* *Complex carbohydrates seemed to be decreasing in the mouth.* *Glucose seemed to be increasing in the mouth.*
What can we conclude from the data?	*We know that there can't be a chemical reaction happening with anything other than complex carbohydrates and glucose.* *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?*

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.*

Suggested prompts	Sample student responses
Do you think we have enough evidence to say what is causing the decrease in complex carbohydrates and the increase in glucose?	*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.*
Is the decrease in complex carbohydrates and the increase in glucose a correlation? Why or why not?	*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.*

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."

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.

Suggested prompts	Sample student responses
What do you think spit is?	*I think it is mostly water. Maybe there is some other stuff in it too, but it is mostly water or drool.* *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.*
What do you think spit is made of?	*I think it is mostly water, but maybe there is some other stuff in it too.* *It tastes like nothing, so it is probably water.*
Why do you think our bodies make spit?	*Our mouths would get really dry without it!* *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.*

5. Read "What's Spit?" 10 MIN

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.

Suggested prompt	Sample student responses
What kinds of evidence should we look for to suggest that there is a chemical reaction happening in our mouths when we eat?	*We might read about new stuff showing up in our mouths or old stuff going away.* *We might read about other kinds of chemicals in our mouths.*

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

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

Suggested prompts	Sample student responses
What kinds of evidence did the article provide to help you answer the question, "Do chemical reactions occur in the mouth?"	*The article said that the mouth starts the process of digestion, which is when food is broken down in the mouth.* *The article mentioned special molecules called enzymes, which help with digestion.*
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?"	*The article mentioned that enzymes in saliva help in the process of digestion. Maybe we could use some of these enzymes to try to digest food outside of the body. We could try testing the food before and after digestion to see if it changes.*

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.

7 MIN

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.

*** 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).

Suggested prompts	Sample student responses
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.

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 ideas that all classmates 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	Sample student responses
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?	*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.

10 MIN

Materials: Science Notebook, tape, *Chemical Reactions in the Mouth Investigation*, *Data Table for Chemical Reactions in the Mouth*

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 *Data Table for Chemical Reactions in the Mouth*. Have students tape *Data Table for Chemical Reactions in the Mouth* 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 *Key for Chemical Reactions in the Mouth Data Table*. An example video has also been provided at Lab Set Up Demonstration of Amylase Investigation - 7.3 Metabolic Reactions Lesson 5 video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**). 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. 15 MIN

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	Sample student responses
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?	*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 N** 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 10 MIN

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.

*** Strategies for This Building Understandings Discussion**
Students may not see how what they figured out from a specific investigation can be used to explain a question or phenomenon from a previous lesson without specific prompting. Ask them to think back to what they saw before and consider how it can be connected.

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.*



Assessment Opportunity

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 6 for complex carbohydrates, proteins, and fats, but this is a good opportunity to elicit student ideas focused only on complex carbohydrates.

Suggested prompts	Sample student responses
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

3 MIN

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?

SCIENCE LITERACY: READING COLLECTION 2

Gut Reactions

1 **Microbiome Balance**
2 **Poop Science**
3 **Feed Conversion Ratios**
4 **Ruminants**

Literacy Objectives

- ✓ Translate information in text to personal experience.
- ✓ Support a position on healthy diet choices with evidence.

Literacy Exercises

- Read varied text selections related to the topics explored in Lessons 1–2.
- Evaluate the reading selections according to provided prompts and criteria.
- Compare and contrast information gained from reading text with information gained from class investigation.
- Prepare a menu for a meal in response to the reading.

Instructional Resources

Student Reader



Collection 2

Science Literacy Student Reader, Collection 2
"Gut Reactions"

Exercise Page



EP 2

Science Literacy Exercise Page
EP 2

Prerequisite Investigations

Assign the Science Literacy reading and writing exercise *after* class completion of this lesson group:

- Lesson 3: Why do molecules in the small intestine seem like they are disappearing?
- Lesson 4: What happens to food molecules as they move through the small intestine and large intestine?
- Lesson 5: Why do large food molecules, like some complex carbohydrates, seem to disappear in the digestive system?

Standards and Dimensions

NGSS

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

Disciplinary Core Ideas:

LS1.A Structure and Function

LS1.C Organization for Matter and Energy Flow of Organisms

Science and Engineering Practices: Asking Questions; Constructing an Explanation; Analyzing and Interpreting Data

Crosscutting Concepts: Systems and System Models; Structure and Function

CCSS

English Language Arts

RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

RST.6-8.6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.

Core Vocabulary

Core Vocabulary: Core Vocabulary terms are those that students should learn to use accurately in discussion and in written responses. During facilitation of learning, expose students repeatedly to these terms. However, these terms are not intended for isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about any concepts in this exercise. Students will benefit from your modeling the use of these words without the expectation that students will use or explain the words themselves.

biome **feed conversion ratio (FCR)**
ruminant

A Glossary at the end of the Science Literacy Student Reader lists definitions for Core Vocabulary and selected Language of Instruction.

1. Plan ahead.

Determine your pacing to introduce the reading selections, check in with students on their progress, and discuss the reading content and writing exercise. If you are performing Science Literacy as a structured, weekly routine, you might implement a schedule like this:

- Monday: Designate a ten-minute period at the beginning of the week to introduce students to the assignment.
- Wednesday: Plan to touch base briefly with students in the middle of the week to answer questions about the reading, to clarify expectations about the writing exercise, and to help students stay on track.
- Friday: Set aside time at the end of the week to facilitate a discussion about the reading and the writing exercise.

You'll proceed with the in-class lesson investigations during this week.

Exercise Page



EP 2

2. Preview the assignment and set expectations. (Monday)

- Let students know they will read independently and then complete a short writing assignment. The reading selection relates to topics they are presently exploring in their Metabolic Reactions unit science investigations.
- The reading and writing will be completed outside of class (unless you have available class time to allocate).
- Preview the reading. Share a short summary of what students can expect.
  - *In "Microbiome Balance," you will find out that some bacteria in an organism's stomach are good and some are bad. Organisms need good bacteria to break down food to use for energy.*

- *In "Poop Science," you'll read about what poop can tell us about an organism, including what it eats, where it lives, and whether it is healthy or not.*
- *"Feed Conversion Ratios" gives you data about how efficient different animals we eat are in converting the food they eat into food humans eat.*
- *By reading "Ruminants," you'll find out about how hooved mammals digest the grasses they eat.*

- Distribute Exercise Page 2. Preview the writing exercise. Share a summary of what students will be expected to deliver. Emphasize that Science Literacy exercises are brief. The focus is on thoughtful quality of a small product, not on the assignment being big and complex.
  - *For this assignment you will be expected to generate a menu for an efficient meal according to a feed conversion ratio.*
- Remind students of helpful strategies they can employ during independent reading. Offer the following advice:
  - *The reading should take approximately 30 minutes to complete.* (Encourage students to break reading into smaller sections over multiple short sittings if their attention wanders.)
  - *A good reading strategy is to scan through the collection first to see the titles, section headers, graphics, and images to see what the selections are going to be about before fully reading.*
  - *Next, "cold read" the selections without yet thinking about the writing assignment that will follow.*
  - *Then, carefully read the Exercise Page to understand the expectations for the writing part of the assignment.*
  - *Revisit the reading selections to complete the writing exercise.*
  - *Jot down any questions for the midweek progress check in class.* (Be sure students know, though, that they are not limited to that time to ask you for clarification or answers to questions.)

3. Touch base to provide clarification and address questions. (Wednesday)

Touch base midweek with students to make sure they are on track while working independently. You may choose to administer a midweek minute-quiz to give students a concrete reason not to postpone completing the reading until the last minute. Ask questions such as these, and have students jot answers on a half sheet of paper:

Suggested prompt	Sample student responses
What's the difference between what people term good and bad bacteria as they relate to the human digestive system?	*Good bacteria in the stomach are an essential part of digestion. They break down the food we eat. These bacteria are part of the microbiome.* *Bad bacteria in the stomach can make you sick or cause harm to the body.*

Suggested prompts	Sample student responses
What can poop tell us about humans and animals?	*Analyzing poop can tell us what an animal has eaten and if it is healthy, sick, or even stressed.* *Studying fossilized poop can tell us what types of animals lived in different places in the past and what ancient animals used to eat.* *Poop can suggest whether there are communicable diseases among the human population and whether or not people have certain illnesses, like excess infection with C. diff.*
What is a feed conversion ratio (FCR)?	*This ratio gives us data about how efficient animals are at converting the food they eat into food humans can eat.* *The FCR is the mathematical relationship between the quantities of feed provided an animal and the weight gained by consuming it.* *Each animal has a different FCR.* *The feed conversion ratios are based on dry food, not wet food.*
Why might it be good for the planet to develop a taste for crickets?	*Crickets have an FCR of 1:1, which makes them very efficient to raise as a food source.* *The food a cricket takes in by eating plants is equal to the amount of nutrition it would provide humans if humans were to eat crickets.*
Why do cows have such high feed conversion ratios?	*They must eat a lot of grass and hay, which travels through their digestive system, to produce milk and meat. Much of the food they eat is excreted as waste.*
What is interesting about the way cows digest food?	*Cows are ruminants.* *Cows eat grasses, hay, and straw. A cow can hold about 95 liters of food in its rumen.* *Cows have four chambers in their stomachs. Each one is responsible for something different.*

Ask a few brief discussion questions related to the reading that will help students tie the text content to students' classroom investigations.

Suggested prompts	Sample student responses
What did analyzing M'Kenna's poop tell her doctors?	*M'Kenna's poop contained additional food molecules that are not found in a healthy person's poop. That means her digestive system is not working properly.*
What did M'Kenna's endoscopy reveal about her intestines?	*In a healthy person, only water and fiber remain in the large intestine, but M'Kenna's test showed that there were other molecules in her large intestine.*

- Refer students to the Exercise Page 2. Provide more specific guidance about expectations for students' deliverables due at the end of the week.
  - *The writing expectation for this assignment is to create a menu for a meal that is appealing and efficient in terms of feed conversion ratios.*
  - *Do research to make sure that your menu is complete, is appealing, and has a low FCR. The research you cite should be credible and endorsed by people who know what they are talking about.*
  - *The important criterion for your work is that your menu includes foods that people will like and do not have high feed conversion ratios.*
  - *Make your menu engaging, like an advertisement, so that people your age will want to try it.*
- Explain that a great menu will have appealing choices and engaging graphics.
- Answer any questions students may have relative to the reading content or the exercise expectations.

Exercise Page



EP 2

4. Facilitate discussion.

(Friday)

Facilitate class discussion about the reading collection and writing exercise.

The four reading selections focus on animal digestive systems. "Good" bacteria work to break down food to convert it to energy or food for other organisms to eat. "Bad" bacteria in the digestive system can cause illness. Some animals are more efficient than others in converting food to energy as measured by a feed conversion ratio. Studying animal waste reveals what the animal has eaten and if it is healthy.

Pages 14–15 Suggested prompt	Sample student response
What is the general purpose of the first selection, "Microbiome Balance"?	*It establishes that there are two types of bacteria in the digestive system. Good bacteria break down food and convert it to energy or waste. They are part of the microbiome. Bad bacteria can make organisms sick.*

Student Reader



Collection 2

SUPPORT—If you are using the recommended word envelope convention, check the envelope to see if it contains any words, phrases, or sentences that students need help understanding. Read key sentences aloud, and provide concise explanation.

Pages 14–15 Suggested prompts	Sample student responses
What is a microbiome?	*A microbiome is a group of microorganisms, like the good and bad bacteria, that thrive in a particular environment, like the stomach.*
What would happen if all the good bacteria were destroyed in your stomach?	*You would not be able to break down food effectively and would get sick with bloating, diarrhea, vomiting, or some other stomach illness.*

Pages 16–19 Suggested prompts	Sample student responses
How does the second selection help you build knowledge on top of what you learned in the first selection?	*The first article provides information about bacteria in the digestive system. "Poop Science" explains that bacteria enable animals to produce waste (poop) that can be studied to learn about animal digestive systems and environments.*
How can studying animal waste tell us if a population is healthy?	*If the waste includes evidence that animals are eating nutritious foods and there is no evidence of unusual bacteria or virus, the population is probably healthy.*
Why does poop smell?	*Bacteria and digestion make poop smell. Bacteria breaking down food or sweat causes odor. If poop smells different than usual, it could be the result of what has been eaten, or it could suggest an illness.*

Pages 20–21 Suggested prompt	Sample student response
What is the general purpose of the third article, "Feed Conversion Ratios?"	*This article explains how efficient different animal products people eat are at producing food from the food they eat. Some animals, like cattle, are much less efficient than others, like chicken or fish.*

SUPPORT—Some students may not be familiar with the scientific terms *DNA* and *biome*. Explain that DNA is the carrier of genetic information from one generation to the next. Poop contains DNA. A biome is a large community of plants and animals. Contrast *biome* and *microbiome*.

CHALLENGE—Challenge interested students to develop an FCR chart that lists at least 25 different foods. Have them sort the list from most to least efficient. Then have them present their findings to the class.

EXTEND—Have students watch a video about sustainable gardening. Follow up with a discussion about the efficiency of producing food in this way.

Pages 20–21 Suggested prompts	Sample student responses
Why do farmed salmon have a very low FCR?	*The feed they eat is converted into the food they provide very efficiently. It takes a lot of feed to produce a pound of beef or a carton of milk, but it takes much less feed to produce a pound of farmed salmon.*
What are some "costs" of farming that don't include financial costs?	*how much space a farmed animal takes up* *how much methane, or greenhouse gas, an animal gives off* *how many resources an animal consumes when it is farmed*

Pages 22–23 Suggested prompts	Sample student responses
What is the general purpose of the fourth article, "Ruminants?"	*This article describes the four chambers that a cow has that enable it to eat and digest fibrous foods—like grass and hay—that people cannot digest.*
What would happen if people ate a cow's diet?	*Although grass is not poisonous to humans, they cannot digest it, so it would be vomited or excreted without any nutritional benefit. Also, human teeth are not intended to grind grass and grains as cows' teeth do, so human teeth would wear away.*

5. Check for understanding.

Evaluate and Provide Feedback

For Exercise 2, students create a menu for a meal that is appealing and efficient in terms of Feed Conversion Ratios.

They should incorporate a little bit of research to ensure the menu has a low FCR and includes foods that people will like.

Use the rubric provided on the Exercise Page to supply feedback to each student.

LESSON 6

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

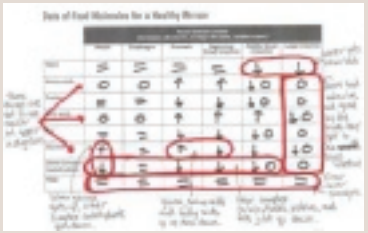
Previous Lesson

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

1 DAY



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

Part	Duration	Summary	Slide	Materials
1	10 min	**ADD TO OUR PROGRESS TRACKERS** 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.	A-C	*Progress Tracker*
2	10 min	**ANALYZE DATA TO DETERMINE IF CHEMICAL REACTIONS HAPPEN IN OTHER ORGANS** 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.	D-J	*Table to Organize Food Molecules Data*, *Food Molecule Data for a Healthy Person*, ruler
3	5 min	**LOOK FOR PATTERNS IN FOOD MOLECULES** 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.	K	food molecule card sets created from *Food Molecule Cards*
4	17 min	**BUILDING UNDERSTANDINGS DISCUSSION TO MAKE SENSE OF PATTERNS IN THE DATA** 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.	L	*Food Molecule Data for a Healthy Person*

Part	Duration	Summary	Slide	Materials
5	3 min	**NAVIGATION** Support students in summarizing what they've figured out during this lesson and connecting their ideas back to M'Kenna's symptoms.	M	

End of day 1

Lesson 6 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• Science Notebook • *Progress Tracker* • *Table to Organize Food Molecules Data* • *Food Molecule Data for a Healthy Person* • ruler		• food molecule card sets created from *Food Molecule Cards*

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.

Online Resources



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.

10 MIN

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.

*** 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.

Suggested prompts	Sample student responses
What did we figure our last class? Do chemical reactions occur in the mouth?	*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.*
What evidence do we have to support our claims?	*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.* *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.* *We read an article that provided us with evidence that a special enzyme called amylase can break down substances in the mouth.* *We conducted an investigation to determine if amylase breaks some types of complex carbohydrates down into glucose, and we discovered that it does!*

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.*

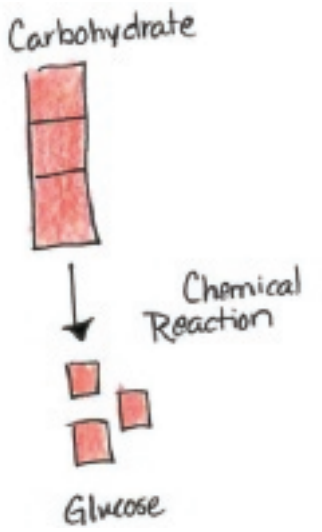
Present **slide B**. Have students follow the directions on **slide B** to develop a 30-second argument using evidence and scientific reasoning with a partner that can support how we should add to our Progress Trackers and revise our model for what happens to food as it passes through the digestive system.



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.



Question	What I Figured Out in Words/Pictures
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 group's Progress Tracker does not need to look exactly the same.

Assessment Opportunity

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**.

Suggested prompt	Sample student response
Do you think that all of our food gets broken down in our mouths?	*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.*

Suggested prompts	Sample student responses
Where do you think other food molecules we eat, like protein, get broken down?	*Maybe in our stomachs? Could we check to see if this happens in other organs in our digestive system?*
What could we do to figure that out?	*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.*

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.

10 MIN

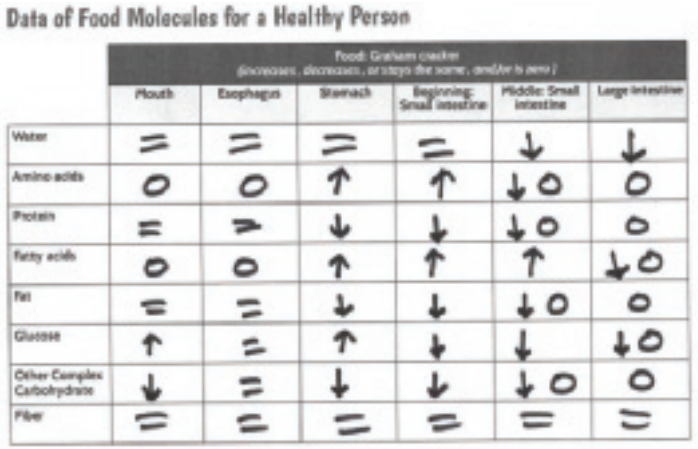
Materials: Science Notebook, *Table to Organize Food Molecules Data*, *Food Molecule Data for a Healthy Person*, ruler

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.*

*** 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.

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 *Table to Organize Food Molecules Data* 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 *Table to Organize Food Molecules Data* 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.



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.

5 MIN

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 prompts	Sample student responses
Think about the graham cracker moving through the different organs of the digestive system.	*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.*
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?	*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

17MIN

Materials: Science Notebook, *Food Molecule Data for a Healthy Person*

Additional Guidance

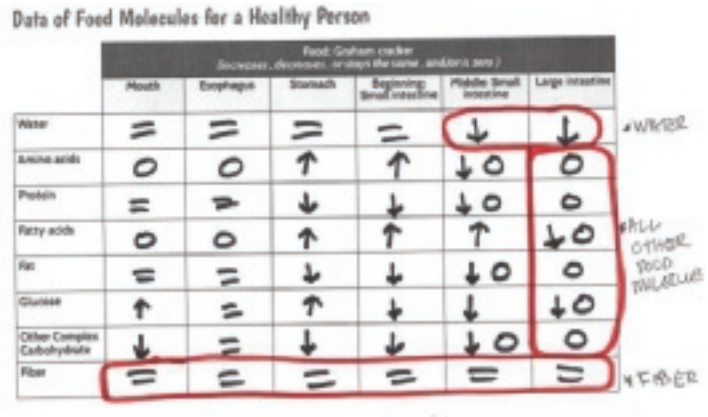
While helping students make sense of the data, students may begin to wonder about what is and what is not healthy. By examining the data of a healthy person, students will be able to see the following patterns emerging:

- 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:

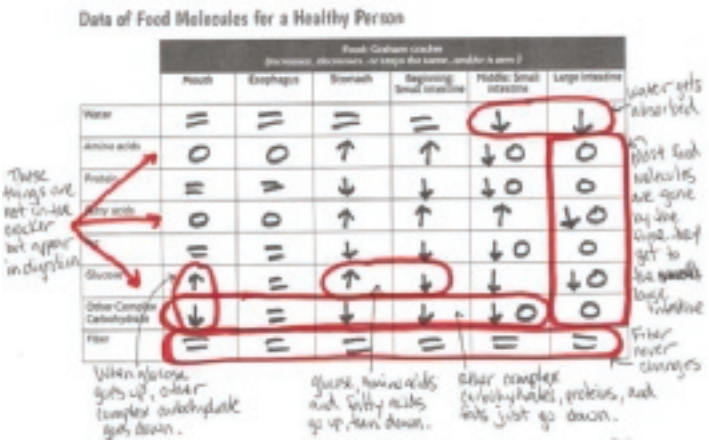
- In the middle of the small intestine, all the substances in food start decreasing, except fiber and fatty acids.
- Some new substances that weren't there before start appearing in the stomach (amino acids and fatty acids), and more glucose appears in the mouth than at the beginning.

Use the following prompts to guide this discussion.

Suggested prompts	Sample student responses
Which molecules only go down over time and never go up?	*Other complex carbohydrates, proteins, and fats only go down. This seems to happen mostly in the stomach and small intestine.*
Which molecules increase and decrease?	*Glucose, fatty acids, and amino acids go up in the stomach and the beginning of the small intestine and then go down.*
Do any types of molecules appear in the food at any point that weren't in it before it was eaten?	*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.*
Did anyone notice patterns in which one substance increased and another decreased in the same location?	*When complex carbohydrates go down, glucose goes up, except in the middle of the small intestine, where they both go down.*

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 *Table to Organize Food Molecules Data* 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 that follow.

Suggested prompt	Sample student responses	Follow-up question
Can someone remind us of the question we are trying to answer?	*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.* *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?"*	*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.*

Suggested prompt	Sample student responses
What are some of your claims?	*Each organ in the digestive system (mouth, esophagus, stomach, small intestine, and large intestine) is performing a different function.* *Large food molecules are mainly broken down in the stomach and the small intestine.* *Small food molecules are mainly absorbed in the small intestine.* *The function of the esophagus does not seem related to breaking down or absorbing large food molecules.*

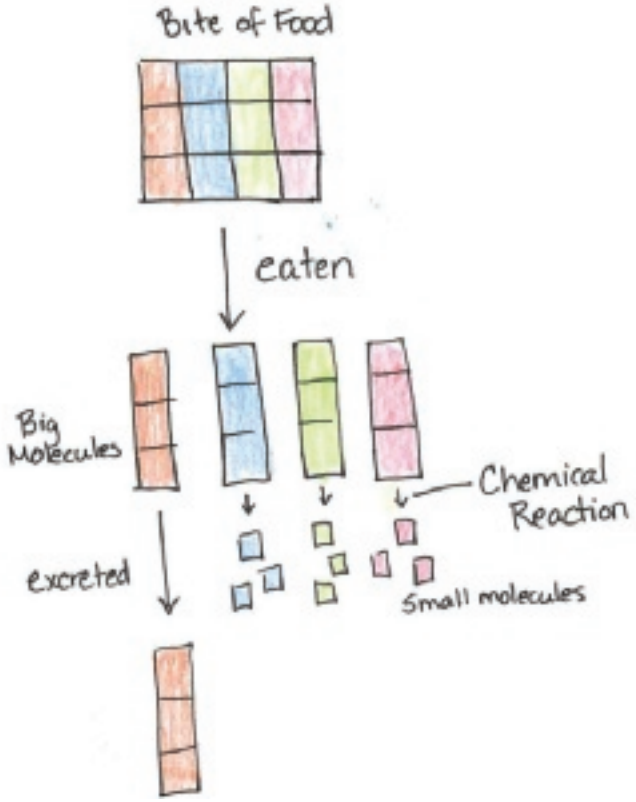
Work as a class to represent findings. Ask students for ideas of how we can represent what is happening to food molecules as they travel through the digestive system by showing the relationship between large food molecules and corresponding smaller food molecules.

Suggested prompt	Sample student response
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?	*Maybe we can show the smaller molecules as little shapes and the larger molecules as chains of those little shapes.*

Suggested prompt	Sample student response
How can we show that the larger molecules appear to be made of similar clusters of atoms that make up the smaller molecules?	*We can use squares (or other shapes) for smaller molecules and a "necklace" of those shapes chained together for the larger molecules.*

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.

Suggested prompts	Sample student response
We said that each organ in the digestive system (mouth, esophagus, stomach, small intestine, and large intestine) is performing a different function. *How did we arrive at that conclusion? What is our evidence?*	*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.*

Suggested prompt	Sample student response
What seems to be true about all of our claims? What can we conclude?	*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.*

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

3 MIN

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.

LESSON 7

What is the function of the digestive system, and how is M'Kenna's digestive system different?

Previous Lesson

We analyzed more food data, noting the food changes in different parts of a healthy digestive system. We noticed patterns in which some molecules decreased by the same amount that other molecules increased. We argued that this is a sign of chemical reactions happening in the digestive system.

This Lesson

Putting Pieces Together

3 DAYS



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

Next Lesson

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

Building Toward NGSS

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

What Students Will Do

Develop a model based on multiple lines of evidence to represent the inputs, processes, and outputs of the digestive system and the role that the system, and the subsystems within it, play in breaking down matter inputs through chemical reactions, absorbing food, and excreting unused matter.

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

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

What Students Will Figure Out

- In a healthy digestive system, multiple subsystems, or organs, work together to help the body break large food molecules down into smaller food molecules.
- Large food molecules are broken down into smaller food molecules through chemical reactions that occur in the mouth, stomach, and small intestine.
- Each organ plays a different role in the breakdown of large food molecules.
- In a healthy person, the small intestine absorbs the small food molecules that had been broken down in preceding organs in the digestive system.
- We can use a model to represent the digestive system and the interactions that occur within it.
- Effective models include inputs, processes, and outputs.

Lesson 7 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Review M'Kenna's symptoms and the investigations we have completed, thus far, to figure out how M'Kenna can experience symptoms in so many different parts of her body.	A	
2	13 min	**WHAT CAN WE EXPLAIN NOW?** Look back at the initial models we developed to explain M'Kenna's symptoms. Consider the investigations we have done since then. Compile all of the pieces of our models from our Progress Trackers into one model.	B	colored pencils, *Compiled Models from Progress Tracker*
3	12 min	**GOTTA-HAVE-IT CHECKLIST** Develop a Gotta-Have-It Checklist to list the important ideas we have figured out so far that we need to include in our new models to answer the question, "How does a healthy digestive system work?"	C	*Gotta-Have-It Checklist*
4	15 min	**DEVELOP MODELS IN SMALL GROUPS** Work in small groups to develop a model to explain, "How does a healthy digestive system work?" Use your Gotta-Have-It Checklist to help. Check off ideas on the list that you used or did not use to develop the model.	D	*Gotta-Have-It Checklist*, chart paper, markers

End of day 1

Part	Duration	Summary	Slide	Materials
5	12 min	**PREPARING FOR CONSENSUS MODEL** Examine at least two other small-group models. "Take" ideas to use in your own model. "Leave" critique, based in evidence, to improve others' models. Brainstorm parts of M'Kenna's digestive system that you think may be functioning differently.	E-F	2 sticky notes, 1 sticky dot, *Self-Assessment: Giving and Receiving Feedback*
6	20 min	**DEVELOPING OUR CLASSROOM CONSENSUS MODEL** As a class, develop a consensus model to describe how a healthy digestive system works. Then, discuss how you think M'Kenna's digestive system is functioning differently than a healthy one. Consider the limitations of the classroom consensus model.	G-H	small-group model, chart paper, markers
7	13 min	**ADD TO OUR PROGRESS TRACKERS** Using the classroom consensus model, individually add to your 3-column Progress Tracker.	I	*Progress Tracker*, colored pencils
				End of day 2
8	2 min	**NAVIGATION** Navigate to the student assessment by considering why doctors might eliminate possible conditions rather than selecting the condition that best fits the symptoms.	J	
9	40 min	**STUDENT ASSESSMENT TASK** As an assessment task, students are presented with five gastrointestinal conditions that might be causing M'Kenna's symptoms. Construct an argument, based on evidence, to eliminate two of the possible conditions.	K-O	*Task Parts 1 and 2: Eliminate Possible Conditions and Identify Missing Evidence*
10	3 min	**NAVIGATION** When students are done with the assessment task, return to the Driving Question Board to find a question that we think we have answered. On a sticky note, record the answer, based on evidence, and post the sticky note near the original question.	P	1-2 sticky notes, Driving Question Board
				End of day 3

Lesson 7 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• Science Notebook • colored pencils • *Compiled Models from Progress Tracker* • *Gotta-Have-It Checklist* • 2 sticky notes • 1 sticky dot • *Progress Tracker* • *Task Parts 1 and 2: Eliminate Possible Conditions and Identify Missing Evidence* • 1-2 sticky notes	• chart paper • markers • small-group model	• chart paper • markers • Driving Question Board

Online Resources



Materials preparation (20 minutes)

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

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

Lesson 7 • Where We Are Going and NOT Going

Where We Are Going

This lesson addresses the DCI element that food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy (LS1.C). Specifically, students pull together their previously developed ideas into one model to show that large food molecules, which make up food, are broken down into smaller food molecules through a series of chemical reactions that occur in the digestive system.

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

Where We Are NOT Going

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

In the student embedded assessment, students are presented with five different gastrointestinal conditions that may be causing M'Kenna's symptoms. Students are not "diagnosing" M'Kenna with a condition. Rather, students are eliminating possible causes of M'Kenna's symptoms based on evidence.

LEARNING PLAN FOR LESSON 7

1. Navigation

5 MIN

Materials: Science Notebook

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

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

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

2. What can we explain now?

13 MIN

Materials: Science Notebook, colored pencils, *Compiled Models from Progress Tracker*

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

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

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

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

Additional Guidance

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

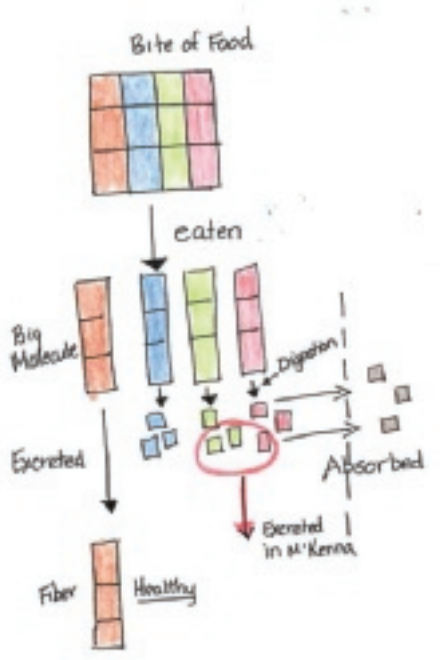
A suggested representation can be found here.

Additional Guidance

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

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

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



Help students generate the idea to mapping their existing models onto a model of the digestive system.

Suggested prompts	Sample student responses
How could we revise our models to show where each of these processes are taking place?	*Maybe we could add our models to a model of the digestive system. We could cut out each of the processes and paste it onto the different parts of the digestive system where it occurs.*
Why would it be important to map our current models of the breakdown of food onto a model of the digestive system? How could this help us explain what is going on with M'Kenna?	*In our last class, we noticed that different parts of the digestive system do different jobs. It is almost like they are smaller parts, or subsystems, of a larger system. If we combine our models with a model of the digestive system, we might be able to better understand how and why structures of the digestive system relate to the functions.* *We have these different pieces, but it's hard to visualize where these different processes are occuring. Often times, we've been looking at charts and graphs to see what's happening, but it would be great to put them all together.* *If we can map our models onto the model of the digestive system, it might help us show where M'Kenna's digestive system might be functioning differently.*

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

3. Gotta-Have-It Checklist

12 MIN

Materials: Science Notebook, *Gotta-Have-It Checklist*

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

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

*** Supporting Students in Three-Dimensional Learning**

As students develop their Gotta-Have-It Checklists, ensure that they have identified different relationships among organs of the digestive system and their respective food molecule outputs (SEP2). These items should help students build their understanding in explaining how food moves through a series of chemical

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

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

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

As students work, circulate to push their thinking.



reactions where it is broken down (LS1.C). In order to do this, the Gotta-Have-It Checklist should identify components of the system (organs) and their interactions (processes, inputs, and outputs) (CCC4).

Key Ideas

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

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

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

Additional Guidance

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

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

Suggested prompts	Sample student responses
Can someone suggest an idea from Lessons 1 through 6 that will help us explain how a healthy digestive system works?	*The digestive system is a long tube with different parts to it (Lesson 1).* *In one part of the digestive system, the small intestine, small food molecules are absorbed and large food molecules aren't (Lesson 3).* *Absorption (in the small intestine) means that the molecules cross the lining of the small intestine (Lesson 3).* *Fiber is not digested at all and is excreted from the body (Lesson 4).* *Large food molecules (most complex carbohydrates, proteins, and fats) can be broken down into smaller food molecules (Lessons 5 and 6).* *In another part of the digestive system, the mouth, some types of complex carbohydrates are broken down into smaller pieces through chemical reactions (Lesson 5).* *Other types of food molecules (proteins and fats) are broken down in other parts of the digestive system (stomach and small intestine) (Lesson 6).*
Based on the ideas we just shared, why are the models we just developed insufficient? Why do we need to add the structures of the digestive system to our models?	*The digestive system is one system inside of our bodies. The digestive system has multiple organs inside it that each do particular functions. These organs, such as the stomach, the mouth, and the small intestine, all work together to help break down and absorb food. All of the organs work together to carry out the functions of the whole system.*

4. Develop models in small groups. 15 MIN

Materials: Science Notebook, *Gotta-Have-It Checklist*, chart paper, markers

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

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

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

Remind students to indicate on their Gotta-Have-It Checklist which ideas they did and did not use in their models.

Prompt students to make sure that their models include their responses to the following questions:

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

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

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

*** Attending to Equity**
As a strategy for differentiation, some students may be more prepared to participate in a small group if they can gather their thoughts individually first. Use *Revised Model (optional)* as an option for students to use to sketch out their ideas and drafts.

*** Supporting Students in Engaging in Developing and Using Models**
Small student groups begin to revise their models to show relationships between different structures in the digestive system and where food is broken down and absorbed. Identifying where these unobservable processes occur in a healthy person will help students predict which processes are not occurring correctly in M'Kenna.

Additional Guidance

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

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

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

Prompts to ask students to support or challenge proposals.

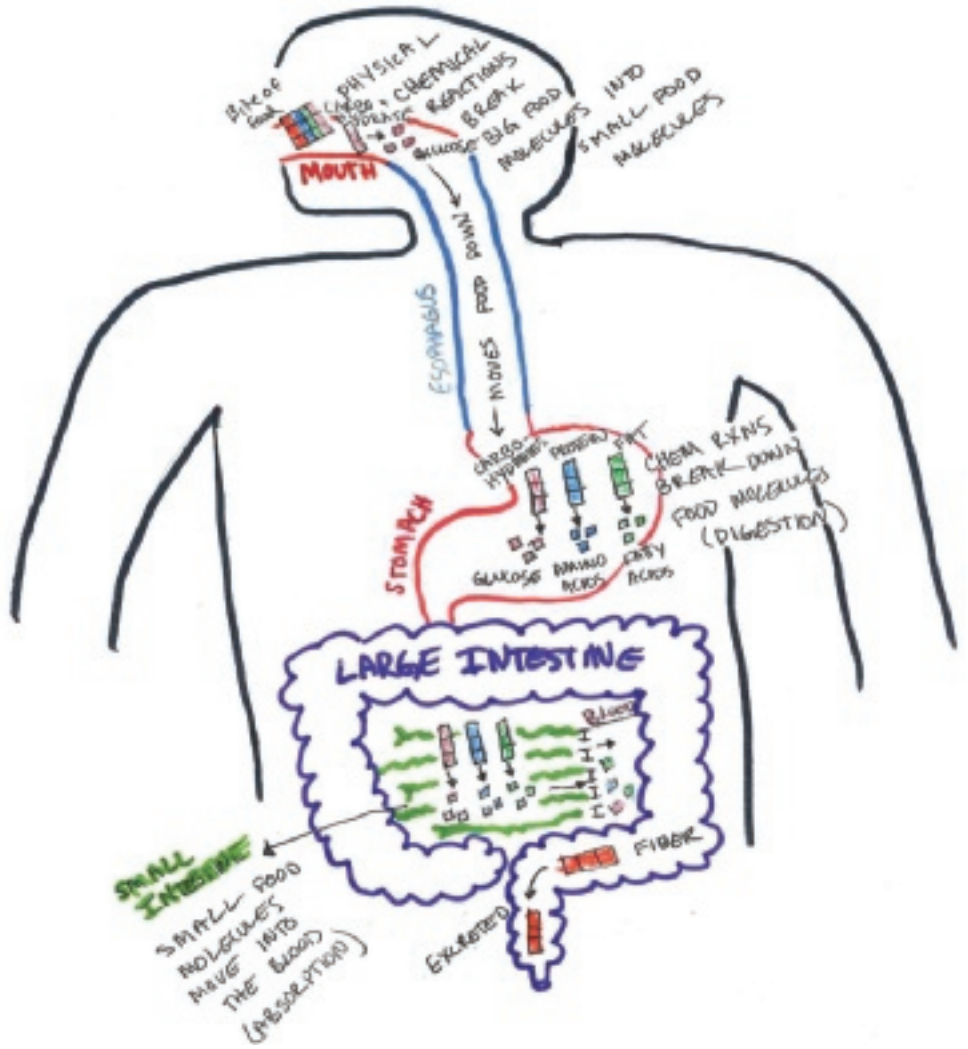
- What ideas are we in agreement about?
- Are there still places where we disagree? Can we clarify these?
- Are there still areas of confusion or discontent?
- Who feels like their idea is not quite represented here?

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

- How are your ideas similar to the small-group model? How are they different?
- Is there more evidence or clarification needed before we can come to an agreement? What is that?

The final consensus model will likely look something like the image to the right. Small-group models should include many of these components and interactions.

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



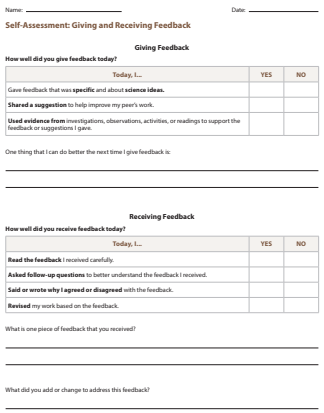
End of day 1

5. Preparing for Consensus Model

12 MIN

Materials: 2 sticky notes, 1 sticky dot

Have students critique one another's models through a gallery walk. Present **slide E**. Tell students that they will be responsible for visiting at least two other small-group models. Hand out copies of the *Lesson 7 Peer Feedback Guidelines*. Review the guidelines and then share that, at the end of this activity, we will get a chance to evaluate ourselves on giving and receiving feedback using *Self-Assessment: Giving and Receiving Feedback*.



Name: _____ Date: _____

Self-Assessment: Giving and Receiving Feedback

Giving Feedback

How well did you give feedback today?

Today, I...	YES	NO
Gave feedback that was **specific** and about **science ideas.**		
Shared a suggestion to help improve my peer's work.		
Used evidence from investigations, observations, activities, or readings to support the feedback or suggestions I gave.		

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

_____

_____

Receiving Feedback

How well did you receive feedback today?

Today, I...	YES	NO
Read the feedback I received carefully.		
Asked follow-up questions to better understand the feedback I received.		
Said or wrote why I agreed or disagreed with the feedback.		
Revised my work based on the feedback.		

What is one piece of feedback that you received?

_____

_____

What did you add or change to address this feedback?

_____

Assessment Opportunity

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

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

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

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

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

*** Supporting Students in Engaging in Argument from Evidence**

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

6. Developing Our Classroom Consensus Model

20 MIN

Materials: Science Notebook, small-group model, chart paper, markers

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

Present **slide G** and introduce the Consensus Discussion.

*** Attending to Equity**

The key ideas shared in the teacher guide are suggestions for important ideas that the model could include. It is important,

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

Remind students of discussion norms. Highlight important ways to talk with one another, including frames for how to agree or disagree respectfully and how to push for justification. Encourage students that it's OK to share an idea that they're not sure about or to disagree with someone's or another group's idea.

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

Key Ideas

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

Listen for these ideas:

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

however, to appropriate the words and ideas that your students use and agree upon during this discussion. Your class list of key ideas could be articulated differently and may include other ideas not listed here. Actively look for different ways that students share and represent their ideas as an opportunity to communicate to your students that different ways of representing our thinking are valuable.

Scientists Circle



The teacher's role is to prompt students to share what needs to be in the model, what evidence they have to support their ideas, and how to represent their ideas. The students' role is to offer a proposal for ideas to include in the model and how to represent those ideas, to support or challenge proposed ideas from peers, and to come to a consensus about what should be included in the model. Suggested prompts are provided to help elicit, probe, and challenge student ideas to help them come to a consensus during this discussion.

During stock-taking:

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

When soliciting ideas to develop or modify the model or explanation:

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

When inviting support or critique:

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

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

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

Suggested prompt	Sample student responses
What is our evidence that M'Kenna's digestive system is different in the location we have identified?	*We know that M'Kenna's digestive system is still capable of breaking down large food molecules into small food molecules, but it doesn't break down as many. Since proteins and fats are broken down in the stomach or the small intestine, we think that there might be something going on with her stomach or small intestine.* *M'Kenna is having trouble absorbing the small food molecules. The small intestine is responsible for absorbing small food molecules, so we think there must be something wrong with M'Kenna's small intestine.*

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

Suggested prompts	Sample student responses
Does our model fully explain all the parts of M'Kenna's digestion that might be different?	*Our model can't explain why M'Kenna's body is not absorbing all the small food molecules that are broken down.*
Does our model fully explain all of McKenna's symptoms?	*No, we haven't even addressed her non-digestive symptoms!*
What do we still need to figure out?	*We need to figure out why M'Kenna's small intestine isn't absorbing as many small food molecules.*
What kinds of evidence do we need?	*Maybe we can look at her small intestine up close to see if there are differences between M'Kenna's digestive system and a healthy one.*

7. Add to our Progress Trackers.

13 MIN

Materials: Science Notebook, *Progress Tracker*, colored pencils

Update the 3-column Progress Tracker. Present **slide I** and pass out the *Progress Tracker*. Tell students that, just as before, when we figure out something big, we add it to our Progress Tracker in the form of the 3-column tracker. Provide time for students to individually update their Progress Trackers using colored pencils based on the classroom consensus model.

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

Below is one suggested representation for the Progress Tracker.

Question	Source of evidence
What is the function of the digestive system and how is M'Kenna's digestive system different?	Evidence from all investigations in Lessons 1-6.

What I figured out in words/pictures



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

Assessment Opportunity

If you can plan to have time between the Progress Tracker update and the student assessment in the next portion of the lesson, you may wish to provide individual feedback on students' Progress Tracker updates. Specifically, focus on providing feedback on LS1.A, LS1.C, SEP2, and CCC4.

Focus on providing students with feedback by targeting:

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

End of day 2

8. Navigation

2 MIN

Materials: None

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

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

9. Student Assessment Task

40 MIN

Materials: Science Notebook, *Task Parts 1 and 2: Eliminate Possible Conditions and Identify Missing Evidence*

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



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

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

Additional Guidance

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

Assessment Opportunity

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

10. Navigation

3 MIN

Materials: 1-2 sticky notes, Driving Question Board

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

Supporting Students in Making Connections in ELA

Students write an argument from evidence to explain why the evidence they selected serves as strong evidence that the condition is NOT causing M'Kenna's symptoms. This connects to the Common Core standard: **CCSS.ELA-LITERACY.WHST.6-8.1.B: Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.**

Students will be reflecting and adding onto their arguments over the course of several days throughout Lessons 7 and 8. This connects to the Common Core standard: **CCSS.ELA-LITERACY.W.6.10: Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.**

LESSON 8

What does the surface of M'Kenna's small intestine look like up close compared with a healthy one?

Previous Lesson

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

This Lesson

Investigation

2 DAYS





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

Next Lesson

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

Building Toward NGSS

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



What Students Will Do

Engage in an argument from evidence supported by scientific reasoning for how a healthy digestive system rearranges matter through chemical reactions and absorbs food, and how and why M'Kenna's digestive system is functioning differently.

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

What Students Will Figure Out

- Body systems are organized by System > Subsystems > Tissues > Cells.
- M'Kenna's intestinal wall surface is flat, and a healthy person's is folded back and forth (forming villi).
- Increased villi height results in more surface area that food molecules come into contact with as they flow through the small intestine; this results in a greater rate of absorption in a healthy small intestine than in M'Kenna's.

Lesson 8 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	3 min	**NAVIGATION** Remind students of their conclusion from Lesson 7 that they needed to collect more evidence about M'Kenna's symptoms to determine which of the possible diagnoses might be causing her symptoms.	A	
2	8 min	**MAP M'KENNA'S SYSTEM TO THE ORGANIZATION OF THE HUMAN BODY SYSTEM** As a class, create a visual map that connects M'Kenna's specific example to the general organization of the human body system.	B	*Zoomed-In Images of the Small Intestine*, chart paper, markers
3	8 min	**EXAMINE THE LINING OF THE SMALL INTESTINE** As a class, zoom into the lining of a healthy small intestine and discover that the finger-like structures, or villi, that line the small intestine are actually made up of cells.	C-D	*Zoomed-In Images of the Small Intestine*, chart paper from previous step, markers
4	20 min	**EXAMINE THE FUNCTION OF THE VILLI** In partners, run the NetLogo interactive simulation of flat versus tall villi in the small intestine. Collect and interpret data to determine the effects of flat versus tall villi on absorption of food molecules.	E-F	Simulation, (See the **Online Resources Guide** for a link to this item.), access to internet-enabled computer devices to run the NetLogo simulation *End of day 1*
5	12 min	**CONSENSUS BUILDING DISCUSSION ABOUT THE STRUCTURE AND FUNCTION OF THE SMALL INTESTINE** As a class, have a Consensus Building Discussion about what we've figured out so far about the structures of the small intestine and their functions.	G	*Connecting the Structure of Villi to Their Function*

Part	Duration	Summary	Slide	Materials
6	5 min	**UPDATE THE 3-COLUMN PROGRESS TRACKER** Students independently use what they have figured out so far in this lesson to update their 3-column Progress Trackers.	H	Progress Tracker, *Progress Tracker*
7	15 min	**ARGUE FROM EVIDENCE: DIAGNOSTIC TASK** Complete *Part 3: Argue from Evidence What's Causing M'Kenna's Symptoms*, which was started in Lesson 7. Argue from evidence which diagnosis (celiac) best explains why M'Kenna is experiencing her symptoms.	I	*Part 3: Argue from Evidence What's Causing M'Kenna's Symptoms*, *Peer Feedback Guidelines*, *Lesson 8 Self-Assessment: Giving and Receiving Feedback*
8	5 min	**REVISIT THE DRIVING QUESTION BOARD** Revisit the Driving Question Board in partners, noting questions on which we've made progress and providing evidence to support those answers. Identify questions that have not yet been answered as possible next steps.	J	*Revisit Questions from Our DQB!*
				End of day 2
		SCIENCE LITERACY ROUTINE Upon completion of Lesson 8, students are ready to read Student Reader Collection 3 and then respond to the writing exercise.		Student Reader Collection 3: *Digestion Chemistry*

Lesson 8 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• *Zoomed-In Images of the Small Intestine* • Science Notebook • A Look Inside the Digestive System (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) • Villi Absorption (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) • *Connecting the Structure of Villi to Their Function* • Progress Tracker • *Progress Tracker* • *Part 3: Argue from Evidence What's Causing M'Kenna's Symptoms* • *Peer Feedback Guidelines* • *Lesson 8 Self-Assessment: Giving and Receiving Feedback* • *Revisit Questions from Our DQB!*	• access to internet-enabled computer devices to run the NetLogo simulation	• chart paper • markers • chart paper from previous step

Materials preparation (20 minutes)

Online Resources



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

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

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

Test to make sure the simulation students will be using is working, following the directions in the student handout: *Connecting the Structure of Villi to Their Function*.

Lesson 8 • Where We Are Going and NOT Going

Where We Are Going

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

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

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

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

Where We Are NOT Going

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

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

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

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

LEARNING PLAN FOR LESSON 8

1. Navigation

3 MIN

Materials: None

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

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

2. Map M'Kenna's system to the organization of the human body system.

8 MIN

Materials: *Zoomed-In Images of the Small Intestine*, Science Notebook, chart paper, markers

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

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

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

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

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

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

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

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

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

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

*** Supporting Students in Developing and Using Structure and Function**

As students make observations about the photos, draw their attention to the structures they notice that make up parts of the lining of the small intestine. Encourage students to make their observations through the lens of structure/function relationships. To deepen students' connection of the structures they're observing with the functions that they might serve, pose the following question while students work on their Notice and Wonder charts: *Can you draw any connections between what you see in these images and what you saw when you looked at the endoscopy results in Lesson 2?*

3. Examine the lining of the small intestine.

8 MIN

Materials: *Zoomed-In Images of the Small Intestine*, Science Notebook, chart paper from previous step, markers

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

Show **slide C**.

Say to students, *We can call these finger-like structures "villi." Let's add this to our word wall.**

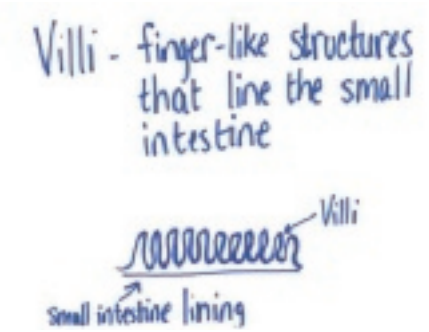
Add "Villi" to the systems mapping chart. Add the word "Villi" to the next line of the systems chart you started earlier, leaving the systems label blank for now. Return to sharing out what students notice and wonder about the villi. Listen for students who share that they can see smaller structures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

*** Attending to Equity**

When new scientific words, like "villi," are introduced, it can be helpful for Emergent Multilingual students to see a reference to those words added to a word wall.

Add these words to the word wall as they emerge in the discussion, rather than before.

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



Show **slide D**.

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

Suggested prompts	Sample student responses
What do you notice about the structure of the micrograph of the small intestine?	*It has smaller structures on it that are all lined up one next to the other.*
Have we seen similar structures before?	*Yes—we saw similar structures in a previous unit.*
What do you think we could call those smaller structures lining the small intestine?	*They look like the cells we've seen in the past, so we think we could call these cells, too!*

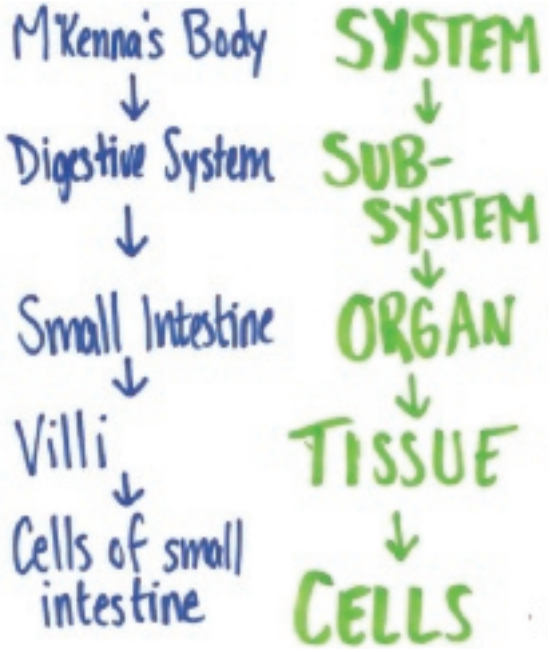
Add to the systems mapping chart. Write "Cells of the Small Intestine" under "Villi" on your systems mapping chart, leaving the systems label blank.

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

Add the word "Cells" and "Tissues" to the systems mapping chart.*

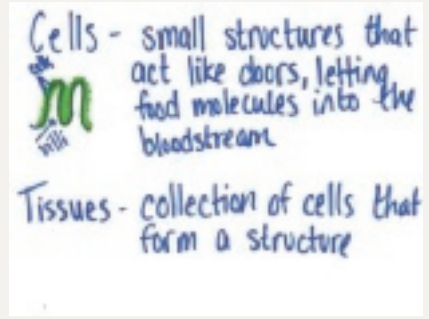
Say, *We just organized some really important information. Now we can see how the digestive system is made up of other, smaller parts, and those parts are made of other parts! The digestive system is a subsystem of the human body, but the parts of the digestive system are also subsystems. Each part of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

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



*** Attending to Equity**

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



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

4. Examine the function of the villi.

20 MIN

Materials: Science Notebook, digestive system and villi absorption interactives (See the **OnlineResources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**), access to internet-enabled computer devices to run the NetLogo simulation

Review what we know about M'Kenna's small intestine. Use the following prompts to help students recall what they know about M'Kenna's small intestine from looking at her endoscopy images compared with the images from a healthy small intestine. Students can go back to the computer simulation A Look Inside the Digestive System (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) Give students five minutes to examine the images independently, so they can jot what they notice and wonder in their Science Notebooks if they wish. Use the following prompts to motivate the use of Villi Absorption to understand how the height of the villi affects absorption of food molecules in the small intestine. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Show **slide E**.

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

*** Attending to Equity**

Students are not given templates for the creation of data tables or graphs in *Connecting the Structure of Villi to Their Function*, so they will have to draw upon prior knowledge of how to construct these to complete the task. Some students may struggle to initiate this task because they cannot recall a visual of what their data table might look like. For those students who are struggling to construct an organized data table, gather them in a small group and work together to co-construct a template for collecting data. Talk through each data point that students must collect as they run trials in the NetLogo interactive simulation so that you are sure students understand how and what to collect. As a group, determine the number of columns that will be needed and what labels are appropriate.

Once students have completed their trials and collected their data, look for students who are struggling to convert their data tables into graphs. In a similar fashion, invite struggling students into a small group. Discuss as a group what labels are appropriate

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

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

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

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

Instruct students to run a minimum of three trials, collecting data in their data tables. Then, have students complete the "Graphing Data" portion of *Connecting the Structure of Villi to Their Function* and answer the questions in the "Making Sense" portion.*

End of day 1

for the *x*- and *y*-axes, then discuss a scale that makes sense. You can use a sample data point to model how to plot a point on the graph, then have students complete the graphing independently at the table. Observe and support as needed.

*** Supporting Students in Engaging in Analyzing and Interpreting Data**
Students organize and use data collected in the NetLogo simulation to develop a graph showing the relationship between villi height and the rate of food absorption.

5. Consensus Building Discussion About the Structure and Function of the Small Intestine

12 MIN

Materials: Science Notebook, *Connecting the Structure of Villi to Their Function*

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

Instruct students to bring their Science Notebooks and the results of their data collection and analysis on *Connecting the Structure of Villi to Their Function*.

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

Key Ideas

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

Listen for these ideas:

- The height of the villi in the small intestine is directly related to the number of cells that allow food molecules to be absorbed into the bloodstream.

*** Attending to Equity**
Students will be asked to recall the information discussed in this Consensus Building Discussion when they make revisions to their 3-column Progress Trackers. To support all learners, keep track of ideas in a public space so that students are not forced to recall these ideas when they make revisions to their models.

*** Supporting Students in Developing and Using Structure and Function**
Through the NetLogo interactive simulation, students are able to

- Taller villi mean more cells, which means that there are more doors for food molecules to pass through.
- Absorption is happening in one direction, from inside the small intestine out into the bloodstream, so the dashed line in our consensus model, which implies multi-directional flow, needs to be revised to look more like one-way doors.
- We can assume that M'Kenna's villi are flat based on evidence from the simulation and the endoscopy images, and, therefore, have fewer cells, or doors, to allow food molecules into the bloodstream. The structure of M'Kenna's small intestine has a direct impact on her small intestine's ability to function as a healthy system would.
- M'Kenna likely has food molecules other than fiber and water in her poop because her villi are flat and not allowing for proper absorption of food molecules out of the small intestine and into the bloodstream.
  See some example discussion prompts below:
- What are some of the key things we figured out about the structures of the small intestine?
- What are some of the key things we figured out about the functions of those structures?*
- How does M'Kenna's small intestine compare with a healthy system?
- What is the role of the villi? What do the villi have to do with M'Kenna's symptoms?

visualize microscopic structures as they adjust the height, or shape, of the villi. As they change the villi height, or shape, they also recognize the impact that this change has on the function of the villi. They identify that the shorter the villi, the lower the rate of absorption of food molecules.

6. Update the 3-column Progress Tracker. 5 MIN

Materials: Progress Tracker, *Progress Tracker*

Use what we've figured out to update the 3-column Progress Tracker. Guide students to use the ideas that were shared during the Consensus Building Discussion to fill in their 3-column Progress Trackers. Show **slide H**.

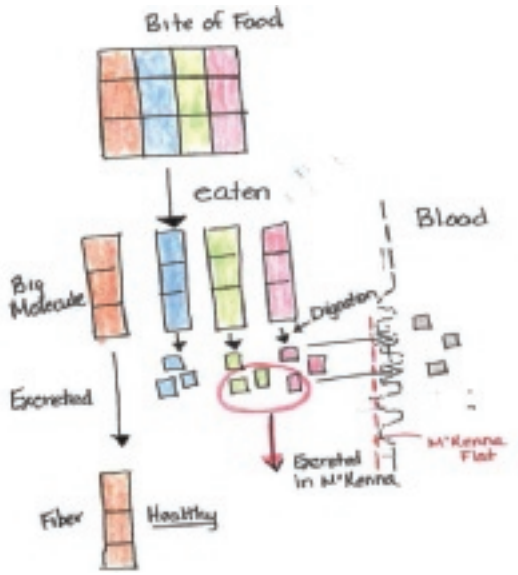


Here is one suggested representation.

Question	Source of evidence
8. What does the surface of M'Kenna's small intestine look like up close compared with a healthy one?	• NetLogo interactive simulation • Close-up images of the healthy villi

What I figured out in words/pictures

- The body is organized into systems and subsystems. So, body system > digestive system > small intestine > villi > cells of the small intestine.
- Absorption is happening in one direction, from inside the small intestine out into the bloodstream, so the dashed line in our Consensus Model, which implies multi-directional flow, needs to be revised to look more like one-way doors.
- Villi height is directly related to the number of cells there are to absorb food molecules into the bloodstream. So, taller villi equal more cells, which increases the rate of absorption.
- M'Kenna's villi are flat, and, therefore, have fewer cells, or doors, to allow food molecules into the bloodstream.
- Healthy villi are finger-like and have more cells to allow more food molecules into the bloodstream.
- M'Kenna likely has food molecules other than fiber and water in her poop because her villi are flat and do not allow for proper absorption of food molecules out of the small intestine and into the bloodstream.



7. Argue from evidence: diagnostic task.

15 MIN

Materials: *Part 3: Argue from Evidence What's Causing M'Kenna's Symptoms*, *Peer Feedback Guidelines*, *Lesson 8 Self-Assessment: Giving and Receiving Feedback*

Use Science Notebooks to argue from evidence for the diagnosis that is most likely causing M'Kenna's symptoms. *Part 3: Argue from Evidence What's Causing M'Kenna's Symptoms* can be completed independently in class or as home learning.

Home Learning Opportunity

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

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

Show **slide I**.

*** Supporting Students in Three-Dimensional Learning**

Students were initially given four diagnoses to choose from that could explain why M'Kenna is having specific symptoms. After narrowing down the diagnoses in Parts 1 and 2 of the Assessment Diagnosis Task, students must now compare the remaining diagnoses to determine which one best explains why M'Kenna is experiencing her symptoms. Students are using the SEP

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



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

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

engaging in argument from evidence by using the CCC structure/function to build towards the DCI LS1.A.

After students create an argument for which diagnosis best explains M'Kenna's symptoms, they compare each other's arguments and provide feedback that is used to revise their arguments.

Assessment Opportunity

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

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

Writing in Science



To support Writing in Science, some students may benefit from assistance as they prepare to organize their argument in writing. For those students who struggle with written organization, provide them with a structure built around sentence stems so that they can craft an argument that demonstrates their content knowledge without getting tripped up by organizational challenges.

You may provide something like:

M'Kenna's symptoms are being caused by _____.

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

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

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

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

Additionally, students can complete the rubric *Lesson 8 Self-Assessment: Giving and Receiving Feedback* to reflect upon the feedback they give to and receive from peers.

8. Revisit the Driving Question Board. 5 MIN

Materials: Science Notebook, *Revisit Questions from Our DQB!*



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

Home Learning Opportunity



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

Show **slide J**. Hand out *Revisit Questions from Our DQB!*

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

ADDITIONAL LESSON 8 TEACHER GUIDANCE

Supporting Students in Making Connections in Math

This lesson connects to several Common Core Math Standards, while students are using mathematical thinking during the NetLogo Simulation.

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

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.

Supporting Students in Making Connections in ELA

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

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

SCIENCE LITERACY: READING COLLECTION 3

Digestion Chemistry

1 **Digestive Aid Advertisements**
2 **Digestive System Products**
3 **Lactose Intolerance**
4 **Stones, Clay, and Plastic**
5 **Post-Surgery Diary**

Literacy Objectives

- ✓ Translate information in text to personal experience.
- ✓ Support a position on the function of the digestive system with reasoning and evidence.

Literacy Exercises

- Read varied text selections related to the topics explored in Lessons 6–8.
- Evaluate the reading selections according to provided prompts and criteria.
- Compare and contrast information gained from reading text with information gained from class investigation.
- Prepare a diagram of the digestive system in response to the reading.

Instructional Resources

Student Reader



Collection 3

Science Literacy Student Reader, Collection 3
"Digestion Chemistry"

Exercise Page



EP 3

Science Literacy Exercise Page
EP 3

Prerequisite Investigations

Assign the Science Literacy reading and writing exercise *after* class completion of this lesson group:

- Lesson 6: What happens to the different substances in food as it travels through the digestive system?
- Lesson 7: What is the function of the digestive system, and how is M'Kenna's digestive system different?
- Lesson 8: What does the surface of M'Kenna's small intestine look like up close compared with a healthy one?

Standards and Dimensions

NGSS

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

Disciplinary Core Ideas:

LS1.A Structure and Function

LS1.C Organization for Matter and Energy Flow of Organisms

Science and Engineering Practices: Asking Questions; Constructing an Explanation; Analyzing and Interpreting Data

Crosscutting Concepts: Systems and System Models; Structure and Function

CCSS

English Language Arts

RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

RST.6-8.6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.

Core Vocabulary

Core Vocabulary: Core Vocabulary terms are those that students should learn to use accurately in discussion and in written responses. During facilitation of learning, expose students repeatedly to these terms. However, these terms are not intended for isolated drill or memorization.

glucose

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about any concepts in this exercise. Students will benefit from your modeling the use of these words without the expectation that students will use or explain the words themselves.

gastrolith **gizzard** **insulin**
lactose **rennet**

A Glossary at the end of the Science Literacy Student Reader lists definitions for Core Vocabulary and selected Language of Instruction.

1. Plan ahead.

Determine your pacing to introduce the reading selections, check in with students on their progress, and discuss the reading content and writing exercise. If you are performing Science Literacy as a structured, weekly routine, you might implement a schedule like this:

- Monday: Designate a ten-minute period at the beginning of the week to introduce students to the assignment.
- Wednesday: Plan to touch base briefly with students in the middle of the week to answer questions about the reading, to clarify expectations about the writing exercise, and to help students stay on track.
- Friday: Set aside time at the end of the week to facilitate a discussion about the reading and the writing exercise.

You'll proceed with the in-class lesson investigations during this week.

Exercise Page



EP 3

2. Preview the assignment and set expectations. (Monday)

- Let students know they will read independently and then complete a short writing assignment. The reading selection relates to topics they are presently exploring in their Metabolic Reactions unit science investigations.
- The reading and writing will be completed outside of class (unless you have available class time to allocate).
- Preview the reading. Share a short summary of what students can expect.
  - *In "Digestive Aid Advertisements," you will find some examples of bad science and persuasive techniques that are used to make audiences believe misinformation about products related to digestive health.*

- *In the second selection, you'll read about products that use digestive system ingredients or components, including how cheese and sausage are made.*
- *"Lactose Intolerance" gives you information about the symptoms and cause of lactose intolerance and how many people have this condition.*
- *By reading the fourth selection, you'll learn about what animals can eat that they cannot digest.*
- *In "Post-Surgery Diary," you'll read about the symptoms that are indicative of digestive conditions and what happens when certain parts of the digestive system are removed.*

- Distribute Exercise Page 3. Preview the writing exercise. Share a summary of what students will be expected to deliver. Emphasize that Science Literacy exercises are brief. The focus is on thoughtful quality of a small product, not on the assignment being big and complex.
  - *For this assignment you will be expected to generate a diagram of the digestive system and label it with the function of each part of the system and related diseases.*
- Remind students of helpful strategies they can employ during independent reading. Offer the following advice:
  - *The reading should take approximately 30 minutes to complete.* (Encourage students to break reading into smaller sections over multiple short sittings if their attention wanders.)
  - *A good reading strategy is to scan through the collection first to see the titles, section headers, graphics, and images to see what the selections are going to be about before fully reading.*
  - *Next, "cold read" the selections without yet thinking about the writing assignment that will follow.*
  - *Then, carefully read the Exercise Page to understand the expectations for the writing part of the assignment.*
  - *Revisit the reading selections to complete the writing exercise.*
  - *Jot down any questions for the midweek progress check in class.* (Be sure students know, though, that they are not limited to that time to ask you for clarification or answers to questions.)

3. Touch base to provide clarification and address questions. (Wednesday)

Touch base midweek with students to make sure they are on track while working independently. You may choose to administer a midweek minute-quiz to give students a concrete reason not to postpone completing the reading until the last minute. Ask questions such as these, and have students jot answers on a half sheet of paper:

Suggested prompt	Sample student response
Why would people need digestive aids?	*Digestive aids can help calm upset stomachs. Some products are made to target gas and gas pain/bloating. Others are specific for lactose intolerance. Some digestive aids can keep your stomach in tip-top shape to prevent any issues from, say, eating spicy food.*

Suggested prompts	Sample student responses
What kinds of problems do people have with digestion?	*When people have digestive problems, they may burp, get gas, have diarrhea, or vomit. Or they might feel a lot of pain in the stomach. They might even lose weight because they cannot eat or continue to have diarrhea over a long period of time.*
Why can't some people eat dairy products, like ice cream, cheese, yogurt, or milk?	*Some people's ancestors come from places where there weren't a lot of cows, so perhaps they didn't develop a tolerance for dairy food and the lactase that it contains.*
What happens if something can't be digested?	*It gets vomited up or pooped out. If something is too big to move out of the body, it can be deadly.*
Can you live without your digestive organs?	*Some organs, like sections of the appendix or the entire gall bladder, can be removed, and people can continue to live full lives. Other organs that are removed need a transplant or artificial replacements because they are necessary for survival.*
What do chemical reactions have to do with digestion?	*The entire digestive system, from the mouth to the anus, is designed for physical churning and chemical reactions to break down food so that small food molecules get absorbed into the body for energy.*

Ask a few brief discussion questions related to the reading that will help students tie the text content to students' classroom investigations.

Suggested prompts	Sample student responses
How did doctors know M'Kenna was having problems with her digestive system?	*She was having nausea and vomiting and was losing weight. It was an ongoing problem.*
How was M'Kenna's digestive system different from a healthy system?	*M'Kenna's body was breaking down large food molecules, but not as many of them are broken down and not as many of the small molecules are absorbed as they are in healthy digestive systems.*

- Refer students to the Exercise Page 3. Provide more specific guidance about expectations for students' deliverables due at the end of the week.
  - *The writing expectation for this assignment is to create a diagram of the digestive system with each part of the system labeled with its name, its function, and a disease related to it.*

Exercise Page



EP 3

- *Do research to make sure that the diagram is complete and accurate. The research used should be credible and endorsed by people who know what they are talking about.*
- *The important criteria for the work are that the diagram is complete, clearly labeled, and accurate.*
- *Make the diagram engaging so that people your age remember it.*

- Explain that a great diagram will be easy to read and understand and have engaging graphics.
- Answer any questions students may have relative to the reading content or the exercise expectations.

4. Facilitate discussion.

(FRIDAY)

Facilitate class discussion about the reading collection and writing exercise.

The five reading selections in Collection 3 focus on the purpose and potential troubles with the digestive system. The previous collection provided information about the "good" bacteria throughout the digestive system. These are involved in the chemical reactions in the body that break down food so the body can digest it and absorb its molecules for energy. Collection 3 explores different types of digestive problems that can occur primarily due to disease. Symptoms range from an upset or uncomfortable stomach to nausea, diarrhea, vomiting, serious weight loss, and agonizing pain. This may result in the need to avoid certain foods, like dairy; the need to supplement the diet with digestive aids; the need to repair an organ; or the need to remove an organ.

Pages 24–25 **Suggested prompts**	**Sample student responses**
What is the general purpose of the first selection, "Digestive Aid Advertisements"?	*People have a lot of common problems with digesting food.* *There are a lot of companies that try to make money by making digestive aid products that offer remedies to these problems.*
What kinds of common digestive problems do people have?	*Gas, stomach pain, diarrhea, and burping are all common digestive problems.*
Why do people have digestive problems?	*overeating foods* *consuming foods that do not agree with them or that they are allergic to* *having a digestive-related condition or disease*
When should someone call the doctor if they are having digestive problems?	*if a digestive problem lasts for several days* *if a digestive problem is excruciatingly painful*

Student Reader



Collection 3

SUPPORT—If you are using the recommended word envelope convention, check the envelope to see if it contains any words, phrases, or sentences that students need help understanding. Read key sentences aloud, and provide concise explanation.

SUPPORT—Some students may not be familiar with the scientific terms *glucose, lactose,* and *enzyme.* Explain that lactose is a type of sugar found in dairy products. In a chemical reaction in the digestive system, lactose is changed by the enzyme lactase into glucose, a simpler sugar that is used by the body. Tell students that chemical names ending in *ose* are sugars and that those ending in *ase* are enzymes. For example, lactase is the enzyme that helps break down the sugar lactose.

Pages 26–27 Suggested prompts	Sample student responses
How does the second selection help you build knowledge on top of what you learned in the first selection?	*The digestive system is a vital body system.* *There are many products that are made from digestive organs or that aid digestion when the digestive system is and isn't working properly.*
What is glucose, and what does it have to do with the digestive system?	*Glucose is a simple sugar made by plants during photosynthesis.* *Glucose is the most important source of chemical energy in all organisms.* *Animals absorb glucose for use in chemical reactions as food containing glucose moves through the digestive system.*
What is diabetes?	*Diabetes is a disease in which the body can't use glucose as an energy source.* *Diabetes occurs when the pancreas does not produce enough insulin, which causes chemical reactions that enable glucose to be used as energy. Diabetes also occurs when there may be enough insulin but it can't get into cells.*

Pages 28–29 Suggested prompts	Sample student responses
What is the general purpose of the third article, "Lactose Intolerance"?	*This article defines lactose intolerance.* *It explains that people with lactose intolerance can experience a variety of digestive problems, including diarrhea, bloating, and nausea.*
What do bacteria and chemical reactions have to do with lactose intolerance?	*Lactase is an enzyme produced by bacteria that is essential to the complete digestion of dairy products.* *Through a chemical reaction, lactase breaks down lactose from milk so the body can use it as energy.* *People who don't produce the enzyme lactase in their small intestines have lactose intolerance.*

CHALLENGE—Challenge interested students to research how common digestive system diseases, such as diabetes, hepatitis, lactose intolerance, and cirrhosis of the liver, are. Have them share their findings with the class.

EXTEND—Have students watch a video about digestion. Follow up with a discussion about the entire digestive process.

Pages 30-31 Suggested prompts	Sample student responses
What is the general purpose of the fourth article, "Stones, Clay, and Plastic"?	*This article discusses the types of things that cannot be digested by animals (not due to a problem with the digestive system).* *Some animals eat stones and dirt that work in their bodies to break down food and carry out toxins.* *Animals also eat things like plastic waste, which they can't digest and that can be deadly.*
What do you think would happen if you ate something you couldn't digest?	*There have been many reports that children have ingested coins or other small objects, like rocks or marbles. These can't be digested.* *Most of the time, a person who swallows something that is inedible will either vomit it up or poop it out whole.* *If an object is sharp or toxic or is unable to come out on its own, it may have to be removed surgically.*

Pages 32-33 Suggested prompts	Sample student responses
What is the general purpose of the fifth article, "Post-Surgery Diary"?	*This article describes what happens when a person has gall bladder surgery to remove a diseased digestive organ.*
What digestive organs can you live without and never miss?	*Students may be able to offer observations from personal or family experience. The gallbladder and appendix can be removed without any major repercussions.* *If other organs are removed, because of cancer, pancreatitis, colitis, Crohn's disease, or other digestive disease, people may need an organ transplant or other means to do the work of organs, such as a colostomy bag.*

5. Check for understanding.

Evaluate and Provide Feedback

For Exercise 3, students should create a diagram of their own digestive system. They should research to create a complete and accurate diagram with labels, organ function, and related diseases. They should use graphics and images to make their diagrams appealing and understandable.

Use the rubric provided on the Exercise Page to supply feedback to each student.

LESSON 9

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

Previous Lesson

We mapped M'Kenna's body to the organization of the human body systems and zoomed in closer into the small intestine. We did an interactive simulation and learned that taller villi have more cells, so they are able to allow for more absorption. We used that model to construct an individual explanation for why M'Kenna's small intestine absorbs less small food molecules than a healthy person's.

This Lesson

Problematizing

1 DAY



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 into clusters related to the system to which they are connected. We revisit M'Kenna's Doctor's Note and realize that, although her symptoms started in the digestive system, there are still symptoms in other body systems. We add two big questions to the DQB: "How can a problem in one body system cause problems in other systems?" and "How are these different systems connected?"

Next Lesson

We will analyze trends in M'Kenna's weight and height data and look at images of weight loss over time. Then, we will read an article that says, when kids lose weight, the fat is being "burned." We will light different types of fats on fire to see what happens when they burn.

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

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

What Students Will 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.

Lesson 9 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	3 min	**NAVIGATION: WHICH QUESTIONS HAVE WE MADE PROGRESS ON?** Prepare to gather around the DQB and note which questions can be answered now and which questions still need more information.	A-B	*Revisit Questions from Our DQB!*, 5 sticky dots, Driving Question Board
2	15 min	**REVISE OUR DRIVING QUESTION BOARD** Students add new questions and reorganize their existing questions on the Driving Question Board.	C	index cards, tape, markers, Driving Question Board
3	10 min	**REVISIT M'KENNA'S DOCTOR'S NOTE** Look back at M'Kenna's symptoms and our systems mapping to think about which symptoms we understand and which ones we still can't explain.	D	*Symptoms and Systems*, *M'Kenna's Doctor's Note*, *Map M'Kenna's Symptoms to Her Body Systems*, chart paper, markers
4	10 min	**PROBLEMATIZE M'KENNA'S SYMPTOMS IN OTHER SYSTEMS**	E	chart paper, markers
5	2 min	**NAVIGATION**	F	
6	5 min	**ADD WHAT YOU'VE FIGURED OUT TO YOUR PROGRESS TRACKERS** Update the 2-column Progress Tracker with students to summarize what they've figured out in this lesson.	G	

End of day 1

Lesson 9 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• Science Notebook • *Revisit Questions from Our DQB!* • 5 sticky dots • index cards • tape • markers • *Symptoms and Systems* • *M'Kenna's Doctor's Note* • *Map M'Kenna's Symptoms to Her Body Systems*		• Driving Question Board • chart paper • markers

Online Resources



Materials preparation (10 minutes)

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

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

Gather materials for revisiting the Driving Question Board, such as index cards, markers, and tape. Make sure students can access *M'Kenna's Doctor's Note* and *Map M'Kenna's Symptoms to Her Body Systems*.

Lesson 9 • Where We Are Going and NOT Going

Where We Are Going

This lesson revisits students' initial questions about how body systems work together to help us grow and have the energy to do the things we want to do. In previous lessons, students developed the idea that there is a difference in the walls of M'Kenna's small intestine that keep her from absorbing food molecules at a healthy rate. This lesson begins to connect that difference to her experiencing symptoms in other systems of her body. This lesson helps the unit shift from just looking at the digestive system towards a bigger focus on the part of the NGSS element LS1.A: Structure and Function for how "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 (MS-LS1-3)".

Where We Are NOT Going

Students do not need to directly say how problems in M'Kenna's digestive system cause her to vomit and have stomach cramps; rather, they should connect the difference in the walls of her small intestine back to a change in the rate of absorption of food molecules.

LEARNING PLAN FOR LESSON 9

1. Navigation: Which questions have we made progress on?

3 MIN

Materials: Science Notebook, *Revisit Questions from Our DQB!*, 5 sticky dots, Driving Question Board

Review and share the questions that students think we have answered. Present **slide A**. Have students take out *Revisit Questions from Our DQB!* Have students read the questions they have made progress on, their answers, and supporting evidence aloud to a partner. Present **slide B** and have students mark, with sticky dots, the questions that they think we have made progress on.



Name: _____ Date: _____

Revisit Questions from Our DQB!

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

Question	Answer and Supporting Evidence

Additional Guidance

Revisiting the DQB helps students track the progress that the class is making toward answering questions that are important to them. This helps build and sustain student buy-in, keeps learning relevant to students, and can generate new questions that will motivate new investigations to conduct in the classroom.

2. Revise our Driving Question Board.

15 MIN

Materials: index cards, tape, markers, Science Notebook, Driving Question Board

Go public with our responses as to why we think we have made progress on these questions. Project **slide C**. Ask students to share which questions have the most dots. Then, have students explain how we have made progress on those questions. After several students share, pick a few students to be class scribes who will write down a consensus statement (from all of the responses) to stick on the DQB. Do this for 5-10 questions, depending on time.

Suggested prompts	Sample student responses
What questions have the most sticky dots?	*The questions about her digestive system!*
Can someone who put a dot on that question explain their evidence for why they think we have made progress on that question?	*Answers will vary.* *We made progress on this question because we now know that M'Kenna's small intestine is different than a healthy small intestine. We saw that her intestinal wall is flat. That means she can't absorb food molecules as fast as a healthy person can!*

Suggested prompt	Sample student response
Does anyone agree or disagree with what _____ said about how we have made progress on that question? Anything we want to add?	*I agree with _____ because, when we did the dialysis tube investigation, we saw that little openings or gates are needed to let food molecules through, and if there are fewer gates, M'Kenna isn't getting enough food molecules out of her small intestine and into her body.*

Take stock of questions we've answered, lingering questions, and new questions.

Say, *We have all of these lingering questions about her other symptoms and body systems. Let's take a few minutes to see if we need to reorganize our questions into any new clusters based on the system they seem to be connected to, and add new questions.*

Generate new questions for the Driving Question Board. Have students write new questions on an index card with large, bold writing so that everyone can see. Remind students to write only one question per sticky note. Ask students to briefly share their questions with the class before posting on the DQB.

Re-organize questions into groups. As students share, questions will naturally start clustering into similar types of questions. Once students have completed their sharing, ask them to identify the categories of questions and help them organize them into clusters by giving them a related "umbrella" question or category label. Students may move existing questions into these clusters.

Suggested prompts	Sample student responses
Now that we have shared what questions we've made progress on, what questions are we still wondering about?	*We didn't figure out about a bunch of her other symptoms, such as brain fog and how she isn't gaining weight!* *We know about the villi, but how are they connected to her other symptoms?*
What new questions do we need to add?	*Wait, why is she not growing? She's not getting enough food, but growing happens in your bones and muscles.*
Are there any questions we need to refine or revise?	*How does food turn into bone or muscle?* *How is digestion connected to those? Brain fog—how are the villi connected to her brain?* *What happens right after food gets into your body?*

Say, *Wow! We did a really great job of figuring out what is going on in M'Kenna's digestive system, but we still have several unanswered questions about her other symptoms and related body systems. Let's take a few minutes to look back at M'Kenna's original doctor's note and our mapping of the different body systems to see what we need to figure out next.*

Collect *Revisit Questions from Our DQB!* as a formative assessment for student questions.



Additional Guidance

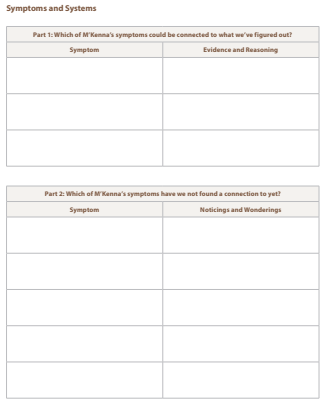
Collect *Revisit Questions from Our DQB!* Keep this handy as a tool to help students return to the DQB throughout the unit to maintain student buy-in. Students can periodically add questions they think we have made progress on during transition times, at the end of the beginning of lessons, or on substitute days. We will officially return to the DQB in the last lesson of the unit, but you can always head back there during lessons when you feel your students are not feeling like they are in the driver's seat or begin to lose connection to our driving question.

3. Revisit M'Kenna's doctor's note.

10 MIN

Materials: Science Notebook, *Symptoms and Systems*, *M'Kenna's Doctor's Note*, *Map M'Kenna's Symptoms to Her Body Systems*, chart paper, markers

Look back at M'Kenna's Doctor's Note. Project **slide D**. Hand out *Symptoms and Systems*. Have students look back (in their notebooks from Lesson 1) at *M'Kenna's Doctor's Note* and *Map M'Kenna's Symptoms to Her Body Systems* to think about which symptoms we understand and which ones we still can't explain.*



Symptoms and Systems

Part 1: Which of M'Kenna's symptoms could be connected to what we've figured out?	
Symptom	Evidence and Reasoning

Part 2: Which of M'Kenna's symptoms have we not found a connection to yet?	
Symptom	Noticings and Wonderings

*** Supporting Students in Developing and Using Systems and System Models**

To support students in system thinking around interactions, encourage students to look at the symptoms that started first and then at the symptoms that started later. Students should see that we have figured out more about the symptoms that originated in the digestive system. However, even though we have figured out more about what is going on in the digestive system, there must be interactions with other systems because M'Kenna is experiencing symptoms in other systems.

4. Problematize M'Kenna's symptoms in other systems.

10 MIN

Materials: Science Notebook, chart paper, markers

Share out noticings and wonderings from M'Kenna's Doctor's Note. Project **slide E**. Have students share out with the class using their noticings and wonderings from *Symptoms and Systems*.

Suggested prompt	Sample student response	Follow-up question
What do we notice about M'Kenna's other symptoms and systems?	*She feels tired and weak all the time and has an elevated heart rate and elevated breathing rate; she has stopped growing and is losing weight.*	*Does anyone want to respond to that idea?*

Suggested prompts	Sample student responses	Follow-up questions
What else are we wondering about?	*We know that the altered structures (flattened villi) in M'Kenna's small intestine are responsible for her celiac, which causes all of her symptoms. But it seems odd that such small structures could be causing so many problems.*	*So, let me see if I've got what you're saying. Are you saying that the villi seem to be such a small and insignificant part of a larger system, our digestive system; though now it seems like these tiny villi don't just affect digestion, but they can also affect the heart, brain, and growth?*
Can someone revoice what _____ said but make it into a more general question?	*How could something so small in one subsystem (the digestive system) have that much impact on other parts of the body?*	*Does anyone else agree with that question?*
How is this possible?	*There must be a connection maybe even too small to see with our eyes, from what is happening in the digestive system and the other systems.*	*What do people think about what _____ said?*
Can someone give me an example?	*It's weird that symptoms that don't seem to have anything to do with the digestive system (like brain fog) are caused by a disease that impacts the digestive system (villi).*	*Say more, please. . . .*
And how do you think this is happening?	*There must be something important that we can learn from the food molecules that can't get through that is needed by the other systems.* *It does seem like the digestive system is affecting other systems. I wonder how these different systems are connected?*	*It sounds like we might need to add those big, overarching questions to our DQB.*

Post the new "big" questions to the DQB. Write the following new questions on a piece of paper or directly on the DQB: "How can a problem in one body system cause problems in other systems?" and "How are these different systems connected?"

Additional Guidance

Students will not directly be able to diagnose M'Kenna's symptoms (which goes beyond performance expectations for this grade band). However, students should be able to recognize that the difference in M'Kenna's small intestine villi causes her to have a lower rate of food molecule absorption. Lower food molecule absorption could be a probable cause for symptoms connected to the digestive system.

5. Navigation

2 MIN

Materials: None

Turn and talk with a partner about what students are wondering now. Project **slide F**. Walk around and listen to partner talk. Ask a couple of students to share out their wonderings with the class.

Suggested prompts	Sample student responses
What else are we wondering about now?	*What is going on with her growth?* *What is happening with her weight?* *How can celiac be causing all of these other symptoms?*
Which one of those symptoms do we want to figure out next?	*Maybe why she is losing weight which might be because it seems like her small intestine isn't taking in or absorbing all the food molecules that it should.*

Say, *If she's not getting food molecules through her small intestine, that could make sense that she would be losing weight. Let's start there and see if we can figure this out.*

6. Add what you've figured out to your Progress Trackers.

5 MIN

Materials: Science Notebook

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



While this is not a time to grade student responses, this is an opportunity to formatively assess how well student understanding is moving towards the idea that the structure of villi in M'Kenna's digestive system are not functional, and this is affecting her other body systems because they interact with one another.

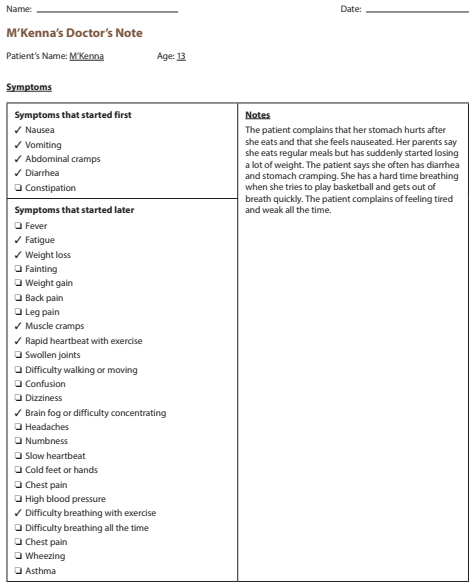
Have students add these ideas to their Progress Trackers using words and pictures.

Additional Guidance

This is a time for students to individually think about what is happening inside the digestive system. It is important that they describe their own current understanding of what is happening within M'Kenna's digestive system. Students should also be encouraged to use both words and pictures to describe their thinking.

In the example Progress Tracker row for this lesson, each of the columns has been completed with ***possible*** student ideas.

Question	What I figured out in words/pictures
9. How can a problem in one body system cause problems in other systems?	We think M'Kenna's problem with not getting food molecules absorbed through her small intestine (digestive system) might be causing problems in her other systems like brain fog, fatigue, and not gaining weight.



Name: _____ Date: _____

M'Kenna's Doctor's Note

Patient's Name: M'Kenna Age: 13

Symptoms

Symptoms that started first

- ✓ Nausea
- ✓ Vomiting
- ✓ Abdominal cramps
- ✓ Diarrhea
- ❑ Constipation

Symptoms that started later

- ❑ Fever
- ✓ Fatigue
- ✓ Weight loss
- ❑ Fainting
- ❑ Weight gain
- ❑ Back pain
- ❑ Leg pain
- ✓ Muscle cramps
- ✓ Rapid heartbeat with exercise
- ❑ Swollen joints
- ❑ Difficulty walking or moving
- ❑ Confusion
- ❑ Dizziness
- ✓ Brain fog or difficulty concentrating
- ❑ Headaches
- ❑ Numbness
- ❑ Slow heartbeat
- ❑ Cold feet or hands
- ❑ Chest pain
- ❑ High blood pressure
- ✓ Difficulty breathing with exercise
- ❑ Difficulty breathing all the time
- ❑ Chest pain
- ❑ Wheezing
- ❑ Asthma

Notes

The patient complains that her stomach hurts after she eats and that she feels nauseated. Her parents say she eats regular meals but has suddenly started losing a lot of weight. The patient says she often has diarrhea and stomach cramping. She has a hard time breathing when she tries to play basketball and gets out of breath quickly. The patient complains of feeling tired and weak all the time.

LESSON 10

Why is M'Kenna losing so much weight?

Previous Lesson

We revisited the Driving Question Board (DQB) to see our progress. We reorganized our DQB cluster questions by body system and revisited M'Kenna's Doctor's Note to look at her symptoms in other body systems. We added two big questions to the DQB: "How can a problem in one body system cause problems in other systems?" and "How are these different systems connected?"

This Lesson

Investigation

2 DAYS





We analyze trends in M'Kenna's weight and height and look at images of weight loss over time. It looks as though the fat is disappearing, which makes us wonder, where is the fat going? We read an article that says, when kids lose weight, the fat is being "burned." We wonder if this is the same "burning" as when we light something on fire. We do an experiment and light different types of fats on fire, weigh them, and compare their properties before and after they burn. We see that they seem to disappear too! This makes us wonder, what is happening to fat when it burns?

Next Lesson

We will conduct two investigations to trap the gases produced by burning food. We will use the results of these investigations to figure out that food needs to undergo a chemical reaction with oxygen to release energy and that carbon dioxide gas and water vapor are products of that process.

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 using graphical displays and statistics to identify temporal relationships to provide evidence for how M'Kenna's pattern of body growth and weight have changed over time compared with typical children her age.

Obtain, evaluate, and communicate information to determine the central ideas in an article to help determine where fat (matter) goes when people lose weight.

Plan and carry out an investigation to produce data to serve as the basis for evidence to answer the question, Where does matter go when people lose weight?

What Students Will Figure Out

- When a person/animal loses weight, fat seems to go away. Some say that, when you lose weight, you "burn" fat.
- When different types of fat are ignited with a flame and allowed to burn, their masses decrease.
- We also notice that the properties of the fats are different after they have been burned.
- Because of these pieces of evidence and our prior knowledge about chemical reactions, this makes us think that a chemical reaction is happening when fat is burned.

Lesson 10 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	7 min	**NAVIGATION** Facilitate an Initial Ideas Discussion to orient students to the lesson question.	A-B	
2	10 min	**IDENTIFY PATTERNS IN M'KENNA'S WEIGHT** Analyze M'Kenna's growth chart, which shows evidence of her recent weight loss. Identify from where M'Kenna is likely losing weight—most of which is from her fat.	C	*Patterns in M'Kenna's Weight*
3	10 min	**BUILDING UNDERSTANDINGS** Facilitate a discussion for students to share their analysis from their "What I see" and "What it means" statements.	D-E2	
4	15 min	**WHERE DOES FAT GO WHEN LOST?** Students read an article that says that kids burn fat when they lose weight. We wonder about how this "burning" applies to our bodies.	F-H	*Children Need More Fat in Their Diets Compared to Adults*
				End of day 1
5	5 min	**INTRODUCE FAT BURNING INVESTIGATION**	I-J	*What Happens to Fat When It Burns?*
6	8 min	**ANALYZE NUTRITION LABELS** Students analyze nutrition labels of duck fat and vegetable oil to see what substances they contain.	K	
7	7 min	**PREPARE FOR INVESTIGATION AND DEMONSTRATE WICK BURN**	L	

Part	Duration	Summary	Slide	Materials
8	20 min	**CONDUCT THE FAT BURNING INVESTIGATION** Have students burn different types of fat and notice what happens as time goes on.	M	*Fat Burning Lab Protocol*, Fat Burning Investigation
9	5 min	**PROGRESS TRACKERS AND HOME LEARNING** Have students work on the "Making Sense" questions, if time permits, and assign the rest of them for home learning to share out at the start of the next period.	N-O	Progress Tracker

End of day 2

Lesson 10 • Materials List

	per student	per group	per class
Fat Burning Investigation materials	• safety goggles	• ½ cup vegetable oil in a cup • 1 pipette • 2 prepared wicks • 6oz of duck fat in a cup • 1 plastic knife • 1 long-reach lighter • 2 small foil tins	• digital scale
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• *Patterns in M'Kenna's Weight* • *Children Need More Fat in Their Diets Compared to Adults* • Science Notebook • *What Happens to Fat When It Burns?* • *Fat Burning Lab Protocol* • Progress Tracker		

Materials preparation (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.

If your classroom has a no-flame policy, you can show students these videos, and they can make their observations and make sense from the data they collect while watching what happens when fat is burned.

(See the **Online Resources Guide** for links to these items. **www.coreknowledge.org/cksci-online-resources**)

Day 2: Burning Fat Investigation

- **Group size:** Four students per group.
- **Setup:** Gather materials for lab. Prepare materials as suggested in the video and the instruction steps below. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

1. Prepare vegetable oil: Pour ½ cup of 100% vegetable oil into an 8 oz cup. Label the cup "vegetable oil." Make 1 cup per group. Make these ahead of time for all groups. The leftover oil can be reused in between classes because each group only needs about 1 tablespoon of oil.

2. Prepare duck fat: Scoop 6 tablespoons of duck fat into an 8 oz cup. Leave a plastic knife in the cup. Label the cup "duck fat." Make one cup per group. This should last for six class periods.

Online Resources





3. Prepare wicks for students to test the duck fat and oil samples: Cut wicks down so that the top of the wicks stands 0.5-in. tall. Prepare two wicks per group, plus a few extra for the class demonstration.



- **Notes for during the lab:** Preparing the duck fat samples can get messy. You may want students to wear gloves when preparing these samples. Knives work better than spoons for preparing the duck fat samples. Also, sometimes the wax from the wick can drip into the vegetable oil when it is burning. If students note that the oil is hardening, double check that it's not actually the wax.
- **Safety:** Make sure you have an area in which you and the students can safely conduct the burn tests in parts 1 and 2. If you and the students do these burn tests in lab, make sure they are on non-flammable lab tables. The amount of smoke and ash that will go into the air is minimal, but you should let your front office know that you are burning things in lab today and make sure that you have temperature-based, rather than smoke-based, fire detectors in lab. If you are concerned about any of these, you can relocate this lab to be done along a concrete surface outside. Again, let your front office know of this before you take students outside. Be sure to have a fire extinguisher available.
- **Disposal:** Allow the fats to cool completely after burning. Then, put them into a non-flammable container (e.g., a coffee canister) and place in the garbage. You can also put the oil and duck fat into a freezer to cool before disposing. The small foil trays can be saved and reused.
- **Storage:** All non-perishable items can be stored for later use at room temperature. Opened oil can be stored on a shelf for one year. Duck fat can be stored in the refrigerator or on a shelf for six months, and leftover amounts should be disposed of in the garbage.

Lesson 10 • Where We Are Going and NOT Going

Where We Are Going

Though students may still have lingering ideas that matter can disappear when it is burned, this lesson will provide additional evidence that maybe something else is happening to it namely, that it is transformed through a chemical

reaction, and the products are going into the air. At this point, it is not important that students identify the products that go into the air, just that their masses decrease. Because we know from previous background that matter can't be destroyed, the matter must be going somewhere.

In prior units, students learned that substances have properties that do not change, such as color, odor, and state of matter. They learned that, in chemical reactions, the atoms that make up the molecules of the old substance break apart and rearrange to form new molecules made of the same atoms but in different arrangements; these new substances have new properties, such as color, odor, and state of matter. They also learned that chemical reactions can release or absorb energy from the surroundings. These ideas are revisited in this lesson and in Lessons 11 and 12.

Where We Are NOT Going

When these molecules break apart and the atoms in them rearrange to form new substances (different molecules), energy is released into the surroundings. Students do not need to know about bonds breaking and forming in this process.

LEARNING PLAN FOR LESSON 10

1. Navigation

7 MIN

Materials: None

Look back and review M'Kenna's unexplained symptom of weight loss. Present **slide A**. Have students turn and talk to the person next to them about what the class has figured out.

Suggested prompts	Sample student responses	Follow-up questions
What did we figure out last class?	*We went back to our DQB to take stock of what we've figured out so far. When we did that, we realized that we didn't have a good explanation of most of her non-digestive symptoms. We thought we could figure out why she was losing so much weight.*	*What do we still have to figure out?*
Which symptom might be the easiest to figure out next?	*why she was losing so much weight*	*Why do you think that?*

Sharing the Initial Ideas Discussion about weight loss. Present **slide B**. Look at M'Kenna's Doctor's Note and remind students that, in the previous session, we decided we still couldn't explain M'Kenna's weight loss. Have students talk to a partner about their initial ideas of why she might be losing so much weight. Have students go public with a couple of initial ideas.



Key Ideas

Purpose of this discussion: Elicit students' initial ideas about what could be causing M'Kenna's weight loss to see if students are able to connect to what was figured out in Lesson Set 1 with her not getting 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.

Listen for these ideas:

Accept all answers. Potential ones listed below.

- M'Kenna isn't getting enough nutrients from food.
- She's throwing up a lot because the food is making her sick.
- Her body is using her fat because when you don't eat a lot, your body loses fat, and you lose weight.

Say, *We have some ideas about what's causing her weight loss, but we need to investigate it more. I have access to M'Kenna's actual weight and height growth charts. Let's take a look at them together.*

Additional Guidance

Weight can be a tricky topic to address in middle school. Some students may be sensitive to learning about weight gain and weight loss, so be mindful of your students' feelings throughout the course of this lesson. Figuring out weight gain and weight loss using unusual examples (e.g., M'Kenna's condition, ultra-athletes, stranded on an island) or nonhuman examples can lessen the anxiety this topic may bring for your students.

2. Identify patterns in M'Kenna's weight. 10 MIN

Materials: *Patterns in M'Kenna's Weight*

Orient students to M'Kenna's height and weight charts. Say, *All we know up to this point is that M'Kenna is losing a lot of weight, but we don't know exactly how much weight or how quickly she's losing it. Some of you mentioned wanting to know more about how much weight she has lost. Doctors also record your weight and height when you visit them. Let's check out M'Kenna's growth and weight chart from her doctor.*

Hand out *Patterns in M'Kenna's Weight* to each student. Ask students if they've ever seen their own height and weight chart from their annual well checks or physicals. Have students explain what they already know about why doctors take these measurements, and how they can help determine a person's overall health from the numbers.

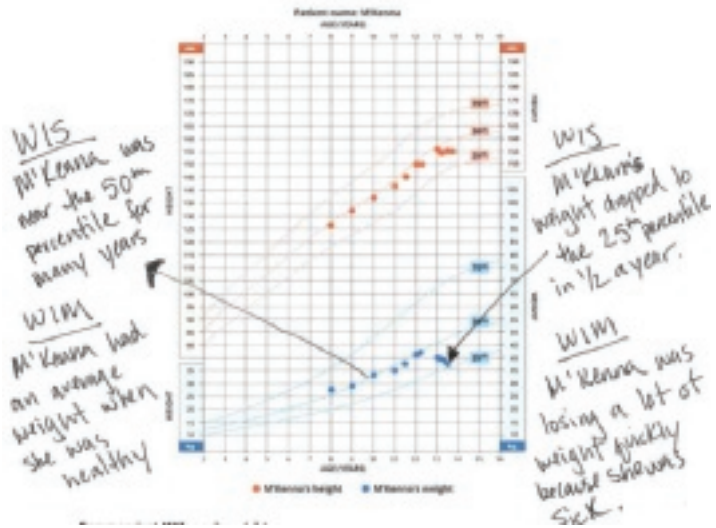
Listen for student ideas such as these:

- *If you stop growing, you might be sick.*
- *They can tell when you have a growth spurt.*
- *If your weight changes a lot, they might think you're sick.*

*** Supporting Students in Engaging in Analyzing and Interpreting Data**

Introduce the idea of statistics to students when analyzing this graph. Give students a brief explanation of percentiles to help them in their data analysis of the growth charts. Explain to students that the 50th percentile means that 50% of kids weigh less than M'Kenna, and 50% weigh more. If she is on the 50th percentile line, she is right in the middle, or

Focus students on the weight chart and set aside the height chart for now. Show students how to read percentiles and make note to students that the weight scale is in kilograms (kg) and not pounds (lbs).* See *Key: Patterns in M'Kenna's Weight* for more guidance on student responses.



Give students time to analyze and interpret the weight graph individually. Prompt students to write "What I see" (WIS) statements first. Remind students to write directly on the graphs, drawing arrows to their observations. After a few minutes, encourage students to transition from WIS statements to "What it means" (WIM) statements. If students are not sure about their WIM statements, they can bring those questions to their groups to figure out.

median, in terms of weight for her age. Median means that, if M'Kenna is one of 100 kids, 50 of them would weigh more than M'Kenna, and 50 would weigh less. Do the same for 75th percentile and 25th percentile. Add the term "median" to your word wall if students are not familiar with it already.

Arrange students into groups to share their analysis. Ask students to compare their WIS and WIM statements with one another. If students want to add to their graphs as they hear their group members share, encourage them to do that. If students could not write WIM statements to explain their observations, ask groups to work to construct WIM statements together. Prompt groups to first discuss the questions at the bottom of the handout. When they are ready, they can write a response. Encourage students to bring any questions or confusions to the whole-group discussion that follows.

3. Building Understandings

10 MIN

Materials: None

Make sense of the patterns in the data as a whole group. Bring students back together in a whole group. Present **slide D** and facilitate a Building Understandings Discussion. Probe a bit deeper as students share their explanations (WIM) to help them articulate their thinking.

Key Ideas

Purpose of this discussion: Prompt students to share at least one WIS and WIM pairing from their analysis to draw out patterns in M'Kenna's weight before she got sick and how it has changed. Ask students to think about what part of M'Kenna's body is losing the weight after looking at **slide E1** and/or **E2**. This problematizes the next piece of this lesson because it looks like the fat is just going away from the pictures, which begs the question, So where does fat go when someone loses weight?

Listen for these ideas:

- M'Kenna's weight has been going down in the last year.
- Her weight loss has been occurring rapidly.
- The man/dog has more fat before.
- The fat spots got smaller and smaller.
- The muscle stayed the same or increased.

Continue to project **slide D** and use the suggested prompts below.

Suggested prompts	Sample student responses
What was the pattern in M'Kenna's weight before she got sick (ages 8-12)?	*She was around the 50th percentile every year.*
How did M'Kenna's weight pattern change? If M'Kenna's weight continues on the new pattern, where do you expect her weight to be at age 14?	*She dropped to the 25th percentile in a year (or less). At age 14, she might weigh 35 kg when she should weigh 55 kg if she was in the 50th percentile.*
If M'Kenna was your patient and you saw this change in her weight pattern, would you be alarmed? Why or why not?	*Yes, because her weight changed so much so fast.*
Even though we didn't focus on her height, did you notice any patterns in her height that you would be alarmed about as well?	*Yes, she is not growing taller anymore either!*

Brainstorm where M'Kenna's weight is going. Ask students to think about what part(s) of M'Kenna's body is losing the weight. Elicit a few initial ideas from students (e.g., students might mention fat or muscle). Present **slide E1** and/or **slide E2**. Tell students that this imaging shows a man's body (or a dog's body) over time as the man/dog has lost weight.



Ask students to take a moment to identify how the body tissue has changed when the man/dog lost weight. Where did the stuff that was lost come from? Where did the stuff go? Ask students to share their ideas.

Additional Guidance

The imagery used on these slides is an enhanced form of x-ray traditionally used for bone density scans. It's called dual-energy x-ray absorptiometry (DEXA). In recent years, DEXA has been used to identify fat tissue for weight loss purposes. We have provided a human example (**slide E1**) and an animal alternative (**slide E2**). Select which slide you prefer most; you only need to present one of them to your students.

Say, *OK, so we think M'Kenna could be losing weight, and it's coming from fat on her body. Why is she losing this fat? How does the fat get out of her body? It can't just disappear, even though that's what it looks like in the pictures. Where does the weight go?*

4. Where does fat go when lost?

15 MIN

Materials: *Children Need More Fat in Their Diets Compared to Adults*

Motivate students to want more information about where fat goes when lost. Present **slide F**. Have students discuss the question on the slide with a partner.

Suggested prompt	Sample student responses
Where do you think the fat goes when someone loses weight?	*Maybe it come out in your poop.* *Maybe you sweat it out.* *We don't really know!*

Say, *Those are interesting ideas! I have an article that talks about fat in our bodies and maybe it will give us some clues as to where fat goes when it's lost.*

Introduce the article. Hand out copies of *Children Need More Fat in Their Diets Compared to Adults*.

Tell students, *We were just looking at one source of fat in the slides, but in this article there are two sources of "fat" discussed. The two types of fat are: (1) "body fat" or fat on our bodies and (2) "dietary fat" or fat molecules that come from the foods we eat. Not all of our body fat comes from eating fat molecules. This article talks about both types of fat on our bodies as well as the fat that kids and adults need to eat.*

Present **slide G**. Have students read the article twice. The first time you should: (1) have students read silently and circle words that they don't know and try to get the main idea or gist of the article, while you circulate among students to assist any struggling readers and (2) on the second readthrough, tell students that the goal is to answer these three questions on the slide with a partner.

Key Ideas

The purpose of reading this article is to plant the idea that one way people use fat is to "burn" it. It's likely that students have heard of burning fat or burning calories when you exercise, but what does that really mean? Is it actually like burning when you light something on fire? That's what we want students to be thinking after reading it.

Present **slide H**. After students have finished their second reading of the article, have students share their responses with a partner while writing the answers to the prompts.



Suggested prompt	Sample student response
According to the article, how do adults and children use fat differently? According to the article, which age group needs the most fat?	*Kids use fat for "normal growth processes" like bone development and making proteins. They need extra calories for growth and development. Adults aren't growing like kids are, so they don't need as much fat.*

Suggested prompts	Sample student responses
How did that affect their recommendations for the amount of fat in a person's diet?	*Babies and toddlers need the most fat. Then older kids need a little more and adults need the least amount of fat in their diets.*
What did the researchers find with children who were 8 years old on average?	*The kids burned more body fat than adults did.*
What do you think they mean by "burned"?	*Like using it, or I'm not really sure.*
Do you think they could mean like really "burn"? Like when you light something on fire?	*I don't think so, but maybe?*
Has anyone ever tried to literally burn fat, light it on fire? What happens?	*No, I've never tried that!* *Or I've seen fat burn when watching my parent grill. I saw that it looked like it melts and kind of disappears a little or gets smaller.*
Since everyone hasn't lit fat on fire, would you like to try it so we can all see what happens?	*Yeah! Let's do that tomorrow.*

End of day 1

5. Introduce fat burning investigation.

5 MIN

Materials: science notebook, *What Happens to Fat When It Burns?*

Have students recall what we decided last class. Present **slide I**. Help students recall that we were wondering about what happens to fat when it burns. At the end of class we wanted to try to light some fat on fire and see what happens to it.

Present **slide J**. Have students brainstorm with a partner the types of fat we should try to burn.

Suggested prompt	Sample student response
What types of fat do you think we should burn?	*Answers will vary.*

Say, *Those are a lot of interesting ideas. It's probably a good idea to burn a couple of different types of fat. I have one type of animal fat and one type of vegetable fat. Let's see what happens with those.**

*** Attending to Equity**
If students have suggestions of types of fat to burn other than vegetable oil and duck fat and can bring them into class, you can incorporate these ideas into the investigation. Make sure these suggestions are 100% fat and don't have other ingredients.

Alternate Activity

If your classroom has a no-flame policy, you can show students these videos, and they can make their observations and make sense from the data they collect by watching what happens when fat is burned.

- Burning the Wick Alone - 7.3 Metabolic Reactions Lesson 10 Video 1 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)
- Oil Burning on a Scale - 7.3 Metabolic Reactions Lesson 10 Video 2 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)
- Duck Fat Burning on a Scale - 7.3 Metabolic Reactions Lesson 10 Video 3 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Say, *Before we burn these types of fat, we should make sure they are solely made up of fat, so we know exactly what we are burning.*

6. Analyze nutrition labels.

8 MIN

Materials: None

Analyze the nutrition labels. Project **slide K**. Show students the two nutrition labels for duck fat and vegetable oil.

Suggested prompts	Sample student responses
What are these two foods made up of?	*The vegetable oil's only ingredient is soybean oil. The animal fat is duck fat.*
Do they contain other substances besides fat?	*No! The total fat column is broken down into other types of fat, but they are all still fats.*
Do they both have any calories?	*Yeah, they have kind of a lot of calories in 1 tablespoon.*
What does having calories mean to you?	*Calories provide you with energy to do things. That's why you have to eat—to have energy to play sports or dance or move around.*
OK, we think that, when foods have calories, they can give you energy. So food gives us energy somehow to do the things we want to do.	*It seemed to be going down.* *It seemed to be going away.*
When we looked at M'Kenna's weight chart or the images of the man/dog losing weight, what seemed to be happening to the fat?	*It seemed to be disappearing.*
This made us wonder, what IS happening to fat when it seems to go away or, like the article said, when the fat is "burned?" In this experiment when we literally burn fat, how could we keep track of the matter? Is there a way we could measure how much matter we have before and after burning?	*Yeah, we could weigh it before and after.*

7. Prepare for investigation and demonstrate wick burn. 7 MIN

Materials: None

Prepare students to make observations. Tell students that we will burn three different items to help us figure out what happens to different types of fat when it burns.

A. the burn of the candlewick alone

B. the burn of vegetable oil (with the help of a candlewick)

C. the burn of the duck fat (with the help of a candlewick)

Distribute copies of *What Happens to Fat When It Burns?*. Project **slide L** and have students set up the observation table for the investigation. Give students three minutes to build the data table shown on the slide in their Science Notebooks.

Demonstrate burning the candlewick alone. Gather students around a demonstration area. Take a 0.5 inch tall piece of candlewick with a metal anchor and place it in the bottom of an empty tea candleholder. Ask students where they have seen these used before.

Place the tea candleholder with the wick into the foil tray. Foil trays can be saved and reused.

Alternate Activity

If you are not able to burn items in your classroom, you can use this series of videos to show your students and collect data from.

- Burning the Wick Alone - 7.3 Metabolic Reactions Lesson 10 Video 1 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)
- Oil Burning on a Scale - 7.3 Metabolic Reactions Lesson 10 Video 2 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)
- Duck Fat Burning on a Scale - 7.3 Metabolic Reactions Lesson 10 Video 3 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)



Ensure student safety. Have students get safety goggles and put them on. Then have students make a circle around the demonstration table and stand at least four feet away from it (for safety and so everyone can see). Ignite the wick. It will burn relatively quickly. Have students write their observations down. Once the wick burns up, provide a brief explanation.

Say, *This wick has a little bit of wax on it, too, which serves as fuel for a bit. How many of you have noticed that wax melts in a candle as the candle burns? Some fuels, like wax, melt first, and then are absorbed into a wick before they can burn. Notice in this situation, though, that the fuel was used up pretty quickly because, once the wick and wax are burned up, the flame goes out, so the wick itself doesn't provide much energy to the system.*

Additional Guidance

This demonstration is included because some students think that only the wick is burning when you burn the wick and the vegetable oil. The purpose of this demonstration is to show students that the wick does burn, but only briefly. In the next part, students will see that the wick will burn, but the continued burn is fueled by the vegetable oil.

Demonstrate how to set up the burn of fats (with the help of a candlewick).

1. Take a new 0.5 inch tall piece of candlewick with a metal anchor and place it in the bottom of an empty tea candleholder. Place the candleholder with the wick in the foil pan.



2. Fill an eyedropper all the way up with vegetable oil and squirt this into the bottom of the candleholder. Repeat this a couple of times, until half of the wick is covered.



Say, *You may have noticed that I am covering half the wick with oil. I am doing this because I want to make sure that the bottom of the strings that the wick is made of is touching the oil so that the wick can absorb the oil, like a paper towel would or like wax in a candlewick.*

Alternate Activity

The Fat Burning Investigation in the next activity section is set up so that students can do this section in small groups. However, you can also do the entire investigation as a whole class demonstration, if that better suits the needs of your students or the safety regulations of your school.

Tell students that this is how they will need to prepare their candleholders with the vegetable oil when they do the lab.

8. Conduct the fat burning investigation. 20 MIN

Materials: Fat Burning Investigation, *Fat Burning Lab Protocol*

Discuss the lab procedure and safety considerations. Ask students to read through the procedure in *Fat Burning Lab Protocol*. Then lead a short discussion by asking students to identify and share important safety considerations with the whole group that they recognize are important to be vigilant about in this particular investigation.

Sample safety considerations

- *Keep our goggles on the whole time.*
- *Stay at least 3 ft away from any of the materials we are testing after we ignite them.*
- *Don't test any materials other than those identified in this procedure.*

Project **slide M**. Ask students if there are any questions.

Additional Guidance

The vegetable oil will burn for a long time if you don't blow it out (more than 10 minutes).

Monitor students as they complete parts 1 and 2 of the investigation. The small foil tins, ½ cup vegetable oil, and 6 oz of duck fat can be reused between classes. Remind students to return to their seats to complete the questions in part 3 of the investigation.



Assessment Opportunity

To students who are having difficulty with the "Making Sense" questions in part 3, you could ask additional questions like, "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?"

9. Progress Trackers and Home Learning 5 MIN

Materials: Science Notebook, Progress Tracker

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

Question	What I figured out in words/pictures
What happens to fat when it's burned?	• When we burn different types of fat, the mass seems to go down! • The properties of the vegetable oil and duck fat change before and after they are burned. • We think this indicates that a chemical reaction is actually happening to the fat.

Assign the rest of the "Making Sense" questions in part 3 for home learning. Present **slide O**.

Home Learning Opportunity



Tell students to complete the questions in part 3 for home learning if they did not finish them in class. The next lesson will start with them reviewing these questions.

ADDITIONAL LESSON 10 TEACHER GUIDANCE

Supporting Students in Making Connections In Math

The growth chart analysis activity provides an opportunity to connect to math in several ways, for example, by engaging students in statistics, interpreting a numerical display of data, using graphical trends to predict future data points, and converting between units of measure (kg to lb). There's a connection to **CCSS Math 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."**

Supporting Students in Making Connections In ELA

When students read through the article twice, they have an opportunity to improve their overall comprehension of the text. The teacher frames the reading to help students focus in on the main idea. Then, in the first reading, students can sort out words or phrases that are unfamiliar and may distract from their ability to attend to the overall meaning of the text. The second reading provides students with an opportunity to refocus their attention on specific questions so that they can provide answers, citing evidence from the text. There's a connection to **CCSS ELA RST.6-8.2: "Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions."**

LESSON 11

What happens to matter when it is burned?

Previous Lesson

We analyzed trends in M'Kenna's weight and height and looked at images of weight loss over time. Then, we read an article that says, when kids lose weight, the fat is being "burned." We wondered if this is the same "burning" as when we light something on fire. We lit different types of fats on fire and saw that they seemed to disappear too!

This Lesson

Investigation

2 DAYS



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 use the results of these investigations to figure out that food needs to undergo a chemical reaction with oxygen to release energy and that carbon dioxide gas and water vapor are products of that process. We wonder if this reaction could happen inside our bodies.

Next Lesson

We will gather multiple sources of evidence to argue that a chemical reaction is occurring to burn food inside the cells of our body. We will consider the purpose of the reaction and analyze activity data to see that, if the activity level changes, then this chemical reaction will happen more or less depending on how much energy our cells need.

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

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.

What Students Will Figure Out

- When food is burned, it goes through a chemical reaction that releases energy.
- Fats require oxygen to release energy.
- When a fat or food reacts with oxygen to release energy, carbon dioxide gas and water vapor are products of that process.

Lesson 11 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	7 min	**NAVIGATION** Facilitate a discussion around the responses to the questions from the *What Happens to Fat When It Burns?* activity to support an argument from evidence that a chemical reaction is occurring and that some of the products of that reaction are going into the air.	A	*What Happens to Fat When It Burns?*
2	10 min	**PLAN AND CONDUCT A CLASS DEMONSTRATION TO CAPTURE THE PRODUCTS FROM BURNING FAT** Have students brainstorm how we could capture the products of the reaction to examine them more closely. As a whole class, conduct the demonstration comparing the masses of a closed and an open system before and after burning vegetable oil, with students recording the weight of the systems before and after a burn.	B-C	tape, Burning Fat in Open and Closed Systems lab
3	8 min	**BUILDING UNDERSTANDINGS DISCUSSION: BURNING FAT IN OPEN AND CLOSED SYSTEMS** Facilitate a Building Understandings Discussion to help students argue that (1) some matter must be going into the air; (2) the flame in the closed system went out sooner than the one in the open system because it ran out of something in the air that it needed; and (3) liquid appeared on the sides of the closed-system container walls when the burn was done, and this liquid might be water.	D	*Burning Fat in Open and Closed Systems*
4	4 min	**ANALYZE DATA TO DETERMINE WHAT IS IN AIR** Students analyze data for the composition of air.	E	
5	10 min	**PLAN AND CONDUCT A CLASS DEMONSTRATION TO MEASURE THE CHANGING GAS CONCENTRATIONS WHEN BURNING FAT** Show students how to construct part of the data table and make predictions about how the amount of gases in the air within the closed system will compare before and after a burn. Conduct the investigation by burning vegetable oil in a closed system, but this time, track the carbon dioxide and water levels and have students record the results. Discuss and record what the results show.	F-J	*Burning Fat in Open and Closed Systems*, Burning Fat in Closed Systems and Measuring Gases lab

6	5 min	**MAKE SENSE OF OUR CLOSED VERSUS OPEN SYSTEM RESULTS** Have students explain how this data compares to what they saw when they were tracking different types of molecules in the graphs of the food we ate as it moved from the mouth and into the stomach, and how this also connects to the claim that they made at the start of the lesson. Students also summarize any clues the claim gives them about what might be happening to food inside our bodies and M'Kenna's body when it is used for energy, or whatever new questions this raises for them.	K	*Making Sense of Burning Fat Investigation Results*
				End of day 1
7	10 min	**NAVIGATION** Have students review the responses to the "Making Sense" questions that they recorded in their science notebooks from the last class to discuss what happens when food burns.	L-M	*Making Sense of Burning Fat Investigation Results*
8	10 min	**CONSENSUS DISCUSSION ABOUT WHAT HAPPENS TO MATTER WHEN IT'S BURNED** Facilitate a Consensus Discussion around the ideas raised in groups in the previous step.	N	discussion norms poster, chart paper, markers
9	5 min	**ANALYZE NUTRITION LABELS TO DETERMINE IF OTHER FOODS PROVIDE ENERGY** Students compare the nutrition labels of carbohydrates and proteins to fat to look for evidence of calories.	O	
10	5 min	**COMPARE CARBON DIOXIDE AND WATER TO FOOD MOLECULES** Students revisit structural representations of food molecules that decreased when burning fat in a closed system and compare that with structural representations of air molecules that increased. The molecular representations serve as evidence to explain that a chemical reaction is occurring between air and food when it releases energy.	P-Q	*Air Molecule Reference*
11	10 min	**ADD TO OUR PROGRESS TRACKERS** Pull students together to update their Progress Trackers to reflect all of the ideas that students have figured out over the last two lessons that help answer the question, "What happens to matter when it is burned?"	R	*Progress Tracker*, markers, chart paper
12	5 min	**NAVIGATION** Ask students to brainstorm what sort of additional evidence we would need to figure out if a similar kind of chemical reaction is happening in our bodies to provide us with energy from food.	S	
				End of day 2
		SCIENCE LITERACY ROUTINE Upon completion of Lesson 11, students are ready to read Student Reader Collection 4 and then respond to the writing exercise.		Student Reader Collection 4: *Burning Calories*

Lesson 11 • Materials List

	per student	per group	per class
Burning Fat in Open and Closed Systems lab materials	• safety goggles		• 2 digital balances (with a range going up to at least 500 g with 0.01 g accuracy or better) • 2 tea candle holders • 1 pipette (for vegetable oil) • 1/2 cup vegetable oil • timer • long-handled lighter or matches • 2 candle wicks on a metal stand (trimmed) • tape • airtight container with sealing lid
Burning Fat in Closed Systems and Measuring Gases lab materials	• safety goggles		• long-handled lighter or matches • 1 pipette (for vegetable oil) • 1 candlewick on a metal stand (trimmed) • ½ cup of vegetable oil • scissors or hobby knife • 4.75 quart Pyrex bowl with rimmed plastic lid • detector for both carbon dioxide and humidity • tape
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• *What Happens to Fat When It Burns?* • science notebook • tape • *Burning Fat in Open and Closed Systems* • *Making Sense of Burning Fat Investigation Results* • *Air Molecule Reference* • *Progress Tracker*		• discussion norms poster • chart paper • markers

Materials preparation (75 minutes)

Online Resources



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.

Let your front office know that you are burning materials in the lab and make sure that you have temperature-based, rather than smoke-based, fire detectors in the lab.

If your class has a no-flame policy, you can show students these videos: closed versus open system (See the **Online Resources Guide** for a link to this resource. **www.coreknowledge.org/cksci-online-resources**), and measuring the gases (See the **Online Resources Guide** for a link to this resource. **www.coreknowledge.org/cksci-online-resources**), and they can make their observations and make sense from the data they collect by watching what happens when fat is burned.

Day 1: Burning Fat in Open and Closed Systems Lab

- **Setup:**
  - Lay out and test the lab materials as suggested in this video and as outlined in this teacher guide. (See the **Online Resources Guide** for a link to this resource. **www.coreknowledge.org/cksci-online-resources**)
  - **Per class:** Make 2 tea candle holders containing 0.5-inch wicks (as you did in Lesson 10) and 3 mL of vegetable oil.
- **Notes for during the lab:**
  - Make sure that your balance can hold at least 500 g and is accurate to 0.01 g.
  - You can cut *Burning Fat in Open and Closed Systems* in half so students get Part 1 and 2 separately.



Safety: Make sure you have an area in which you can safely conduct the burn tests. If you do these burn tests in class, make sure they are on non-flammable lab tables. The amount of smoke and ash that will go into the air is minimal, but let your front office know that you are burning things in lab today and make sure that you have temperature-based, rather than smoke-based, fire detectors in the lab. If you are concerned about any of these, you can relocate this lab to be done along a concrete surface outside. Again, let your front office know of this before you take students outside. Be sure to have a fire extinguisher available.

- **Disposal:** Allow the fats to cool completely after burning. Then, put them into a non-flammable container (e.g., a coffee canister) and place in the garbage. You can also put the oil into a freezer to cool before disposing.
- **Storage:** All non-perishable items can be stored for later use at room temperature. Opened oil can be stored on a shelf for one year.

Day 2: Burning Fat in Closed Systems and Measuring Gases Lab

- **Setup:**
  - Lay out and test the lab materials as suggested in this video and as outlined in this teacher guide. (See the **Online Resources Guide** for a link to this resource. **www.coreknowledge.org/cksci-online-resources**)
  - Cut a small slot in the lid of the Pyrex bowl so that the cord of the carbon dioxide and humidity detector can just fit through. (See the photo on the next page.)

- Make sure to test the carbon dioxide and humidity detector. It should turn on automatically and show readings for each condition.
- **Per class:** Make 1 tea candle holder containing a 0.5-inch wick (as you did in Lesson 10) and 3 mL of vegetable oil.



Safety: Make sure you have an area in which you can safely conduct the burn tests. If you do these burn tests in the lab, make sure they are on non-flammable lab tables. The amount of smoke and ash that will go into the air is minimal, but let your front office know that you are burning things in lab today and make sure that you have temperature-based, rather than smoke-based, fire detectors in the lab. If you are concerned about any of these, you can relocate this lab to be done along a concrete surface outside. Again, let your front office know of this before you take students outside. Be sure to have a fire extinguisher available.

- **Disposal:** Allow the fats to cool completely after burning. Then, put them into a non-flammable container (e.g., a coffee canister) and place in the garbage. You can also put the oil into a freezer to cool before disposing.
- **Storage:** All non-perishable items can be stored for later use at room temperature. Opened oil can be stored on a shelf for one year.

Lesson 11 • Where We Are Going and NOT Going

Where We Are Going

In the Scope and Sequence, the chemical reactions units addressing NGSS PEs MS-PS1-1, MS-PS1-2, MS-PS1-3, MS-PS1-5, and MS-PS1-6 come before this unit. In that prior instruction, students learned that the atoms that make up the molecules of the old substance break apart and rearrange to form new molecules made of the same atoms, only in different arrangements; these new substances have new properties, such as color and odor. Students learned that chemical reactions can release or absorb energy from the surroundings. These ideas are reinforced and built upon in Lessons 5-7, 10, and 11.

While in previous lessons students may have had lingering ideas that matter can disappear when it is burned, this lesson provides evidence that matter does not disappear in the chemical reaction during the burning process. This is due to the conservation of mass in a closed system. This also confirms that a chemical reaction has occurred due to the production of two gases—carbon dioxide and water (vapor).

This lesson solidifies the two ideas identified in the *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 undergoes a chemical reaction with oxygen that releases stored energy—can emerge. (page 196)" This lesson also motivates students to think about how, by the end of grade 8: ". . .in most animals (and plants), oxygen reacts with carbon-containing molecules (sugars) to provide energy and produce carbon dioxide" (page 148).

Where We Are NOT Going

In this lesson, students put together that food molecules have carbon, hydrogen, and oxygen atoms connected together. When food molecules break apart, the atoms in them rearrange to form new substances (different molecules), and energy is released to the surroundings. However, students do not need to know about bonds breaking and forming in this process, as this is above grade level. Additionally, this lesson and unit do not address the rearrangement of matter by plants. This will be addressed in the next Unit 7.4.

This lesson addresses the conservation of matter after a chemical reaction. It explicitly confirms that, if these reactions occur in a closed system, the mass of the entire system does not change. In order to remain in the middle-school grade band, students are not asked to balance equations. As stated in the assessment boundary of NGSS MS-PS1-5: "Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces."

LEARNING PLAN FOR LESSON 11

1. Navigation

7 MIN

Materials: *What Happens to Fat When It Burns?*

Ask students to share their ideas from the *What Happens to Fat When It Burns?* Begin class by presenting **slide A** and having students share out their responses from Lesson 10.

Say, *Last time we burned vegetable oil and duck fat and saw that, after several minutes of burning, the mass of both fats decreased. Look back at your responses to Part 3: Making Sense from What Happens to Fat When It Burns? and pick one question to explain your reasoning to your group before we share out as a class.*

Suggested prompts	Sample student responses	Follow-up questions
Based on the property changes you observed, what can you explain about what happened to the fat in these containers beyond just saying "they burned"?	*A chemical reaction must have occurred.* *Energy was produced because we saw the light and felt the heat.*	*Can someone remind me what we mean when we say "chemical reaction"?*
Compare the mass of each container before and after each fat burned. If matter can't disappear, how can you explain the patterns in your data?	*If the mass of the container went down, that must mean the amount of fat is going down.* *The mass went down because some stuff probably went into the air.*	*Say more about what you mean by "stuff went into the air."*
What clues does this give you about what might be happening to food inside our bodies and M'Kenna's body when it is used for energy? Or, what new questions does this raise for you?	*(Answers may vary. Accept all responses.)*	*Who can add on to the idea that _____ is building?* *Was anyone else also thinking of that question?*
We said stuff might be going into the air when fat is burned, and that might be the reason the mass was going down. But how would we know if this was true? What evidence could we collect to prove this was happening?	*Maybe we could see something going into the air when stuff is being burned. Like sometimes we see some black stuff.* *Maybe we could collect stuff going into the air or capture it somehow.*	*How would doing that help us?* *How would that help answer our question if something is going into the air?*

Summarize students' questions. *Say, Wow! Our investigations seem to have led us to have even more questions. How exciting! These are really interesting ideas about what might be happening when we burn fat. We have thought about the mass decreasing, a chemical reaction occurring, and energy being produced! Let's take a few minutes to revise our investigation to help us figure out even more about what happens in the air when fat is burned.*

2. Plan and conduct a class demonstration to capture the products from burning fat. 10 MIN

Materials: Burning Fat in Open and Closed Systems lab, science notebook, tape

Brainstorm how to redesign the investigation to capture what is produced from burning the oil. Project **slide B**. Read the slide and have students turn and talk with a partner for a minute. Then ask for a few students to share their ideas with the whole group:

Suggested prompts	Sample student responses
What are some ideas that you and your partner had for redesigning this investigation?	*We could try to trap the air around the thing we are burning in a container (or bag).**
	We need to make sure that we can seal the bag or container so that nothing can get in or out of the system.
What are some things we will need to keep similar?	*We will need to put everything on the balance.*
	We will want to use the same oil, wick, and little containers.
	We need to make sure to take the mass at the beginning and end of the investigation.

Motivate the need to conduct a controlled experiment. Prompt students to think about whether we could do this investigation with only an experimental group (the closed system).

Suggested prompt	Sample student responses	Follow-up questions
If we redid the burn investigation with just a closed system, would that be enough for us to be able to tell anything?	*Yes, because we did an open-system burn last class.*	*How would we tell if there is actually a difference in our closed system when doing it this time? What would we compare to our closed system?*
	No, I disagree. If we just used a closed system, it wouldn't be enough to draw any conclusions.	

Additional Guidance

You may want to introduce the idea of running a **control condition**, which is a useful thing to do when conducting investigations, so that you have something to compare your results to. Emphasize that the open system is our control condition because a good control group should have results that are known. We know from previous experiments that the mass will decrease in the open system. What we are wondering is if matter is going into the air and if the mass will change in a closed system, so that's our experimental group.

*** Supporting Students in Developing and Using Energy and Matter**

Students may refer back to closed-system experiments that they may have done in their prior work during the Chemical Reactions units. Emphasize that closed-system experiments allow scientists and engineers to trap all the matter in the system so that they can verify that the matter is conserved in physical and chemical processes. Later in this lesson, students will make the connection that, as energy is transferred as light and heat during a chemical reaction, matter is literally moving into the air.

Have students discuss the following questions.

Suggested prompts	Sample student responses
How could we measure if something is coming out in the closed and open systems?	*We could do the same thing as last time, and measure how much they weigh before and after they burn.*
What would that tell us?	*We could see if the weight lost between the open and closed system are the same or different. It would tell us if something is going into the air if the mass stayed the same in the closed system. It also might tell us if a chemical reaction is happening.*
Turn and talk with a partner. What do you predict would happen? Why?	*We think the same thing would happen as last time with the open system. The mass should decrease. But I think the mass might stay the same in the closed system because I think something new is being produced and going into the air.*

Suggest that we try to set this kind of condition up, take some measurements from it, and see whether that helps us figure anything out.

Say, *So, some of us think that the fat could be going into the air and some of us are really interested in trying to "capture" the stuff around the fat before and after it burns. Let's see if doing closed- and open-system experiments helps us figure out where the fat is going when the mass of the fat (oil) decreases when burned.*

Have students set up their data tables. Present **slide C**. Hand out copies of *Burning Fat in Open and Closed Systems* and have students tape it onto a new page in their science notebooks.

Have students label the first row of the table in part 1 as an OPEN system and the second row of the table as a CLOSED system.

Safety Precautions



Ensure student safety by:

- Have students get safety goggles and put them on.
- Then have students collect their science notebooks and chairs and make a circle around the demonstration table. They should sit at least four feet away from it (for safety and so that everyone can see). Emphasize that the energy release in the demonstrations can be dangerous if they get too close.
- Students will be at a common demonstration area for the remainder of this investigation, which is why having seats with them will be helpful.

Perform the demonstration of the open and closed system burns as a class.

1. Take out two tea candle holders with vegetable oil and wicks already in them. Tell students that each has vegetable oil in it.



2. Zero the first electronic balance. Mass the tea candle holder, oil, and wick assembly. Have students record this initial mass of the open system in their data tables.

3. Light the wick and set the timer for 1.5 minutes. Leave the open system on the balance. Let this burn while setting up the closed system. Then record the mass of the open system.



4. Place a loop of tape on the back side of the lid of the airtight container. Stick the second tea candle holder assembly to this loop of tape on the lid. This helps secure the tea candle holder assembly to the lid so that it doesn't slip and spill when you seal the lid on the container. Light the wick. Have another person place the clear part of the airtight container over this.



5. Once the lid is seated into the container, press the button on the lid (which is now on the bottom) to seal the system.



After you press the button on the bottom of the lid should look flat.



6. Zero the second electronic balance. Then mass the entire closed system container with the food (vegetable oil) burning in the tea candle holder. Wait a few seconds for the numbers to stop changing and for the system to equalize on the balance. Have students record the initial mass of the closed system in their data tables. Leave the container on the balance.



7. In 1-2 minutes, the vegetable oil in the closed system will burn out. Have students start taking qualitative observations of this system and record them and the mass of the system now (it should have remained unchanged). Have students record the final mass of the closed system.
8. Suggest that we keep letting the oil burn for another couple of minutes and see whether we notice any mass changes (or additional mass changes, as it will have already probably dropped by 0.1- 0.2 g by now). While this is happening, have students make additional observations of the closed-system container and record anything else interesting that they notice in it. After burning for about 4 minutes, blow out the flame and have students record the final mass of the open system.



Additional Guidance

This electronic balance goes to the 0.01 g. It is very sensitive to movement (even of the air). If the mass seems to be fluctuating, have the students stand back and make sure they are not touching the table or moving air around. If you notice the mass start to increase, give the balance a few seconds to get to an amount and stay there before recording the mass. If mass continues to fluctuate, take the entire system off the balance, zero it, and place the system back on. You should get the same mass as when you started.

Alternate Activity

Students may suggest to let the wick-oil assembly continue to burn on the balance. This will get hot but it is OK to do and will support students in connecting the idea of the mass decreasing with the amount of fat decreasing.

3. Building Understandings Discussion: Burning Fat in Open and Closed Systems

8 MIN

Materials: science notebook, *Burning Fat in Open and Closed Systems*

Have students develop explanations for their results. Students can now remove their safety goggles, but have them keep them out for the next investigation.

Project **slide D**. Tell students that you are assigning pairs of students to Turn and Talk about one of three questions—A, B, or C—and then report what they discussed in a couple of minutes to the whole group.

Count off pairs of students standing next to each other, "A, B, C, A, B, C. . ." Then have students find another student with the same letter. Give student pairs two minutes to discuss their question.*

*** Attending to Equity**
Depending on the needs of your students, you can determine if students should be in homogeneous ability groups or heterogenous (mixed) ability groups. Alternatively, you could have students find a partner who is different from them in some way—perhaps a person who attended a different elementary school or has a different type of hair.

Additional Guidance

If nothing appears on the sides of the closed-system container, just count off pairs to discuss questions A and B. There should be some water condensation that appears, which is a product of burning oil. It's OK if it doesn't come up here. Students will see evidence of the humidity increasing in the next experiment.

Facilitate a Building Understandings Discussion. Have students who discussed question A share an idea that they heard their partner share. Encourage all students to work with and build off their ideas, adding on, offering alternate explanations, or restating the ideas shared so far. Give a couple of minutes to discuss each of the questions (six minutes total).



Key Ideas

Purpose of this discussion: Prompt students to share out what they think their results from burning fat in open and closed systems mean. Students should notice and wonder about why the flame went out so quickly in the closed system. This problematizes the next piece of the lesson during which students try to figure out what is being produced from this chemical reaction.

Listen for these ideas:

- The mass of the closed system did not change because we were able to trap whatever was going into the air. The open system mass still went down.
- The flame in the closed system went out sooner than the one in the open system because it ran out of something in the air that it needed.
- Liquid appeared on the sides of the closed-system container walls when the burn was done, and this liquid might be water.

*** Attending to Equity**
Some students will probably know that fires need oxygen to burn from prior background knowledge, even though we don't have empirical evidence for this yet. It is OK if students don't say it is oxygen and just say air. We will look at data in Lesson 12 that shows levels of oxygen going down and being used in this chemical reaction.

Suggested prompts	Sample student responses
A. When burning the fat, why did the mass of the closed system remain stable, while the mass of the open system changed?	*In the open system, the stuff that used to be in the fat went into the air and spread out around the room, which is why the mass of the system decreased. So, since the mass decreased, that must mean the amount of fat left in the tea candle holder decreased.* *But even if stuff went into the air in the closed system, we had it trapped, so we could still detect its mass inside the container.*
B. Why did the flame in the closed system go out so much sooner than the one in the open system?	*It ran out of air.* *It ran out of oxygen.** *The oxygen got used by the fire.* *There wasn't enough oxygen left for the fire to keep burning.*
C. What did you see in the air and on the sides of the closed-system container walls when the burn was done? What do you think that substance might be?	*(Accept all responses, such as water, smoke, condensation, etc.)*

Assessment Opportunity

This is a midway point in building towards the Lesson Level Performance Expectation of "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 produces carbon dioxide and water) to describe why the mass of oil burned in an open system changes but in a closed system stays the same." Students should be able to compare the different experimental systems and explain that the open system changed because matter was going into the air, but the mass of the closed system stayed the same because we were able to trap the matter; instead of leaving the system, the matter stayed in the container, and thus could be read by the scale. If students do not make this connection, have them draw where they think the matter went in both the closed and open systems.

Motivate students to look more closely at what is in the air around us.

Suggested prompts	Sample student responses
Why do you think the flame went out in the closed system but stayed lit in the open system?	*The fire in the closed system probably ran out of air, but the open system could use as much air as it needed.*
So I hear you saying that, even though there was still fat (oil) in the container, the flame went out quickly in the closed system. Did I get that right?	*Yeah, the flame went out because fire needs air (or oxygen), and it ran out of it in the closed system.*
So is oxygen the only thing in the air? *OR* *What do you think is in the air that the fire needs?*	*I'm not totally sure.*
Do you know everything that's in the air?	*I think there is dust. I'm not really sure of everything that's in the air.*
How could we find out what's in the air?	*Maybe someone has a list of what's in the air.*

Say, *I've got some data that shows the most common substances found in the typical air around us. Let's take a look and see what we find.*

4. Analyze data to determine what is in air.

4 MIN

Materials: science notebook

Notice and wonder about the gases in air. Project **slide E**. Ask students if they recognize any of these gases shown in the table on the slide and what they know about them. Then ask which of the atoms in the chemical formulas for these gases are ones we have encountered before in our investigations.*

Suggested prompts	Sample student responses
What do you notice and wonder about the gases typically found in air?	*There are a lot of different gases in the air!* *Wow! There is so much nitrogen, 78%.* *The humidity can vary. What does that mean?*
Which of these gases have you heard of before?	*Nitrogen, oxygen, carbon dioxide, water vapor.* *I haven't heard of argon; what is that?*
Notice the symbols for the atoms that make up the molecules, N, O, C, H, Ar. Which of these symbols have we seen in our previous investigations?	*N, O, C, H.*
Does anyone recall what atoms those symbols stand for?	*nitrogen, oxygen, carbon, hydrogen*

*** Attending to Equity**
Depending on where you are located, students may be able to make connections to either low or high humidity based on familiarity with their local community. This is an opportunity to have your students come to a consensus definition to describe how much water is in the air and add to your word wall using their personal experiences with water vapor (or lack thereof) in the air.

Additional Guidance

Some students may notice that the possible percentages for water vapor in the air can range from 0 to 4 percent; but if it was 4 percent, then the other numbers wouldn't add up to 100 percent. If this arises, emphasize that this is a good noticing and important mathematical thinking. Ask students what they think will happen to the other percentages of other gases in the air, in conditions in which the water vapor in the air reaches 4 percent. Students should say that these will drop.

Problematize what we could do to figure out what gases are changing in the air when burning fat.

Suggested prompts	Sample student responses
So, we think that this reaction might need oxygen from the air. We think that gases went into the air, which might be a result of the reaction. We think they did because the mass of the closed system did not change.	*I don't know?! Maybe nitrogen?* *Could oxygen also go into the air?* *Carbon?*
So, what gases do you think went into the air when we burned the food?	
How could we figure out what gases went into the air?	*Remember when we wanted to know what food molecules were in different foods? We used something (an indicator) to help us see molecules that were there but were too small to see. Is there something like that for gases in air?*

Say, *I have a device that can detect a couple of the gases in the air. We can use this to measure the changes in the amount of gases in the air as a result of burning the oil. Let's try this test again.*

5. Plan and conduct a class demonstration to measure the changing gas concentrations when burning fat.

10 MIN

Materials: Burning Fat in Closed Systems and Measuring Gases lab, science notebook, *Burning Fat in Open and Closed Systems*

Introduce the second investigation system. Tell students that we will do the test again for just a closed system, following a similar procedure, but this time, we will use a tool to measure the gas levels in each system so that we can see whether the amounts are changing.*

Make predictions for the second investigation system. Project **slide F**. Emphasize that there are detectors that can detect other types of gases, too, but this detector can only detect a subset of them (carbon dioxide and water vapor). If students wonder, "Isn't it important to see if there are any changes in N_2 or argon?" say that the detector you have can only measure CO_2 and water, but maybe they could think of a way to measure N_2 or argon in our classroom.

*** Supporting Students in Engaging in Planning and Carrying Out Investigations**
Optional: If time permits, press your students to explain how you could run a control condition for this experiment. Students may suggest running the detector with an open system (with the glass bowl off and burning the same wick-oil assembly) or leaving the bowl on top and running the detector without burning a wick-oil assembly.

Give students a minute to fill in the first column of the part 2 data table shown on the *Burning Fat in Open and Closed Systems* handout for the substances they have been investigating: something from the air, oil/fat, water vapor, and carbon dioxide.

Then project **slide G**. Demonstrate how to make predictions in column A by filling out what we think happens to the amount of something needed from the air in a sealed container as the flame burns and eventually goes out.

Ask students what they predict will happen to the mass of the food as it burns. Students will say, *It decreases*. Emphasize that, since we all agree on this prediction, we should fill in the first column with a down arrow ↓.

Safety Precautions

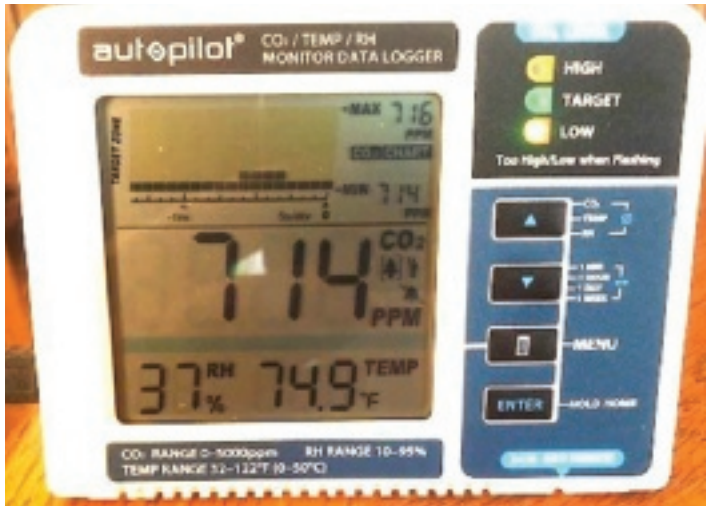


Ensure student safety.

- Have students put their safety goggles back on.
- Students should still be in a circle around the demonstration table at least four feet away from it (for safety and so that everyone can see).

Take the initial measurements of the air and food in the closed system. If your school has a no-flame policy, play Burning in a Closed System - 7.3 Metabolic Reactions Lesson 11 Video 4 (See the **Online Resources Guide** for a link to this resource. **www.coreknowledge.org/cksci-online-resources**).

Add a tea candle holder with a wick. Then put it on the electronic balance. Zero the balance. Add oil using a pipette until the bottom of the wick is covered. **Record the initial mass of the tea candle holder assembly with the oil.**



Show students the carbon dioxide and relative humidity detector. Show **slide H** to reference the different parts of the detector.

Tell students that we will be recording the values for the carbon dioxide and water vapor (humidity) in the air now and after the burn.

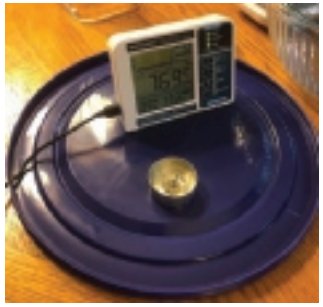
Practice running the investigation. Ask for a student volunteer to read the readings off of the detector for the amount of carbon dioxide and water vapor (relative humidity). Have them show the other students where they are getting the information on the detector. (The image above shows a carbon dioxide reading of 714 parts per million (ppm) and a relative humidity reading of 37 percent.)

Once values stabilize as much as possible, have students record the carbon dioxide and water vapor values on *Burning Fat in Open and Closed Systems* in column B before the burn. Project **slide I**.

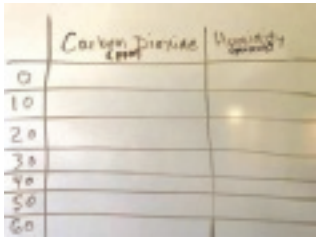
Additional Guidance

A nonessential idea in this lesson is to understand what relative humidity measures. But it is worth pointing out that 100 percent humidity does not mean that the air is filled with only water vapor molecules. Here is a short summary you can share with students to explain what it is measuring. Say: *Relative humidity isn't a measure of the percentage of water in the air, but rather how close the amount of water in the air is to the maximum that can be in the air before it reaches the maximum that can be held in the air. For example, 100 percent relative humidity means that the air can't hold any more water vapor without it clumping together and coming out in little droplets. On some days, 100 percent relative humidity could mean that the air has reached that 4 percent value we saw in the range of possible amounts of water vapor found in the air from day-to-day and place-to-place.*

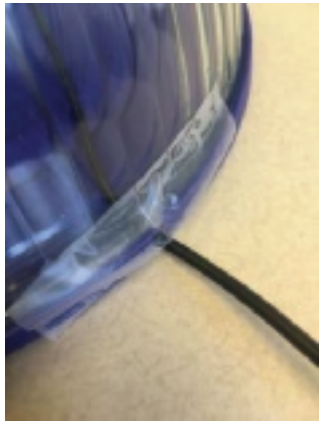
1. Place the tea candle holder with oil and wick on the upside-down cover for the Pyrex bowl. Place the detector next to the candle holder so that there is enough room to place the Pyrex bowl upside down over both things and still have the edge of it sitting on the cover. The cord of the detector should run through the slot that you have cut in the lid.



2. Have a couple of student volunteers get ready to read off carbon dioxide and humidity values from the monitor every 10 seconds when you say "Go." Have one person read off carbon dioxide readings, one person read off relative humidity readings, and one person say "Now" every 10 seconds. Have another student record these on the board or on a piece of chart paper for the class to reference.



3. Have a piece of tape ready to tape over the hole where the cord enters the bowl, and seal the system closed.



4. Light the wick. Now place the Pyrex bowl upside down over both the tea candle holder assembly and detector and set it in the lid. Tape over the hole where the cord enters the bowl. This is not an airtight system, but it will suffice for capturing the buildup of gases from the burn. Say, "Go." Now have students read off and record carbon dioxide readings every 10 seconds.



5. After about a minute, the carbon dioxide reading in the container will get above 4,000. This will be the last reading students will be able to report before the "high" warning light comes on.

In another minute the flame will burn out. **Then place just the tea candle holder assembly on the balance and record the final mass of the tea candle holder assembly with the oil.**

Refer to **slide J** and have students record the final values for each substance in their data tables. This is highlighted in the green cells in column C on the slide.

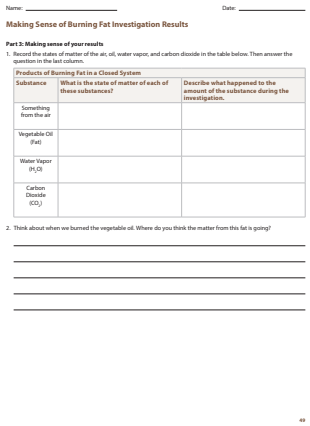
Have students individually add arrows in column D, showing them carbon dioxide and humidity going up ↑ (based on the results measured from columns B and C).

6. Make sense of our closed versus open system results. 5 MIN

Materials: science notebook, *Making Sense of Burning Fat Investigation Results*

Project **slide K**. Hand out *Making Sense of Burning Fat Investigation Results.*

Assign the "Making Sense of Your Results" questions (part 3) as home learning. If time permits, have students return their chairs to their regular tables and work on the questions on *Making Sense of Burning Fat Investigation Results*. If time is short, or some students are not done, assign the completion of these questions for home learning. Emphasize that sharing their responses to these questions will be what we do at the start of the next class.



Name: _____ Date: _____

Making Sense of Burning Fat Investigation Results

Part 3: Making sense of your results

1. Record the states of matter of the air, oil, water vapor, and carbon dioxide in the table below. Then answer the question in the last column.

Products of Burning Fat in a Closed System		
Substance	**What is the state of matter of each of these substances?**	**Describe what happened to the amount of the substance during the investigation.**
Something from the air		
Vegetable Oil (Fat)		
Water Vapor (H_2O)		
Carbon Dioxide (CO_2)		

2. Think about when we burned the vegetable oil. Where do you think the matter from this fat is going?

_____

_____

_____

_____

_____

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End of day 1

7. Navigation

10 MIN

Materials: science notebook, *Making Sense of Burning Fat Investigation Results*



Have students review and share their answers to *Making Sense of Burning Fat Investigation Results*. Present **slide L**, which has the four questions from the handout that students will discuss in small groups.

Once all students have found their responses and read through them once to themselves, present **slide M**, which outlines a small-group discussion protocol for students to share their ideas about the "Making Sense" questions.*

Assign students to groups of three and give them about seven minutes to share their ideas in small groups, following the protocol on **slide M**.

*** Attending to Equity**
The talking stick protocol is used to ensure equitable floor time for all students in the discussion. The later rounds of discussion encourages students to work with and build off of each other's ideas that are shared in the group.

8. Consensus Discussion About What Happens to Matter When It's Burned

10 MIN

Materials: discussion norms poster, chart paper, markers

Facilitate a Consensus Discussion. Project **slide N**. Gather the class in a Scientists Circle. Review the class created discussion norms and have students pick one to focus on during this Consensus Discussion. Use this opportunity to establish agreement on the ideas that groups were converging on related to the questions discussed in the previous step.*

Key Ideas

Purpose of this discussion: See what we can agree upon regarding what happens to matter and energy when fat is burned in a closed system.

Listen for these ideas:

- Light and heat energy were produced.
- Water appeared on the walls of the container.
- Carbon dioxide increased.
- In order for some substances to increase, other substances had to decrease.

Suggested prompts	Sample student responses
What connections about matter and energy did you make to other students' ideas during the talking stick protocol?	*My partner said that the matter of some substances went down, and I said the matter of other substances went up.* *My partner said that energy was produced.*
Can you be more specific?	*We saw that the mass of the oil decreased, and the amount of carbon dioxide and water increased.*
How do we know energy was produced in this reaction?	*We could see the light and feel the heat.*

*** Strategies for This Consensus Discussion**
You may want to stagger the arrangement of students in the circle so that students are talking to new people next to them in the discussion. It is important to use words that the class agrees upon to capture the essential ideas outlined here, rather than using the exact wording in this teacher guide.

Suggested prompts	Sample student responses
Where did that energy come from and what evidence do we have that there was energy there to start?	*The food! The energy was in the oil, and we saw in Lesson 10 that vegetable oil has a lot of calories from fat (which we can use to measure energy).*
So what about other foods we eat besides vegetable oil—can those be burned for energy, too?	*If we know that other foods have calories, then we should be able to burn those as well.*

9. Analyze nutrition labels to determine if other foods provide energy.

5 MIN

Materials: None

Examine nutrition labels to determine if other foods also have energy in the form of calories. Project **slide O**. Ask students to make noticings about how the food labels for carbohydrates and proteins compare to fat as a source of energy. Ask students to recall the fat label from Lesson 10.

Carbohydrate food label: Marshmallow

Marshmallow

Nutrition Facts

Serving Size Pieces (28g)
Servings Per Container about 10

Amount per serving
Calories 100

	% Daily Value*
Total Fat 0g	0%
Sodium 20mg	1%
Total Carbohydrate 24g	8%
Sugars 17g	
Protein 0g	

Not a significant source of calories from Fat, Saturated Fat, Trans Fat, Cholesterol, Dietary Fiber, Vitamin A, Vitamin C, Calcium and Iron.

*Percent Daily Values are based on a 2,000 calorie diet.

INGREDIENTS: CORN SYRUP, SUGAR, DEXTROSE, MODIFIED CORNSTARCH, WATER, GELATIN, CONTAINS LESS THAN 2% OF TETRASODIUM PYROPHOSPHATE, NATURAL AND ARTIFICIAL FLAVOR, ARTIFICIAL COLOR.

Protein food label: Tuna

Tuna

Nutrition Facts

Serving Size 2oz (56g/about 1/4 cup)
Servings Per Container 245

Amount per serving
Calories 60 Calories from Fat 10

	% Daily Value*
Total Fat 1g	2%
Saturated Fat 0g	0%
Trans Fat 0g	
Cholesterol 25mg	8%
Sodium 0mg	10%
Total Carbohydrate 0g	0%
Dietary Fiber 0g	0%
Sugars 0g	
Protein 13g	26%

Vitamin A 0% • Vitamin C 0%
Calcium 0% • Iron 4%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

INGREDIENTS: WHITE TUNA, WATER, VEGETABLE BROTH, SALT, PYROPHOSPHATE.

*** Attending to Equity**

Add this working definition of fuel to your class word wall so that all students can have a consensus on what the class means when using the word "fuel." To support Emergent Multilingual learners, make sure to write and draw examples of different fuels. You can also ask students to say the names of fuels in their home language and add those words to the word wall.

Suggested prompts	Sample student responses
What food molecules are these mostly made up of?	*Marshmallows are mostly made of carbohydrates. Tuna is mostly made of protein.*
Do they contain other substances besides fat?	*They have a few other things like sodium, but sodium isn't a food molecule and neither are those weird chemical names we can't pronounce in the marshmallow.*
What else do you notice?	*Both marshmallows and tuna have calories!*
Can you remind us what you mean when you say "calories?"	*Calories are the energy our bodies need to do things like play basketball. Like fat, it has a lot of calories.*
So, do you think that, if we burn these foods, the same thing would happen as when we burned the oil?	*We were able to burn the fat and transfer energy as light and heat. So maybe we could burn these foods and they would transfer energy as light and heat, too.*
Do you think we could burn other non-food things and get energy from them?	*Answers will vary.* *We could burn a candle.* *Gasoline is burned by cars and can catch fire.* *We burn fuel in our grill or on the stove.* *wood*
So, you are saying that all of these food items, like marshmallows, duck fat, and vegetable oil, and non-food items, like wood and gasoline, have something in common? We could burn any of these things, and we would get energy out of the system?	*Yeah, I guess that's right!*
*So, these are all types of "fuels." A fuel is any material/matter that can react with other substances so that it releases energy.**	*Well, when we burned fat, we made carbon dioxide and water, so if we burn these foods, we might make those same things.*
If you burned these other foods as fuel, what do you predict would be the products?	

Alternate Activity

Students may want to burn other specific foods (such as marshmallows or cheese puffs) to determine if they provide energy. If time permits, students can build a stand to burn food using a paper clip taped to a piece of cardboard that is wrapped in tinfoil or in a chunk of clay.

There is also an optional home learning (see the **Online Resources Guide** for a link to this item, **www.coreknowledge.org/cksci-online-resources**) or possible substitute day reading about using different fuels to power vehicles (such as a french fry bus) any time after Lesson 11.

10. Compare carbon dioxide and water to food molecules.

5 MIN

Materials: science notebook, *Air Molecule Reference*

Revisit the molecular representations of food to look for evidence for the source of matter in the products of carbon dioxide and water. Use *Air Molecule Reference* and *Analyze Data from Eating a Graham Cracker*. Project **slides P** and **Q**.

Pose the question, *If carbon dioxide and water molecules are being produced when foods are transferring energy through burning, then the atoms that make them up must be coming from somewhere. Where are they coming from?*

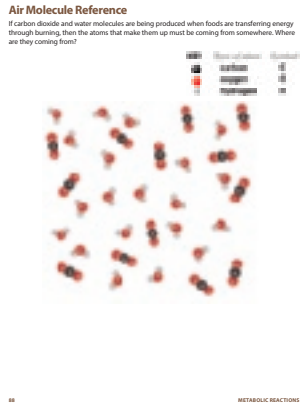
Hand out *Air Molecule Reference* to each pair of students. Tell elbow partners to use this reference to help them discuss this question further.

After a minute, have students share their ideas with the whole class.

Suggested prompts	Sample student responses
Where do you think the atoms that make up the carbon dioxide and water molecules that started appearing in the container came from as we burned the food?	*They came from the food molecules that were burned!* *Maybe they came from the air, too.*
How is that possible? Who can say more about that?	*When we burned the food, the molecules that were part of the food got broken apart, and those atoms rearranged to make new molecules when they reacted with the air.* *Carbon dioxide and water are made of similar atoms to fat!*
So, I hear you saying we started with one substance and ended up with more of other substances through a reaction?	*We said that a chemical reaction must be occurring because the substances we ended up with are different than the ones we started with.*
Can someone remind me what we call the stuff we start with in a chemical reaction?	*We call what we have at the beginning of a reaction the reactants.*
And what do we call the stuff we end up with at the end of the reaction?	*We call what is left over or produced from a chemical reaction the products.****
So what would be our reactants and products when we burn fat as a fuel?	*We start with the air (oxygen) and fat/food as our reactants.* *During the reaction, light and heat are released, and we end up with an increase in carbon dioxide and water as our products.*

*** Attending to Equity**

If your word wall from the Unit 7.1 is still up, walk over to the definitions that your class created for reactants (the substances you start with in a chemical reaction) and products (the new substances that occur after a chemical reaction); if not, add "reactants" and "products" to the word wall for this unit.


Air Molecule Reference

If carbon dioxide and water molecules are being produced when foods are transferring energy through burning, then the atoms that make them up must be coming from somewhere. Where are they coming from?

11. Add to our Progress Trackers.

10 MIN



Materials: science notebook, *Progress Tracker*, markers, chart paper

Ask students to return to their seats to update their Progress Trackers. Hand out the three-column *Progress Tracker*.

Present **slide R**. Say, *Wow, we have really figured out a lot about changes in energy and matter when burning fat. Before we take a few minutes to individually capture our thinking in our 3-column Progress Trackers, let's summarize our consensus ideas. Can someone give me a 30-second speech summarizing everything we have figured out about burning fat today? The rest of the class will listen to make sure we have evidence to support those ideas and be ready to agree or disagree.*

Tell students that we have just spent a lot of time building understanding and then coming to a consensus on what we think is happening to food molecules when fat is burned. Now, we are going to individually construct an explanation in the form of a model (or some other representation) for showing how what we have figured out helps explain what happens to food molecules when they are burned.

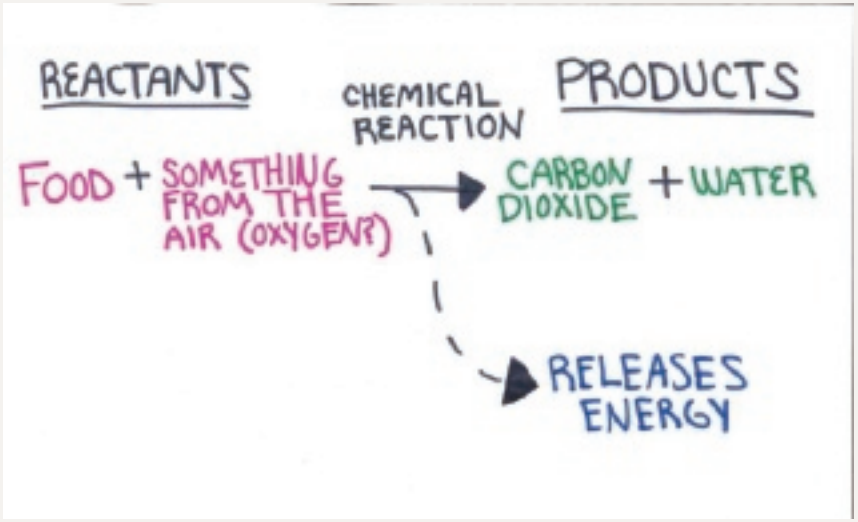
Have students add what we have figured out to their Progress Trackers along with the lesson question and source of evidence that led to these findings.

Here is one representation of what students might write.

Question	Source of evidence
11. What happens to matter when it is burned?	• Burning food in open and closed systems and measuring the mass of both systems. • Burning food in a closed system and measuring the change in concentrations of gases in the air. • Molecular composition of air.

What we figured out in words/pictures

- When food is burned, a chemical reaction occurs because energy is released in the form of heat and light, and different substances are made.
- The concentration of gases in the air changed when the oil was burned. Both carbon dioxide and water increased.
- Matter is also conserved when the new substances are made because the mass of the closed system remained the same before and after burning the oil.



12. Navigation

5 MIN

Materials: None

Have students brainstorm next steps with a partner. Have students return their chairs to their desks. Present **slide S**.

Say, *But now we are wondering, how does this work in our body system? The data we observed shows this for burning fat in a dish, but is this how it happens in our bodies?*

Ask students to turn and talk about ideas for the two questions on the slide for a couple of minutes.

Have students share out their ideas in the last three minutes.

Suggested prompts	Sample student responses
Do you think a similar kind of chemical reaction is happening in our bodies to provide us with energy from food to do things?	*Maybe, since I have heard that you breathe these gases in and out.* *Some sort of chemical reaction must be happening, but I don't know how similar it is to this one.*
Are we having little fires to burn things, like fat, protein, and glucose, for energy inside our bodies?	*No, because there isn't a flame inside of us, is there?* *Wait, is this why we get hot when we exercise?*
What additional evidence could we collect to help us investigate this?	*We could measure the air we breathe out.* *We could see if these gases are in our bodies.* *We could get data from inside different parts of the body to see if a chemical reaction with food is happening there.*

SCIENCE LITERACY: READING COLLECTION 4

Burning Calories

1 What's a Calorie?
2 Diet Pills
3 Hunting for Calories
4 Carb Loading

Literacy Objectives

- ✓ Translate information in text to personal experience.
- ✓ Support a position on balancing calories expended with calories taken in.

Literacy Exercises

- Read varied text selections related to the topics explored in Lessons 9–11.
- Evaluate the reading selections according to provided prompts and criteria.
- Compare and contrast information gained from reading text with information gained from class investigation.
- Prepare a chart that displays a balance of calories taken in and calories expended in response to the reading.

Instructional Resources

Student Reader



Collection 4

Science Literacy Student Reader, Collection 4
"Burning Calories"

Exercise Page



EP 4

Science Literacy Exercise Page
EP 4

Prerequisite Investigations

Assign the Science Literacy reading and writing exercise *after* class completion of this lesson group:

- Lesson 9: How can a problem in one body system cause problems in other systems?
- Lesson 10: Why is M'Kenna losing so much weight?
- Lesson 11: What happens to matter when it is burned?

Standards and Dimensions

NGSS

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

Disciplinary Core Ideas:

LS1.A Structure and Function

LS1.C Organization for Matter and Energy Flow of Organisms

Science and Engineering Practices: Asking Questions; Constructing an Explanation; Analyzing and Interpreting Data

Crosscutting Concepts: Systems and System Models; Structure and Function

CCSS

English Language Arts

RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

Math

CCSS.MATH.CONTENT.6.EE.A.1
Write and evaluate numerical expressions involving whole-number exponents.

Core Vocabulary

Core Vocabulary: Core Vocabulary terms are those that students should learn to use accurately in discussion and in written responses. During facilitation of learning, expose students repeatedly to these terms. However, these terms are not intended for isolated drill or memorization.

calorie **carbohydrate**

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about any concepts in this exercise. Students will benefit from your modeling the use of these words without the expectation that students will use or explain the words themselves.

kilocalorie **over-the-counter**

A Glossary at the end of the Science Literacy Student Reader lists definitions for Core Vocabulary and selected Language of Instruction.

1. Plan ahead.

Determine your pacing to introduce the reading selections, check in with students on their progress, and discuss the reading content and writing exercise. If you are performing Science Literacy as a structured, weekly routine, you might implement a schedule like this:

- Monday: Designate a ten-minute period at the beginning of the week to introduce students to the assignment.
- Wednesday: Plan to touch base briefly with students in the middle of the week to answer questions about the reading, to clarify expectations about the writing exercise, and to help students stay on track.
- Friday: Set aside time at the end of the week to facilitate a discussion about the reading and the writing exercise.

You'll proceed with the in-class lesson investigations during this week.

Exercise Page



EP 4

2. Preview the assignment and set expectations. (Monday)

- Let students know they will read independently and then complete a short writing assignment. The reading selection relates to topics they are presently exploring in their Metabolic Reactions unit science investigations.
- The reading and writing will be completed outside of class (unless you have available class time to allocate).
- Preview the reading. Share a short summary of what students can expect.
  - *In "What's a Calorie?" you will read about the concerns around calories and diet and how calories are related to heat and weight.*
  - *In the second selection, you'll find out how different diet pills are intended to work to help people lose or gain weight.*

- *"Hunting for Calories" confirms the need for animals, including humans, to get enough food to survive.*
- *In the fourth selection, "Carb Loading," you'll read about how different types of foods affect energy and endurance levels.*

- Distribute Exercise Page 4. Preview the writing exercise. Share a summary of what students will be expected to deliver. Emphasize that Science Literacy exercises are brief. The focus is on thoughtful quality of a small product, not on the assignment being big and complex.
  - *For this assignment you will be expected to generate a chart that plans the balance of the number of calories expended with the number of calories taken in.*
- Remind students of helpful strategies they can employ during independent reading. Offer the following advice:
  - *The reading should take approximately 30 minutes to complete.* (Encourage students to break reading into smaller sections over multiple short sittings if their attention wanders.)
  - *A good reading strategy is to scan through the collection first to see the titles, section headers, graphics, and images to see what the selections are going to be about before fully reading.*
  - *Next, "cold read" the selections without yet thinking about the writing assignment that will follow.*
  - *Then, carefully read the Exercise Page to understand the expectations for the writing part of the assignment.*
  - *Revisit the reading selections to complete the writing exercise.*
  - *Jot down any questions for the midweek progress check in class.* (Be sure students know, though, that they are not limited to that time to ask you for clarification or answers to questions.)

3. Touch base to provide clarification and address questions. (Wednesday)

Touch base midweek with students to make sure they are on track while working independently. You may choose to administer a midweek minute-quiz to give students a concrete reason not to postpone completing the reading until the last minute. Ask questions such as these, and have students jot answers on a half sheet of paper:

Suggested prompts	Sample student responses
What does it mean to burn calories?	*The chemical reaction that happens in your body as you use the food that you take in is a kind of burning because it gives off heat as the glucose in your body combines with oxygen. The glucose is being "burned" in your cells.*
What kind of food provides the most calories per ounce?	*Fats provide the most calories per ounce. Foods that are high in fat include nuts, butter, oils, cream, fatty cuts of meat, and whole-milk cheeses.*
What are some ways diet pills claim to help people lose weight?	*Some claim to help burn fat by giving a feeling of energy so you move more. Others claim to curb appetite. Others claim to suppress the appetite or change how your digestive system absorbs food.*

Suggested prompts	Sample student responses
What would happen to sharks if seals were not available for them to eat?	*They would starve or have to travel to hunt for other sources of food, which might not be as nutritious for them.*
Why would it not be good for you to eat a lot of fatty foods before playing a challenging game?	*Fat does not burn quickly in your body, so it would not give you a burst of energy, and eating fatty food could make you sick to your stomach.*

Ask a few brief discussion questions related to the reading that will help students tie the text content to students' classroom investigations.

Suggested prompts	Sample student responses
How could a problem in M'Kenna's digestive system affect her energy levels and growth?	*If calories are not being broken down and absorbed in her digestive system, the food cannot provide the energy all her other body systems need to move, think, and grow.*
Would diet pills help M'Kenna?	*No, she is already losing too much weight. Stimulating her body or suppressing her appetite would probably make her lose even more weight.*

- Refer students to the Exercise Page 4. Provide more specific guidance about expectations for students' deliverables due at the end of the week.
  - *The writing expectation for this assignment is to create a chart that balances a list of planned activities for a day and how many calories will be burned by each activity with a list of foods to eat whose calorie count will equal the number of calories expended. For example, about 200 calories are burned during sleep. A medium banana has about 100 calories, and an apple has about 100 calories, which balances the calories burned while sleeping.*
  - *You will need to find credible sources to find calorie counts to make sure your charts are complete and accurate. You should cite and be able to defend your sources, although all counts will be approximate.*
  - *The important criteria for the work are that the chart is complete and includes accurate calorie data that balances.*
  - *Make the chart engaging so that people your age remember it.*
- Explain that a great chart will be easy to read and understand and have engaging graphics.
- Answer any questions students may have relative to the reading content or the exercise expectations.

Exercise Page



EP 4

4. Facilitate discussion.

(FRIDAY)

Facilitate class discussion about the reading collection and writing exercise.

The four reading selections in Collection 4 focus on calories that animals take in when they eat and "burn" as fuel to live. The previous collection focused on the digestive system and what problems can occur if parts of the digestive system are not working properly. Regardless of a functioning digestive system, if animals do not get enough calories, they lose weight and can die if they do not find other sources of food. If animals eat too many calories, the extra calories are stored in the body as fat. The body does not "burn" fat as quickly as it does sugar or glucose. This is good for hibernating animals, since slow-burning fat will keep them alive if they are not active. But for animals that are active and for humans who want to engage in strenuous activity, carbohydrates are a better immediate food choice because the body absorbs and uses that fuel much more quickly and efficiently.

Pages 34–35 **Suggested prompts**	**Sample student responses**
What is the general purpose of the first selection, "What Is a Calorie?"	*It clarifies what a calorie is.* *People generally know from nutrition labels that foods contain different numbers of calories. The number of calories in a food refers to the total amount of energy you get from all the ingredients in a serving of that food.*
What happens if you eat exactly the number of calories you burn?	*You will not lose or gain weight.* *Your body will use all the energy you get from eating for growth and all bodily functions.*
When might it be good to eat more calories than usual?	*You need to eat more calories if you are expecting to engage in strenuous activity.*
When might it be good to eat fewer calories than usual?	*You don't need to eat as many calories if you are not moving around very much.*

Pages 36–37 **Suggested prompt**	**Sample student responses**
How does the second selection help you build knowledge on top of what you learned in the first selection?	*Many people are looking for easy and quick ways to lose weight.* *People can have high amounts of fat stored in their bodies from eating too many calories that their bodies did not burn.*

Student Reader



Collection 4

SUPPORT—If you are using the recommended word envelope convention, check the envelope to see if it contains any words, phrases, or sentences that students need help understanding. Read key sentences aloud, and provide concise explanation.

SUPPORT—Some students may benefit from breaking down the word *carbohydrate* into its parts: *carbon* and *hydrate* (water). Water is H_2O, two hydrogen atoms bonded to one oxygen atom. Carbon is essential for life. It forms compounds with other elements and is a significant percentage of the human body.

CHALLENGE—Challenge interested students to research what empty calories are, with examples, and report their findings to the class.

EXTEND—Have students watch a video about calories and nutrition. Follow up with a discussion about the calories people get from different foods.

Pages 36–37 Suggested prompts	Sample student responses
Why would a diet pill that stimulates your body to burn calories more quickly not be good for you?	*You might get too hyper or overexcited.* *You might not make good choices.* *Diet pills are not good for everybody.*
Why would a diet pill that suppresses your appetite or changes how your digestive system absorbs food not be good for you?	*If a pill changes your digestive system or suppresses your appetite, you might not get the energy from the food you eat.* *Not absorbing the nutrients from the food you eat can make you sick.*

Pages 38–39 Suggested prompts	Sample student responses
What is the general purpose of the third article, "Hunting for Calories"?	*All animals need calories to live.* *Animals generally hunt for food that is good for them.* *Hunting, grazing, or foraging for food is a major focus of an animal's life.*
How do people hunt for calories?	*Farmers and food companies produce food for the masses of people, who "hunt" for food in grocery stores, restaurants, and school cafeterias.*

Pages 40–43 Suggested prompt	Sample student responses
What is the general purpose of the fourth article, "Carb Loading"?	*There are different types of calories that people eat.* *Hibernating animals build up on fat calories to survive a long winter without eating.* *Loading up on carbohydrates before strenuous activity is best for being able to break down calories to release energy efficiently.*

Pages 40–43 Suggested prompts	Sample student responses
What are complex carbohydrates?	*Carbohydrates are essential nutrients that are converted into glucose during the process of digestion.* *Carbohydrates are made up of carbon, hydrogen, and oxygen.* *Complex carbohydrates are starchy foods such as potatoes, corn, noodles, bread, cereals, and many other foods.* *In contrast, simple carbohydrates are mainly different forms of sugar that provide quick energy like an apple or orange.*
Why are so many people concerned about eating too many carbs?	*Eating too many carbohydrates can raise your blood sugar levels.* *If your body doesn't burn the calories from carbohydrates, this sugar turns into fat and results in weight gain.*

5. Check for understanding.

Evaluate and Provide Feedback

For Exercise 4, students should create a chart of a balanced diet for themselves, one that balances the number of calories each student would expect to burn with the number of calories they take in and shows a balance of proteins, fats, and carbohydrates.

Use the rubric provided on the Exercise Page to supply feedback to each student.

LESSON 12

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

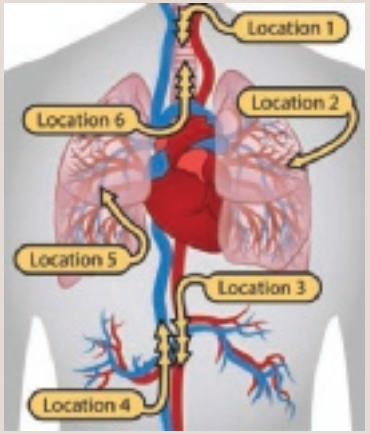
Previous Lesson

We conducted two investigations to trap the gases produced by burning food. We used the results of these investigations to figure out that food needs to undergo a chemical reaction with oxygen to release energy and that carbon dioxide gas and water vapor are products of that process. We wondered if this reaction could happen inside our bodies.

This Lesson

Investigation

2 DAYS



We gather multiple sources of evidence, such as observing a chemical reaction after blowing into BTB solution, to prove that a reaction between food and oxygen happens in the cells of the body to provide them with energy and releases carbon dioxide and water. This 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. We consider the purpose of the reaction and analyze activity data to see if when the activity level changes, whether this chemical reaction happens at a different speed.

Next Lesson

We will build small-group models, drawing primarily on what we figured out in Lessons 8-12, to explain how food is rearranged in the body to create energy, store matter for later use, and use matter for growth. We will compare our models and then develop a consensus model to explain how a healthy body obtains energy and how M'Kenna's body could be functioning differently.

Building Toward NGSS

MS-LS1-3, MS-LS1-5, MS-LS1-7

What Students Will Do

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.

What Students Will 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 in the body rearrange glucose and oxygen into carbon dioxide, water, and energy that the cells can use.
- This reaction, called cellular respiration, happens when we're resting, but even more when we exercise.

Lesson 1 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Review that chemical reactions can be used to release energy from food. Pose the question, "Does this chemical reaction between food and oxygen really happen in our bodies?"	A-B	
2	15 min	**BTB INVESTIGATION: DEMONSTRATION** Gather evidence that a similar type of chemical reaction is happening in the body by having each student blow into bromothymol blue (BTB).	C	BTB Investigation
3	10 min	**BUILDING UNDERSTANDINGS DISCUSSION** In a Building Understandings Discussion, help students make sense of the evidence they collected in the BTB investigation, which demonstrates that we are breathing out carbon dioxide.	D	
4	8 min	**FOLLOW THE PATH OF AIR IN OUR LUNGS** Gather evidence from an image of alveoli in the lungs and from comparing the size of glucose, carbon dioxide, and the molecules in the air we breathe. Map the parts of the respiratory system to what we generally know about body systems. Help students figure out that the molecules in the air we breathe and carbon dioxide are small enough to pass through lung membranes and in and out of the blood.	E-H	systems mapping chart from Lesson 8
5	17 min	**ANALYZE OXYGEN AND CARBON DIOXIDE LEVELS IN THE BLOOD** Students analyze oxygen and carbon dioxide levels in the blood. Help students figure out that the chemical reaction is happening in cells in the body.	I-J	*Oxygen and Carbon Dioxide in the Blood - Part 1*, tape, blank loose leaf paper

End of day 1

6	7 min	**NAVIGATION: MAKING SENSE** Facilitate an Initial Ideas Discussion to make predictions about how the chemical reaction that provides cells with energy would vary across different tissues and between periods of rest and activity.	K-L	
7	20 min	**INTERPRETING ACTIVITY DATA** Interpret oxygen consumption data to see which cells in which parts of the body use the most oxygen while at rest. Analyze and interpret glucose data in the blood over 24 hours to figure out that the chemical reaction is always happening and that it happens more when we are exercising.	M-O	*Interpreting Activity Data - Part 2*, tape
8	15 min	**FACILITATE CONSENSUS DISCUSSION AND UPDATE THE 3-COLUMN PROGRESS TRACKER** In a Scientists Circle, facilitate a Consensus Discussion, then update the 3-column Progress Tracker to represent the ideas that (1) chemical reactions between food and oxygen are happening in cells inside the body; (2) reactants are transported from the lungs (oxygen) and small intestine (glucose) to the cells, and products (carbon dioxide and water) are transported from the cells through the blood; and (3) reactions happen all the time in the body, while at rest and even more while active.	P-Q	*Progress Tracker*, chart paper, markers
9	3 min	**NAVIGATION: TAKING STOCK** Consider how what we've figured out can help us explain M'Kenna's non-digestive symptoms.	R	*Revisiting Symptoms and Systems*

End of day 2

Lesson 12 • Materials List

	per student	per group	per class
BTB Investigation materials		• 1 straw • 1 plastic cup with 10 mL diluted BTB • safety goggles	• 2 cups with 10 mL of diluted BTB in each cup • 1 plastic cup with 10 mL of carbonated water with eyedropper • 1 plastic cup of with 10 mL plain water
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• science notebook • *Oxygen and Carbon Dioxide in the Blood -Part 1* • tape • blank loose leaf paper • *Interpreting Activity Data - Part 2* • *Progress Tracker* • *Revisiting Symptoms and Systems*		• systems mapping chart from Lesson 8 • chart paper • markers

Online Resources



Materials preparation (25 minutes)

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

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

If your class does not have access to bromothymol blue (BTB) or sufficient BTB to conduct the investigation, you can play this video. (See the **Online Resources Guide** for a link to this resource. **www.coreknowledge.org/cksci-online-resources**)

Day 1: BTB Investigation

- **Group size:** Three students per group
- **Setup:**
  - To make the diluted BTB solution, add 25 mL of BTB (straight from the container) to a 1000 mL beaker. Add water to the beaker until it reaches the 1000 mL line. The BTB solution should appear light blue in color. If it does not, it is possibly over-contaminated with carbon dioxide so pour it into a container and leave it open to the air so that the carbon dioxide can dissipate.
  - ****Be sure to test a small sample of your tap water to make sure that no color change occurs. Some tap and bottled water have additional minerals in them that will change the color of the BTB. If this is the case, try changing your*

water source to using a different filtered or deionized water. Fill 1 clear plastic cup with 10 mL of bromothymol blue solution (BTB) for every 3 students. Prepare enough for all classes ahead of time.

- Fill one clear plastic cup with about 10 mL of BTB (for the class demonstration) for each class.
- Fill one plastic cup with 10 mL carbonated water for each class. Do not throw away the bottle.
- Fill one plastic cup with the 10 mL of plain water for each class.

- **Notes for during the lab:** Some sources of water for dilution might make the BTB solution take longer to change color because of the added minerals. Be sure to test by blowing into the BTB with a straw to make sure you can see the color change with a small sample before diluting the full amount.
- **Safety:** Students should wear safety goggles while breathing into the BTB. The solution is not hazardous but if it comes into contact with the skin or eyes, rinse thoroughly with water for 15-20 minutes. If swallowed, get medical attention.
- **Disposal:** Disposal should be in accordance with applicable regional, national, and local laws and regulations. Local regulations may be more stringent than regional or national requirements.
- **Storage:** Keep in a tightly closed container. BTB can be stored at room temperature with a shelf life of approximately 36 months.

Lesson 12 • Where We Are Going and NOT Going

Where We Are Going

This lesson addresses a key Disciplinary Core idea that, in animals, oxygen reacts with carbon-containing molecules to provide energy and produce carbon dioxide (LS1.C). Specifically, students are introduced to the idea that this chemical reaction happens in cells and energy is released. Students figure out that the respiratory and circulatory systems work together to move reactants to the cells and products out of the body. Students do not need to know the specific chemical reaction for cellular respiration.

This lesson also addresses the idea that sugars are used immediately (LS1.C). Students figure out that cells immediately use the energy produced by this reaction for organs to function while at rest and use more glucose and energy when the body is active.

This lesson also builds upon the idea that was developed in previous lessons that substances can move across the surface of an organ. In this lesson, students figure out that oxygen and carbon dioxide can also pass through membranes because they are small like glucose.

Where We Are NOT Going

Students do not need to know how cellular respiration happens in cells or how cells use the energy.

LEARNING PLAN FOR LESSON 12

1. Navigation

5 MIN

Materials: None

Present **slide A** to the class and have students turn and talk to review what we figured out in the last class and what new questions we have now.

Additional Guidance

Encourage students to look back in their science notebooks to review some of the ideas the class came up with in the previous class.

Listen in on the discussions, prompting students to use their science notebooks to support their thinking. After a couple of minutes, ask students to share these with the whole group.

Suggested prompts	Sample student responses
What did we figure out last class?	*Food goes through a chemical reaction when it is burned. In this chemical reaction, something in the air is used up, and carbon dioxide and water are products, as well as energy, which we saw in the forms of heat and light.*
What questions did this raise for us?	*Can this really happen in our bodies? Where does it happen?*

Say, *Let's start by figuring out if this chemical reaction might be happening in our bodies.*

Present **slide B**. Introduce the first half of the lesson question by posing: "Does this chemical reaction to burn food happen inside our bodies?"

Additional Guidance

Students need to come to an agreement that the chemical reaction they figured out in the last class is happening in our bodies before they address the second half of the Lesson 12 question, "And if so, how do our energy needs affect the reaction?" Students investigate the second half on day 2 of this lesson.

Discuss evidence we would see if this chemical reaction were happening in the body. Have the class think through how we could gather evidence. Encourage students to consider what would be different about the evidence we would collect if we exercised.

*** Attending to Equity**

Students will have encountered the terms, "chemical reaction," "reactant," and "product," in previous units. To support all learners and to ensure that all students feel comfortable with these terms, consider pausing the learning to add these words to the word wall if you have not already done so. Co-construct definitions with students based on their understanding and experience from previous units.

Suggested prompt	Sample student response
If this chemical reaction were happening in our bodies, what evidence would we see of substances going into or coming out of our bodies?	*We would see something from the air, maybe oxygen, and food going in, and carbon dioxide and water coming out.*

Tell students that we'll look for some of this evidence, specifically focusing on one reactant (something from the air, possibly oxygen) and one product (carbon dioxide) in this lesson.*

2. BTB Investigation: Demonstration

15 MIN

Materials: BTB Investigation

Introduce bromothymol blue (BTB), a carbon dioxide indicator.

Say, *I have another indicator we can use, called bromothymol blue, or BTB for short, that indicates the presence of carbon dioxide. Let's see how we might use this indicator to gather evidence to see whether this reaction is happening in our bodies. I also have a known source of carbon dioxide we can use to test how the indicator works.*

Additional Guidance

Be sure to test a small sample of your tap water to make sure that no color change occurs. Some tap and bottled waters have additional minerals in them that will change the color of the BTB. If this is the case, try changing your water source to a different filtered or deionized water. Also, some water might make the BTB solution take longer to change color because of the added minerals. Be sure to also test blowing into the BTB with a straw to make sure you can see the color change with a small sample.

Project **slide C**, which shows the label for carbonated water. Ask students to notice what is in the ingredients of this liquid.

Share with students that carbonated water is water with added carbon dioxide.* After establishing that it has both water and carbon dioxide in it, suggest that we make some observations about what happens when we mix BTB with this carbonated water, which has a lot of carbon dioxide in it, and compare the results to what happens when we mix BTB with water that doesn't have carbon dioxide in it.

Alternate Activity

If students are unsatisfied by your explanation that carbonated water is water with added carbon dioxide simply based on the food label, consider showing a video or providing an additional short reading that explains how carbonated water is made. You could share information, for example, about how the SodaStream machine makes carbonated water out of tap water.

Demonstrate the color of BTB when mixed with two known sources.

Have students create the table on **slide C** in their science notebooks and record the results for the first row of the table. Pour about 10 mL of BTB into a glass beaker and walk around showing students what color it is with no water added. Have them record the color of the BTB in the entire column for "Color before mixing."

Next, show students what happens when you add plain water to the BTB in the beaker. Take an eyedropper full of distilled water and squirt it into the BTB. Swirl the beaker. Show students the color of the liquid after adding water. The color should remain blue. Have students add the results to the data tables in their notebooks.

Say, *OK, next I am going to add a small amount of carbonated water to the liquid, which is a combination of water and carbon dioxide. We'll examine the color, and then I will add some more. Let's see how it affects the BTB.*

Take a new eyedropper, fill it with carbonated water, and squirt the water into the BTB. Swirl the beaker. Walk around and show the results. Fill the eyedropper again with the carbonated water and squirt it into the BTB. Swirl the beaker again and walk around to show the results. Have students record their observations.

Suggested prompts	Sample student responses
What do you notice?	*The carbonated water made the BTB change to a green/yellow color.*
What does the color change tell us?	*The BTB changes color when it comes in contact with carbon dioxide, so this tells us that the carbonated water really does have carbon dioxide in it.*

Make some predictions about what we will see if we mix BTB with the air we exhale.

Suggested prompts	Sample student responses
What should we see happen to the color of the BTB if we mix it with the air we exhale from our lungs and that air has more carbon dioxide in it than the surrounding air does?	*It should turn colors (green or yellow), depending on how much carbon dioxide is in it.*
How could we mix air that we exhale from our lungs into this liquid?	*We could blow into it.*

Additional Guidance

If students don't suggest blowing into it, say, "If we were to use a straw to blow into the BTB, do you think we would see a color change? Should we try that?"

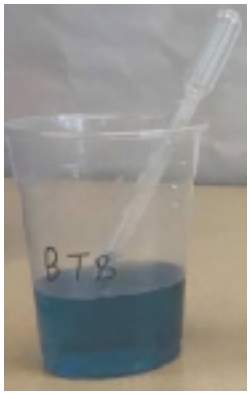
Ensure student safety. Ask student volunteers to wear goggles while handling BTB solution.

- Have students pick one volunteer per group of three to four students to get a straw and a clear plastic cup with 8–10 mL of BTB solution already in it.

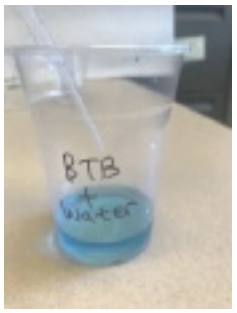


- Remind students not to share the straw and to keep one end of it in the BTB liquid the whole time.
- Remind students to breathe in between blowing bubbles into the BTB and to be careful to not accidentally suck the BTB into their mouths.

1. Set up one beaker with 10 mL of BTB solution and an eyedropper. Set up another beaker with 10 mL of plain water and an eyedropper. Have students record the color of the BTB in their data tables in their science notebooks.



2. Add one eyedropper full of plain water to the BTB. Swirl the water and the BTB in the beaker and show students the color of the BTB. Have students record the color of the BTB and water in their data tables in their science notebooks.



3. Add one eyedropper full of carbonated water to the BTB. Swirl the carbonated water and the BTB in the beaker and show students the color of the BTB. Have students record the color of the BTB and water in their data tables in their science notebooks.





Alternate Activity

If you prefer, you can have every student in the group perform the BTB experiment so that each student gets a chance to blow into the solution.

Tell students that they may need to keep blowing bubbles into the solution for a little over a minute to notice any effects and that holding the beaker against a piece of white paper will allow them to see any color changes more easily.

Conduct the investigation. Give students four minutes to send one person up to get a cup and a straw, conduct the test at their tables, record their results, dump the liquid in the sink, and throw away the straw and cup.

3. Building Understandings Discussion

10 MIN

Materials: science notebook

Make claims based on this evidence. Project **slide D**. Give students a couple minutes to add their responses to the questions on this slide to their science notebooks.



Facilitate a Building Understandings Discussion.

Key Ideas

Purpose of this discussion: The purpose of this discussion is for students to start making the claim that we have a growing body of evidence that a chemical reaction of burning food could be happening in the body.

Listen for these ideas:

- The air we exhale contains carbon dioxide.
- Carbon dioxide is a product of a chemical reaction when food is burned.
- We breathe in air through our nose and mouth and it travels to our lungs.

Suggested prompts	Sample student responses
What does the color change from blowing into the BTB tell you about the air coming out of our lungs?	*We breathe out carbon dioxide.*
How does this support the claim that a chemical reaction, like the one we figured out last class when we burned the oil, is happening inside our bodies?	*The burning reaction produces carbon dioxide. And that is also what is coming out of us!*
Where does that carbon dioxide in our breath come from inside our bodies?	*our lungs*
When you breathe in air, where does that air go inside your body?	
Why do you think you have air going in and carbon dioxide coming out of your lungs?	*I'm not totally sure!? Maybe there is a chemical reaction in our lungs?*

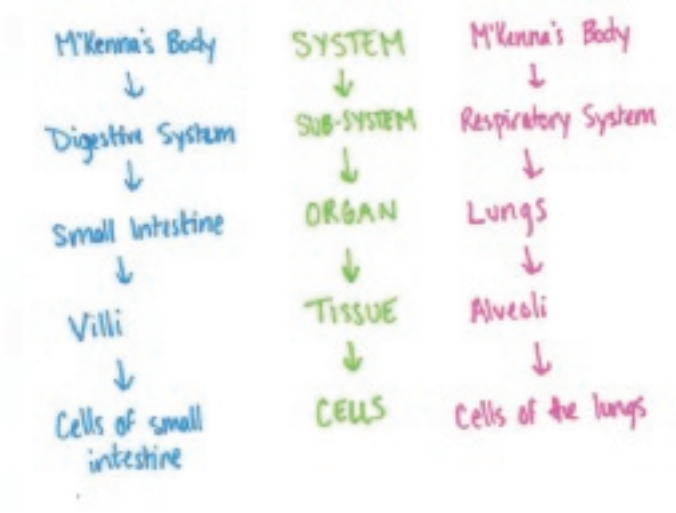
Say, *If we think this chemical reaction might be happening in the body and air is going in and carbon dioxide is coming out, where is this air going to and where is this carbon dioxide coming from in our bodies? Earlier in this unit, we followed the path of food to help us figure out what happens to food. Let's follow the path of air to help us figure out where these gases are going to and coming from in our lungs.*

4. Follow the path of air in our lungs.

8 MIN

Materials: science notebook, systems mapping chart from Lesson 8

Compare the organization of the respiratory system to the digestive system and general body systems. Project **slide E**. Use the image on the slide to have students trace the path of the air that is inhaled, which travels to the bottom of the lungs (the red circle). As students come to the projector to do this, map the respiratory system to the general organizational structure of body systems, like you did in Lesson 8.



On the same chart paper that you used in Lesson 8, add a third column in which you will track the respiratory system.

Begin by adding "respiratory system" next to "subsystem."

Say, *Air that enters through our noses or mouths travels down our windpipes, or tracheas, into our lungs through a branching network of smaller and smaller air tubes. These are called bronchial tubes.*

Add the term "lungs" next to "small intestine" on the chart.

Say, *Tiny air sacs (alveoli) line the sides of the ends of these air tubes, like the red circle shows.*

Add the term "alveoli" next to "villi" on the chart.

Suggested prompts	Sample student responses
Do you notice a pattern between the digestive and respiratory systems?	*Yeah, both of these body systems seem to be organized in the same way, with systems, subsystems, organs, and tissues.*
I see that pattern, too. In fact, all of our body systems have this same general structure. If this is true, what other structure do you predict you would see in this part of the lung tissue?	*We should see that the alveoli are made up of cells.*

Say, *What other structure do you predict you would see in this part of the lung tissue?*

Give students a minute to turn and talk about their predictions with a partner.

Say, *Let's take a closer look at that spot where those air sacs are located.*

Project **slide F** with an image of alveoli and another image of the cells that line the alveoli and have students share their observations and ideas with the whole class. Let students know that the blue, red, and yellow areas in the image are dye so that the parts of the cells are more visible.

Suggested prompts	Sample student responses
What do you notice about the structures in this part of the lungs?	*They are made up of a lot of tiny circles or sacs, and those are made up of cells.* *They are covered with what looks like blood vessels.*
If these red branching vessels contain blood, what might happen to gas particles when they reach the edge of these air sacs and run up against the surface of the blood?	*Maybe they go into and out of the blood. It could be similar to how glucose crosses into the bloodstream through the villi. Maybe gases go through the lung membrane wall and into the blood?*
What determines whether a molecule can pass through a membrane?	*How big it is. Small molecules like glucose can pass through, but big molecules like starch (a special type of complex carbohydrate) can't.*
How would we know whether gas molecules like carbon dioxide are small enough to pass through the lung membrane into blood?	*We need to see how big the molecules are and if they're small enough to pass through.*

Additional Guidance

If students aren't remembering, project **slide L** from Lesson 3, which compares the starch and glucose molecules. This will help remind students that really big molecules cannot pass through membranes.

Examine the size of molecules in the air and glucose. Project **slide G** and have students turn and talk to discuss what they know about glucose, how it gets into the blood, and what parallels they can draw to gas molecules like carbon dioxide.

Additional Guidance

Prompt students to use the idea of small food molecules crossing a membrane in the small intestine to get to the blood as a way of making sense of how other small molecules get in and out of cells and move between systems. Students first explored this concept in Lesson 8.

Share ideas in a whole-class discussion. Project **slide H** and discuss how gas molecules would get in and out of the body if a chemical reaction is happening in the body.

Suggested prompts	Sample student responses
Could the molecules in the air get into the blood from the lungs? Why or why not? *Could carbon dioxide move through the lungs? Why?*	*The gas molecules in air are really small, even smaller than glucose. So they can probably pass through the lung membrane into the blood like glucose did with the small intestine.*
We know that for food to burn, it needs something in the air because the fire went out when we didn't allow more air to go into the closed system. Looking again at the different molecules in air—which gas molecule do you think is most likely the one that is needed in the chemical reaction to burn food?	*We're pretty sure it's oxygen.*
(Refer to the closed-system container you used in Lesson 11.) So, if the chemical reaction with food needs oxygen to keep burning, what would happen to the oxygen levels inside the closed container as food is burning?	*The oxygen levels should go down over time because the chemical reaction would be using up the oxygen to burn the food.*
So, if a chemical reaction to burn food is happening inside our bodies and if it's the oxygen that is needed to burn food, what would you predict would happen to the oxygen levels inside our bodies?	*I guess the oxygen levels inside our bodies should go down, too, if they are using the oxygen in a chemical reaction to burn food.*
If a chemical reaction to burn food is happening inside our bodies and if carbon dioxide is produced when you burn food, what would you predict would happen to the carbon dioxide levels inside our bodies?	*The carbon dioxide levels inside our bodies should go up if it is being produced in a chemical reaction to burn food.*
Should we check out those levels of gases inside our bodies and see what we find?	*Yeah!*

5. Analyze oxygen and carbon dioxide levels in the blood.

17 MIN

Materials: science notebook, *Oxygen and Carbon Dioxide in the Blood - Part 1*, tape, blank loose leaf paper

Introduce blood data. Project **slide I** and have students look at *Oxygen and Carbon Dioxide in the Blood - Part 1*, which shows the same data.

Say, *This is some blood work from a healthy person that shows the person's oxygen and carbon dioxide levels in different places around the lungs inside the person's body. Let's see if this can help us figure out whether a chemical reaction is happening, and if so, where it's happening.*

*** Attending to Equity**

If students struggle to interpret the data laid out in the data table in *Oxygen and Carbon Dioxide in the Blood - Part 1*, ask them to first verbalize what a change in levels would indicate. Ask, "If you see

Divide into pairs to analyze the graphic. Give students five minutes to work in pairs to complete the questions in part 1 of *Oxygen and Carbon Dioxide in the Blood - Part 1*, analyzing and interpreting the blood data and answering the questions. Have students tape the handout into their science notebooks and answer questions.*

Facilitate a Building Understandings Discussion. Bring the whole class together to make sense of the blood data. Consider presenting **slide I** as the class looks at the oxygen and carbon dioxide levels in the blood, so they can point to specific evidence. During this discussion, be sure to make a public record of the key ideas that emerge.

Key Ideas

Purpose of this discussion: Make sense of the blood data to understand that, when oxygen levels drop, it indicates that the oxygen is being used in different parts of the body to cause chemical reactions.

Listen for these ideas:

- Oxygen levels change the most between the point at which oxygen enters the blood and when it returns to the heart.
- Oxygen levels decrease and carbon dioxide levels increase when blood is returning from other parts of the body.
- The decrease in oxygen and increase in carbon dioxide indicate that a chemical reaction is occurring in the parts of the body between the location where oxygen enters the blood and when blood returns to the heart from other parts of the body.
- Oxygen and carbon dioxide pass through the lung membrane into the blood because the molecules are small enough, smaller even than glucose, which passes through the membrane of the small intestine into the blood.
- When we burned things in Lesson 11, a chemical reaction occurred when a reactant and fuel were combined, which produced carbon dioxide and water and released energy in the form of heat and light. This burning is occurring in the body, but we don't see a "fire." In our bodies, energy is transferred as heat and a usable form of energy for our cells.

Suggested prompts	Sample student responses
Where do the oxygen levels change the most?	*They change the most between when oxygen travels to other parts of the body and when it returns from them.*
How do the oxygen levels change in these other parts of the body? Do they increase or decrease when they are there?	*They decrease.*
Where do the carbon dioxide levels change the most?	*They change the most between when carbon dioxide travels to other parts of the body and when it returns from them.*
How do the carbon dioxide levels change in these other parts of the body? Do they increase or decrease when they are there?	*They increase.*

the oxygen levels go down, what would that mean? What about the carbon dioxide levels?" Have students highlight or add arrows to their data tables to indicate where they see a change in levels. This will assist students with sensemaking as they look at the data.

It may also be beneficial to draw a connection to the work students did in Lesson 8 when they analyzed food molecule data to determine which organ in the digestive system is responsible for breaking molecules down and absorbing them across the cell membrane.

*** Attending to Equity**

One strategy for differentiation might be to call up the image of body systems from Lesson 1.



For students who struggle to visualize the flow of the circulatory system to all parts of the body, use this image to demonstrate that the blood moves through the circulatory system both into and out of the heart/lungs.

Suggested prompts	Sample student responses
What clues does this give us about where the chemical reaction is happening that is using food and oxygen to provide the body with energy and produce carbon dioxide in the process?	*The chemical reaction must be happening in other parts of the body.*
How does this relate to the burning we did in Lesson 11? Are there little fires inside our bodies?	*Kind of. The chemical reaction is really similar because nutrients from food are reacting with oxygen to produce energy. Instead of the energy being released as light like the flame we saw, it's releasing energy that the body is using to power the heart, brain, muscles, etc. Carbon dioxide is a product in both scenarios.*
What do we know about all the tissues that make up the parts of our bodies? What smaller structures are they made of?	*cells*
Could glucose and oxygen molecules in the blood go into cells across their cell membranes? Could carbon dioxide come out of cells and go into the blood? Why?	*Yes, they are all small enough molecules.*

Additional Guidance

If students use language such as "carbon dioxide gets created," probe further by asking, "Do you mean created out of nothing or created out of or produced out of something else? Can the atoms that make it up appear out of nowhere? Where is the matter that makes up the carbon dioxide coming from?" This will push students to remember that this carbon dioxide is a product of a chemical reaction between food and oxygen.

Additional Guidance

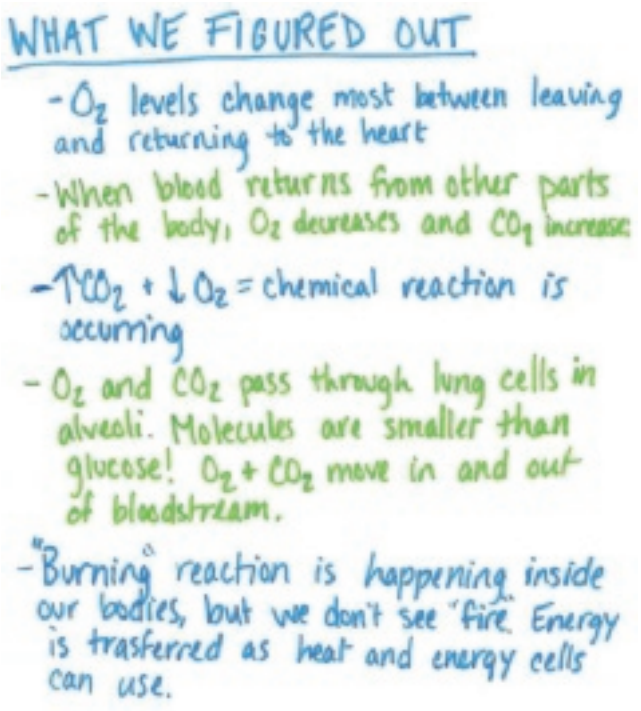
If students need help remembering that each organ is made of tissues, which are made of tightly packed cells, you can use a virtual microscope to gather evidence of this (see the **Online Resources Guide** for a link to this item, **www.coreknowledge.org/cksci-online-resources**). Have students explore the heart muscle sample by focusing on the repeating patterns in tissues. Prompt students to notice that each tissue is composed of smaller subunits (cells) that look almost identical to each other. Thus, cells make up tissues, which make up organs, and cells in different tissues work together to perform different functions in different organs.

Summarize our findings that chemical reactions to burn food happen inside our bodies. Suggest that we seem to have found a lot of evidence for the idea that the chemical reaction that releases energy from food molecules is happening in the cells throughout our bodies. Keep track of students' ideas on a public record. One suggested representation appears on the following page.

Project **slide J**. Refer to the class artifact and summarize the main points of what the class has figured out.

Have students complete an exit ticket on a loose leaf sheet of paper. Do you think we have a chemical reaction to burn food happening inside our bodies? Why or why not?

Then ask students to turn and talk with a partner to start brainstorming some predictions for the three questions at the bottom of this slide.



Home Learning Opportunity

You can have students complete the exit ticket and questions on the slide for home learning if you are short on class time.

End of day 1

6. Navigation: Making Sense

7 MIN

Materials: science notebook

Conduct an Initial Ideas Discussion to share predictions. Project **slide K**. Read through the prompts and questions. Ask students to share their predictions from last class.

Key Ideas

Purpose of this discussion: Students will revisit their predictions about how different levels of physical activity would impact the chemical reactions occurring in the cells of the body that provide the body with energy.

*** Supporting Students in Engaging in Obtaining, Evaluating, and Communicating Information**

Students have gathered some evidence to make the claim that the body uses more energy during times of activity than at times of rest. They identify data that they

Listen for these ideas:

- Cells in the heart, lungs, and brain require the most energy.
- Increased physical activity, such as running, causes the muscles to need more energy than when the body is at rest.
- Increased mental activity, such as studying, causes the brain to need more energy than when the brain is at rest.

Additional Guidance

It is important that at least one student brings forward the idea that increased physical activity may cause certain parts of the body to require more energy and, therefore, more oxygen and glucose. If students do not come up with these ideas right away, prompt them to think about the times during which they used up a lot of energy. Ask students to think about what they were doing in those moments. They will likely say that they were exercising or working hard on a project that required a lot of mental energy. Capitalize on these ideas and help move students toward the connection to the body parts (muscles, brain) that needed more energy.

Suggested prompts	Sample student responses
Which cells in which parts of the body do you think would need to use the most energy during a typical day?	*maybe your heart or lungs* *maybe your brain*
What if you were running or jogging? Why?	*Your muscles. Because they are moving more.*
What if you were studying? Why?	*Your brain because that part of you is doing a lot, but the rest of your body isn't.*

Say, *What claim can we make about our predictions for how an increase in physical or brain activity might impact which cells in the body would need to use the most energy? Write a claim in your science notebook.**

Brainstorm ideas for data that we would need to find this out. Project **Slide L**. Have students turn and talk with a partner for a minute to brainstorm ideas.

Suggested prompts	Sample student responses
What kind of data might be helpful for us to figure out which cells in which parts of the body use the most energy during a typical day?	*maybe glucose data or energy-use data for cells in different tissues* *maybe oxygen or carbon dioxide in the blood of different tissues*
What kind of data would we need to see if exercise or studying changed how much energy cells need?	*We need to measure the energy use of different tissues, like the muscles or brain, during different activities.*

need to analyze and clarify this claim. In the next activity, students will examine the effects of exercise on oxygen and glucose levels in the body. Students will be able to assume that, if more of the reactants (glucose and oxygen) are used and more energy and carbon dioxide (products) are produced, the cells in some parts of the body are requiring more energy when active than when they are at rest. Students are then able to clarify their claims to reflect this new information.

Suggested prompts	Sample student responses
How would knowing the amount of oxygen or glucose used by the cells in different tissues in the body help us check our predictions?	*The amount of oxygen or glucose used by the cells should be related to the amount of energy they need. Oxygen and glucose are both needed for the chemical reaction that produces energy in the body.*
What other data could we use to determine which cells in different tissues are using glucose to make energy?	*We would want to see where and when oxygen and glucose are being used in the body.*

7. Interpreting Activity Data

20 MIN

Materials: science notebook, *Interpreting Activity Data - Part 2*, tape

Introduce the oxygen data. Tell students that we're going to look at data that show the amount of oxygen that the cells in different organs use for the chemical reaction that releases energy from food when the body is at rest.

Make observations about the use of oxygen in different organs at rest. Present **slide M**. Ask students to first share patterns they notice and then share what these patterns tell them about the energy needs of cells in those organs.

Suggested prompts	Sample student responses
What patterns do you notice?	*Muscles use the most oxygen and the brain the second most.*
How does this data support the claim that food is being used for fuel in all the cells inside our bodies?	*We know from Lesson 11 that oxygen and fuel are needed for the "burning" chemical reaction and that a product of that reaction is carbon dioxide. That's how our cells get energy, and we know from a previous unit that every part of our bodies is made up of cells. The graph shows that all different parts of our bodies are using oxygen, so we can assume that a chemical reaction is happening in all of the cells inside our bodies.*
Why would cells in some of these organs be consuming more oxygen than cells in other organs?	*They need more energy. These organs are used more, so they are more active.*
Why would heart cells need energy? To do what?	*to help the heart beat and to pump blood*
Why would brain cells need energy? To do what?	*to help us think and figure things out*
Why would cells in the digestive system need energy? To do what?	*to help us break down food*
Why would cells in our muscles need energy? To do what?	*to help us move*

Make predictions about the energy needs of cells during increased activity. Project **slide N**. Help students make predictions about glucose and oxygen levels in the blood during periods of increased activity and connect this to the needs of cells.

Suggested prompts	Sample student responses
Do you think these percentages would stay the same when you exercise?	*No. When our muscles are active, they may need more oxygen to produce more energy.*
What do you predict would be the effect of exercising on the amount of glucose in our blood?	*The amount of glucose should start decreasing because glucose is the fuel for the chemical reaction that produces energy in the cells.*
What effect do you predict eating would have on glucose levels in our blood?	*Glucose levels would probably increase after eating because glucose gets absorbed into the bloodstream during digestion.*

Introduce students to the glucose data. Remind students that we decided the cells inside our bodies are using glucose and oxygen to provide us with energy. Tell students we're going to look at blood glucose levels throughout the day and decide how changes in glucose levels give us information about the energy needs of different body parts.

Divide students into groups to analyze the graph. Present **slide O**. Pass out copies of *Interpreting Activity Data - Part 2*. Have students analyze the graph using the I^2 sensemaking strategy and answer the questions below it. Have students tape this handout into their science notebooks.

Additional Guidance

The Identify and Interpret (I^2) strategy was introduced in Lesson 2 and revisited in Lesson 4.

Lead a whole-class Building Understandings Discussion to make sense of the graph together.

Key Ideas

Purpose of this discussion: Students will draw connections between what they have gleaned from the oxygen and glucose data to explain that increased activity, either physical or mental, increases the need for energy in certain parts of the body. Therefore, oxygen and glucose are needed more in those parts of the body so that a chemical reaction can occur.

Listen for these ideas:

- Glucose levels go up after eating.
- Exercise causes glucose levels to decrease more rapidly because the glucose is being used to provide energy.
- Certain cells in the body, such as those in the heart, lungs, and muscles, need more energy when exercising, so more glucose is burned.

Suggested prompts	Sample student responses
Earlier, you predicted what the effect of eating and exercising would be on glucose levels in the body. How did the data you examined support or refute your predictions?	*We predicted that the blood glucose levels would increase after eating and decrease after exercising. We were correct!*
So, to summarize, what happens to glucose levels right after you eat?	*Glucose levels increase after each meal.*
What is different about how glucose levels change when you exercise after meals versus when you don't?	*Glucose levels increase after meals, but not as much as when you don't exercise. The glucose level decreases more quickly between meals when you exercise versus when you don't.*
What does this tell us about the rate of the chemical reaction between food and oxygen during exercise?	*Glucose must be getting used up more quickly when you exercise versus when you don't.*
Why would more of that reaction need to occur when we exercise?	*We need more energy when we exercise, so we would have to burn more glucose to provide that.*
Which cells in your body do you think are burning glucose to get energy when you're running?	*Your muscles to move, heart to beat faster, and lungs to breathe faster.*

Say, *Revisit the claim you wrote down in your science notebook about the impact of an increased activity level in the body or brain on the parts of the body that need the most energy. Take into account what you've figured out from the data you analyzed and clarify your claim.*



8. Facilitate Consensus Discussion and update the 3-column Progress Tracker. 15 MIN

Materials: science notebook, *Progress Tracker*, chart paper, markers

Facilitate a Consensus Discussion in a Scientists Circle. Have students bring their science notebooks with them.

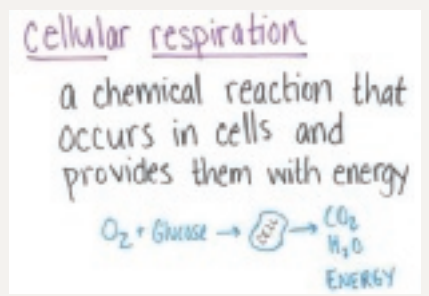
Project **slide P** and ask students to contribute their ideas to the questions below with the whole class to determine what they've figured out and what they want to represent in their 3-column Progress Trackers. If time is short, you may want to record the ideas that students share directly on chart paper in a public space (e.g., poster), showing what the class agrees needs to go into their 3-column Progress Trackers.

Suggested prompts	Sample student responses
What chemical reaction is happening in the cells of our bodies that uses food as fuel?	*Our cells are burning food as fuel.*
What does this reaction provide to the cells of our bodies?	*It provides energy to the cells of our bodies.*

*** Attending to Equity**
When new scientific words, like "cellular respiration," are introduced, it can be helpful for Emergent Multilingual students to see a reference to those words added to a word wall.

Here is one possible representation:

Suggested prompts	Sample student responses
How do reactants (oxygen and small food molecules like glucose) get into the body and to cells?	*Cells have doors in their cell membranes that small molecules can pass through.*
How do products (carbon dioxide and water) leave the cells and the body?	*Cells have doors in their cell membranes that small molecules can pass through.*
How do our energy needs affect the reaction? Do our cells always need the same amount of energy?	*When we exercise, certain parts of our body need more energy, so the reaction happens more and uses up more glucose. When we're resting, the reaction happens less, so we use less glucose.*
How are our circulatory and respiratory systems involved in providing the reactants to the cells and in removing the products from them produced by this chemical reaction?	*Oxygen enters the body through the lungs and then is pumped around to all the cells through the blood. Carbon dioxide is released in the reaction. It leaves the body through the blood, and then we breathe it out through our lungs.*
How does this help explain how the digestive, circulatory, and respiratory systems might be connected?	*The digestive system processes the food we eat and breaks it down so that small food molecules like glucose can pass into the blood to be fuel for cells to burn. The respiratory system brings oxygen into our bloodstream. The circulatory system delivers the glucose and oxygen to different parts of the body so that a chemical reaction can occur where the body needs energy. The circulatory system returns the products to the respiratory system so that they can be breathed out through the lungs.*



Name the chemical reaction that occurs in cells and provides them with energy as "cellular respiration."

Say, *It seems that we are in agreement that there is a chemical reaction occurring in cells that provides the cells with energy. Scientists call this type of chemical reaction "cellular respiration." Let's add this to our word wall.**

Alternate Activity

If students aren't able to make connections between the circulatory and respiratory systems, ask them, "How do oxygen and glucose get to the cells? How does the carbon dioxide get out of the cells and our bodies?"

Remain in a Scientists Circle to update the 3-column Progress Tracker. Project **slide Q**.

Ask students to argue from evidence for how what we figured out helps explain (1) whether a chemical reaction between food and oxygen happens in our bodies and, if so, (2) how our energy needs affect the reaction.

Ask students to share ideas for how to represent the chemical reaction happening in the cells, how the reactants get to the cells, and how the products leave the cells and body.

As a class, come to a consensus for how to update the 3-column Progress Tracker to represent these ideas and record what you agree upon on a class 3-column Progress Tracker/chart paper in a public space (e.g., on a poster).

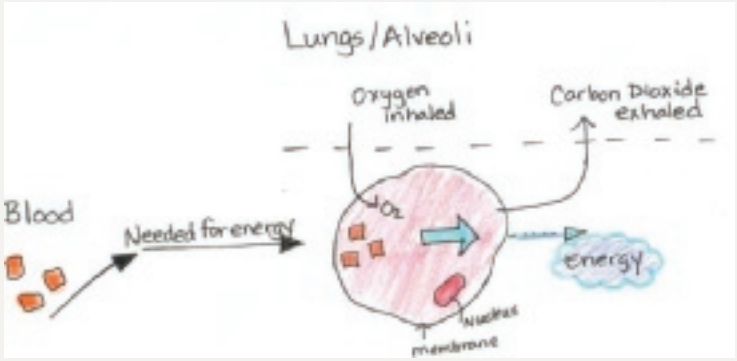
Have students add these ideas to their individual 3-column *Progress Tracker* along with the lesson question and sources of evidence that have led to these findings.

Here is one suggested representation:

Question	Source of evidence
12. Does this chemical reaction between food and oxygen happen in our bodies (and if so, how do our energy needs affect the reaction)?	• BTB indicator and color changes from the air we exhale • Images of respiratory system and alveoli • O_2 and CO_2 data in the bloodstream • Glucose levels in the bloodstream • Graphs of oxygen used by different parts of the body

What I figured out in words/pictures

There is a chemical reaction happening in our cells that rearranges food (glucose) in our blood and oxygen into carbon dioxide and water. In that process, called cellular respiration, energy that the cells can use while at rest or when active is released. Cells use more glucose and more energy when we're active. Oxygen gets to cells when it is inhaled through the lungs and goes from the blood to the cells. Carbon dioxide leaves the cells, is transported through the blood, and is exhaled through the lungs.



9. Navigation: Taking Stock

3 MIN

Materials: *Revisiting Symptoms and Systems*

Say, *We need to celebrate! We've figured out some really important science ideas about the way that our body systems work together. Now I think we're ready to connect our understanding to some of M'Kenna's other symptoms.*

Present **slide R**. Assign home learning to be completed before the next lesson: Students should revisit *Symptoms and Systems*, which they should have taped into their science notebook. Pass out *Revisiting Symptoms and Systems* to students and have them copy some of the non-digestive symptoms they listed in part 2 of the table in *Symptoms and Systems* into the blank table at the top of *Revisiting Symptoms and Systems*. Instruct students to choose some of the symptoms and try to connect them to some of what they've figured out about the way the body systems are interconnected.

Tell students that, in the next class, we will use the ideas that they identify as important criteria in an explanation that will help us build models to explain what is happening inside M'Kenna.

Home Learning Opportunity



In this home learning assignment, students begin to take stock of how what they've figured out in Lessons 9–12 could help explain what's going on with M'Kenna's non-digestive symptoms. This prepares them for putting all the pieces together in Lesson 13. Remind students to use evidence they've gathered in Lessons 9-12 to support their ideas.

LESSON 13

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

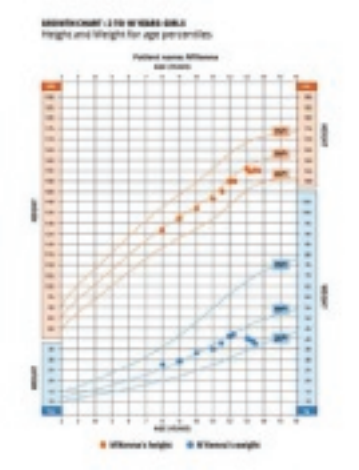
Previous Lesson

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

This Lesson

Putting Pieces Together

2 DAYS



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

Next Lesson

We will investigate different organisms and argue from evidence whether (1) our organism does chemical reactions to break down and burn food molecules and (2) it has the same structures inside its body that work together to do those processes. Then we will come together to share our findings and generalize across organisms.

Building Toward NGSS

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

What Students Will Do

Develop models of three possible pathways showing how food is rearranged in the body to create energy, store matter for later use, and use matter for growth within a body system.

Construct an explanation to explain the relationships between differences in M'Kenna's digestive system and a healthy digestive system in order to predict symptoms (effects), such as M'Kenna's decreased growth rate.

What Students Will Figure Out

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

Lesson 13 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	10 min	**NAVIGATION AND REVIEW THE PROGRESS TRACKER FROM LESSONS 8-12** Review the ideas we've figured out so far on the Progress Tracker that might help us answer our questions about how the body uses food for energy, and what we have noticed so far in our investigations.	A-C	Progress Tracker, highlighter
2	15 min	**DEVELOP SMALL-GROUP MODELS TO EXPLAIN HOW A HEALTHY BODY USES FOOD** Develop small-group models to explain: "How do our bodies use food not needed right now? How do our bodies use food needed for growth?"	D	chart paper, markers, *Three Pathways Inside Our Bodies*
3	8 min	**COMPARE MODELS WITH ANOTHER SMALL GROUP** Have students compare their models with another small group.	E	small-group models
4	7 min	**START TO BUILD A CLASSROOM CONSENSUS MODEL** Have students share similarities and differences in their models and come to a consensus. Visually represent the classroom consensus model on the board or a poster.	F	*Three Pathways Inside Our Bodies*, colored pencils, chart paper, markers

End of day 1

5	15 min	**CONTINUE TO BUILD A CLASSROOM CONSENSUS MODEL** Have students come to a consensus on pathways 2 and 3 and visually represent the classroom consensus model on the board or a poster.	F-J	*Three Pathways Inside Our Bodies*, colored pencils, chart paper, markers
6	15 min	**CONNECT WHAT WE'VE FIGURED OUT TO M'KENNA'S OTHER SYMPTOMS** Review M'Kenna's symptoms and explain how they might be connected to what we've figured out.	K	
7	13 min	**DEVELOP INDIVIDUAL EXPLANATIONS FOR M'KENNA'S OTHER SYMPTOMS** Have students individually use the consensus model and *Gotta-Have-It Checklist* to write an explanation of how a shortage of food entering M'Kenna's bloodstream could have caused her other symptoms.	L	colored pencils, consensus model
8	4 min	**ADD TO OUR PROGRESS TRACKERS** Using the classroom consensus model, students individually add to their 3-column Progress Tracker or *Gotta-Have-It Checklist*.	M	*Progress Tracker*, colored pencils
9	3 min	**HOW IS M'KENNA NOW? (OPTIONAL)** Conclude the class investigation into M'Kenna's symptoms by learning more about who M'Kenna is and how she is doing now.	N	*Who is M'Kenna, and what happened to her?*

End of day 2

Lesson 13 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• science notebook • Progress Tracker • highlighter • chart paper • markers • *Three Pathways Inside Our Bodies* • colored pencils • *Progress Tracker* • *Who is M'Kenna, and what happened to her?*	• small-group models	• chart paper • markers • consensus model

Materials preparation (25 minutes)

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

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

Gather materials for the classroom consensus model.

Make extra copies of *Three Pathways Inside Our Bodies* for students to use in small-group modeling and again while developing the consensus model.

Online Resources



Lesson 13 • Where We Are Going and NOT Going

Where We Are Going

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

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

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

Where We Are NOT Going

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

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

LEARNING PLAN FOR LESSON 13

1. Navigation and review the Progress Tracker from Lessons 8-12. 10 MIN

Materials: science notebook, Progress Tracker, highlighter

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

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

Additional Guidance

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

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

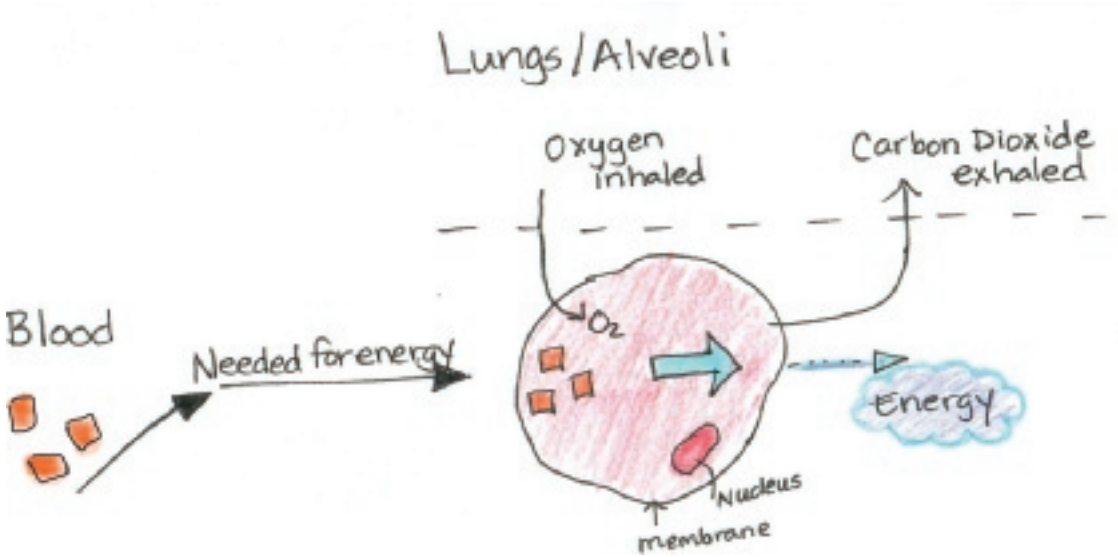
Record a Gotta-Have-It Checklist of agreed-upon ideas from the Progress Tracker that students nominate. Project **slide B**. As a class, determine which ideas from the list seem as though they will be the most useful for our current question. Students can put a check mark near their own version of that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

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

Additional Guidance

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

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



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

- "How do our bodies use food for energy?"

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

Suggested prompt	Sample student response
How a healthy body uses food for energy is a piece of the puzzle we've been figuring out! What happens to small food molecules, like glucose, after they are absorbed by the body?	*They go into the bloodstream. We saw that in the simulation and images of the small intestine.*

Suggested prompts	Sample student responses
How do food molecules get to the cells?	*Food molecules go into the blood which goes to cells. We saw this in the simulation.*
What happens to food molecules once they reach a cell? What evidence do you have to support this idea?	*In a healthy body, the cell uses oxygen to burn the food, which produces energy that the body can use. This is a chemical reaction. We saw that this could happen outside of the body when we burned the food. We inferred that it happens in the body when we exercised and breathed out less oxygen and more water and carbon dioxide.*
How does oxygen for the chemical reaction get to the cells?	*Oxygen goes into the blood from the lungs.*
What is left over from the chemical reaction, and how does it leave the body?	*Carbon dioxide and water are produced. They leave through the blood and lungs, and then people breathe those out. We saw evidence for this when we saw our breath change the color of the BTB solution. We also saw that data that tracked carbon dioxide and oxygen levels in the blood. The oxygen levels decreased at the same point that carbon dioxide increased in the body due to the chemical reactions occurring to burn food.*

2. Develop small-group models to explain how a healthy body uses food. 15 MIN

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

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

Suggested prompt	Sample student response
After we checked in on the DQB, we were focused on figuring out one particular non-digestive symptom of M'Kenna's. What was that again? (If students need extra help, ask them to recall the growth charts they analyzed.)	*We were trying to figure out—why was M'Kenna losing weight and not growing?*

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

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

Prepare to build small-group models. Project **slide D**. Have students record those questions in the next two blank lines on *Three Pathways Inside Our Bodies*. Once students have reviewed what we're trying to explain and the ideas that can help us, get them ready to build their small-group models.

Students will create three total pathways to represent: (1) how the body uses food for energy, (2) how the body uses food not needed right now, and (3) how the body uses food for growth. Students already developed the first model to show how the body uses food for energy.

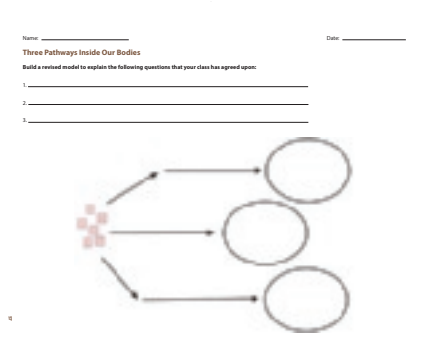
Work in small groups to develop a model to explain how a healthy body uses food not needed right now (pathway 2) and food needed for growth (pathway 3). While students are working, walk around the room and look at their models. Where needed, use questions to help students fully articulate their thinking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

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

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

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

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


Name: _____ Date: _____

Three Pathways Inside Our Bodies

Build a revised model to explain the following questions that your class has agreed upon:

1. _____
2. _____
3. _____

Additional Guidance

Prompts for eliciting and probing student proposals for what should go in the model:

- How did your group explain what happens to food molecules not used right away?
- How could the food molecules be used to support growth?
- Where does growth occur inside the body?
- What parts inside the body are developed when you are growing?
- What evidence do you have to support your idea(s)?
- How should we represent this?

Prompts to ask students to support or challenge proposals:

- What ideas are we in agreement about?
- Are there still places where we disagree? Can we clarify these?
- Are there still areas of confusion or discontent?
- Who feels like their idea is not quite represented here?

3. Compare models with another small group. 8 MIN

Materials: science notebook, small-group models

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

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

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

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

Additional Guidance

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

4. Start to build a classroom consensus model. 7 MIN

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

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

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

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

*** Attending to Equity**
Not all students are comfortable being the "only one" who voices a disagreement or a potentially wrong idea. Ask students to think about what they heard their group members saying, and ask the room if *their group members'* ideas are represented in the class discussion. This supports all students to share, to listen, to be heard, and to be represented.

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

Key Ideas

Purpose of this discussion: At the end of this learning set, the purpose of this Consensus Discussion is to build a common, class-level model to explain how a healthy body uses food, drawing on all the ideas learned in Lessons 8–12. The teacher's role is to prompt students to share what needs to be in the model, evidence they have to support their ideas, and how to represent it. The students' role is to offer proposals for a model, support or challenge proposals, and come to a consensus about what should be included in the model.

Look for these ideas to include in the class's Gotta-Have-It Checklist:

- The digestive system takes in food and breaks it down through chemical reactions, and the small food molecules get absorbed into the body's circulatory system through the small intestine.
- The respiratory and circulatory systems work together to bring food molecules and oxygen to cells in the body and to remove carbon dioxide.
    - Some organs in the respiratory system that work together include the following: nose, mouth, and lungs.
    - Some organs in the circulatory system that work together include the following: blood and heart.
        - The blood moves food molecules to cells (optional).
        - The blood brings oxygen to cells from the respiratory system (optional).
        - The blood removes carbon dioxide and water from cells through the respiratory system (optional).
- Humans need to take in food. Food is a type of fuel, which means that it can react with other substances to release energy.
- Cells rearrange food and oxygen through a chemical reaction, which creates carbon dioxide and water and releases energy that cells can use.
- The body system's inputs are food (molecules mainly with C,H,O's) and oxygen. The outputs are mainly carbon dioxide, water, and energy (students might also include poop, which is mostly fiber and water).
  Facilitate a Consensus Discussion about how a healthy body uses food not needed right now (pathway 2). Students should offer proposals for what should go in the model, support or challenge these proposals based on evidence, and propose modifications.

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

End of day 1

5. Continue to build a classroom consensus model. 15 MIN

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

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

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

Additional Guidance

Prompts for eliciting student proposals for what should go in the model:

- What is one of the key components of your model that explains how the body uses food?
- What evidence do you have to support your idea?
- How should we represent this?

Prompts to ask students to support or challenge proposals:

- What ideas are we in agreement about?
- Are there still places where we disagree? Can we clarify these?
- Are there still areas of confusion or discontent?
- Who feels like their idea is not quite represented here?

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

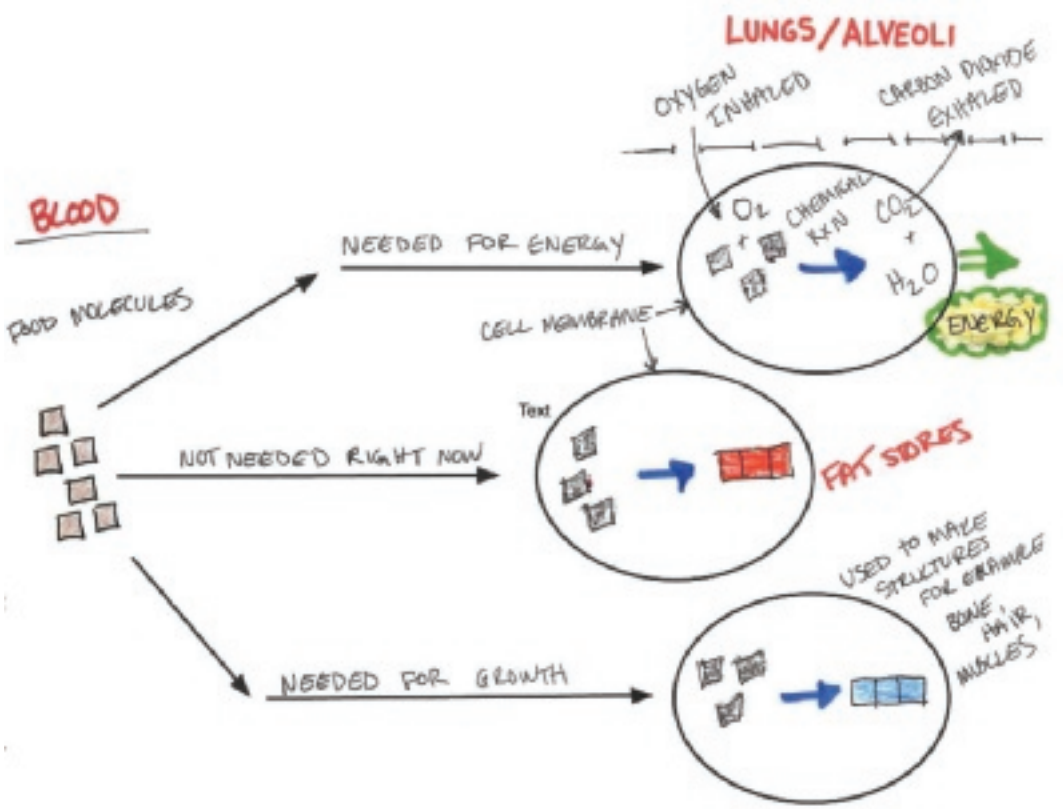
- How are these explanations similar? How are they different?
- How could we modify what we have so that we account for the evidence we agree is important to consider?
- Is there more evidence or clarification we need before coming to an agreement? What is that?

Have students record the final representation of the classroom consensus model on *Three Pathways Inside Our Bodies*. Your representation will look something like the next image, but representations can vary. The main idea is to establish a pathway so that food molecules can become fat stores or be used for growth, muscle building, nutrients for cells between meals, and so forth. Add these additional details if it seems to make sense for your model, even though students will not have evidence to back up those details at this point in the unit.

*** Strategies for This Building Understandings Discussion**

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

- Is there evidence we've seen that fat can be a fuel?
- What other explanation can explain a person losing weight from their body?
  - If fat turned to energy, what happened to all the carbon, hydrogen, and oxygen atoms?
  - If fat turned to sweat, which is mostly water, what would happen to the carbon atoms?



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

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

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

Then say, *But, does M'Kenna have a lot of food molecules in her blood?* (Refer to squares representing the food molecules, such as glucose).

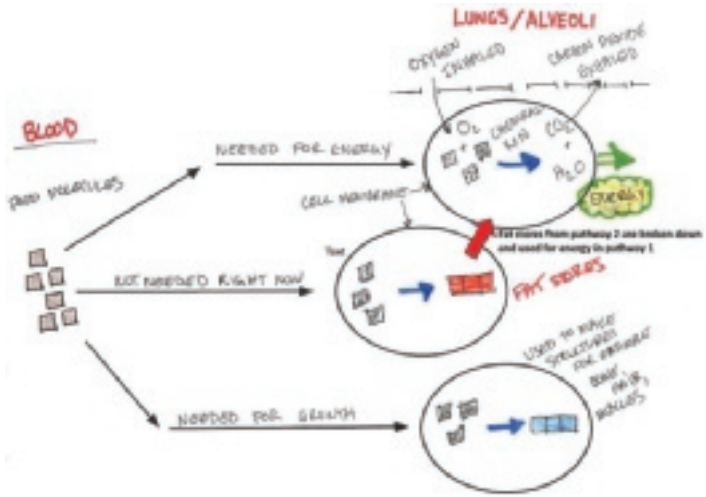
Have students Turn and Talk to a partner about the question on the slide. Present **slide G**. Students should talk about the question, "Does M'Kenna have a lot of food molecules in her blood; why or why not?"

Have students share their thoughts with the whole group.

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

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

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



Suggested prompts	Sample student responses
So what if her body ran out of fat stores? Where might her body use energy from instead?	*She could use the food molecules going to growth in pathway 3.* *Oh! Maybe that's why she stopped growing, too!*
Could our cells use fat instead of glucose? Let's check out their molecular structures to see how similar or different they are to one another.	

Compare a glucose molecule and a fat molecule. Present **slide I** or pull out the food molecule cards. Have students quietly make observations about the similarities and differences between the fat and glucose molecules.

Report out similarities and differences between glucose and fat molecules. After about 1 minute of think time, pull students together to report out some of the similarities and differences that they noticed.

Prompt students to consider whether they think that, based on their examination of molecules and the evidence collected in previous investigations, our cells can use fat for energy. Encourage students to support their ideas with evidence and to ask questions of one another's ideas or present alternative ideas. If students present alternative explanations, prompt them to trace the atoms to fully explain where the *stuff* goes in their explanation.

Additional Guidance

The citric acid cycle is a key metabolic pathway that the body can use to metabolize carbohydrates, fats, or even proteins for energy usage. Understanding the specifics of that pathway are beyond grade-band. Instead, the emphasis is on describing that (food) molecules are broken apart and put back together and that, in this process, energy is released.

Suggested prompts	Sample student responses
What did glucose have in it?	*carbon, hydrogen, and oxygen*
What are the differences between glucose and fat molecules?	*Fat is bigger than glucose.* *Fat has long chains, and glucose is more compact (and/or round).*
What are similarities between glucose and fat molecules?	*They are both made from carbon, hydrogen, and oxygen atoms.* *They are both molecules found in foods.* *They burned when we tested them.*
What do you think about this question now? Do you think a fat molecule stored in our arm, leg, or stomach could be used as fuel for a chemical reaction?	*Probably, because the duck fat was a fuel and vegetable oil was a fuel. If it has carbon and hydrogen, it can provide the same reactants for the chemical reaction.*

Suggested prompt	Sample student response
So, where does the matter go when a person loses weight?	*When someone loses weight, they burn fat. We learned that when you burn fat the products are carbon dioxide, which is breathed out, and water. So I guess we mostly breathe the matter out into the air!*

Update the class Gotta-Have-It Checklist. Project **slide J**. Summarize the class findings and update the class Gotta-Have-It Checklist with these additional ideas:

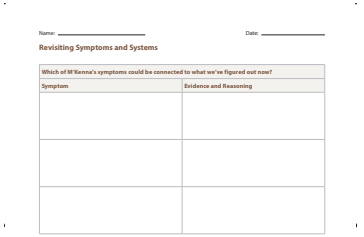
- When the body takes in excess food, it can be stored for later in the form of fat molecules in the body.
- When the body doesn't take in enough food, it can use the stored fat or food molecules dedicated for growth to burn as fuel. Most of the matter goes into the air when fat is burned.

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

6. Connect what we've figured out to M'Kenna's other symptoms. 15 MIN

Materials: science notebook

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


Name: _____ Date: _____

Revisiting Symptoms and Systems

Which of M'Kenna's symptoms could be connected to what we've figured out now?	
Symptom	**Evidence and Reasoning**

Suggested prompt	Sample student responses
Which of M'Kenna's symptoms could be connected to what we have figured out?	*We think that weight loss, fatigue, rapid heartbeat with exercise, brain fog, and difficulty breathing with exercise may all be related because they all have to do with cells using energy.* *Last lesson we saw that some cells need more energy than others. For example, muscles need the most, then the digestive organs, then the brain. When you exercise, your muscles would need to use up more oxygen for the chemical reaction to provide energy for the cells in our muscles to use.*

Suggested prompts	Sample student responses
What would you predict would happen if your muscles couldn't get enough energy?	*We'd get tired. We would also get sore muscles.* *Maybe that's why we start breathing faster!?*
You said that other organs in our body, like our brain and heart, also need energy. What do you think would happen if those didn't get enough energy either?	*Maybe our brain would get tired, too?* *Our heart would beat faster. Maybe our heart gets tired?*
How might M'Kenna absorbing less food be related to her feeling fatigued and tired?	*She's not absorbing as much food in her small intestine.* *She's using food as fuel in the same way; but she just doesn't have as much food, so she can't get as much energy.*
What parts of her body need energy that might not be getting enough, which could be related to her symptoms?	*her brain, her muscles, and her heart*

7. Develop individual explanations for M'Kenna's other symptoms.

13 MIN

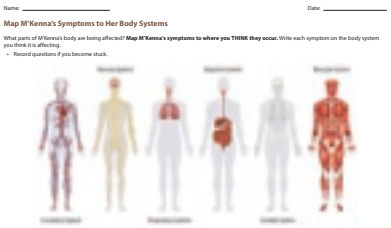


Materials: science notebook, colored pencils, consensus model

Project **slide L**.

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

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



Name: _____ Date: _____

Map M'Kenna's Symptoms to Her Body Systems

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

- Record questions if you become stuck.

Alternate Activity

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

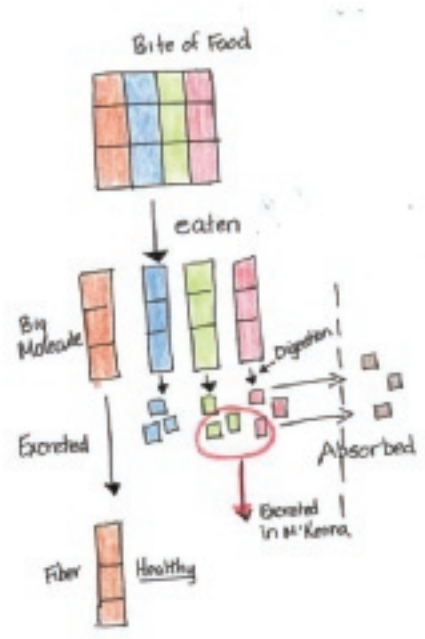
Bring the class together to share out potential connections. By the end, each body system should have its own short explanation for how a food shortage in M'Kenna might be connected to the related symptoms in that body system. Invite different students to share out with the whole class.

Assessment Opportunity

An example of a connection students might make is having students think about how her slowed growth rate would help them connect this symptom to the skeletal system. They could refer back to the article they read in Lesson 10 about how kids need more fat in their diets because they use it for growth. If M'Kenna is using fat to maintain daily functions because she's not getting enough from her food, this could cause her to lose weight. As a result, as she uses up her fat stores, she would have a slowed growth rate because she's using everything already in her body for daily functions needed by cells. Evidence of this was shown in her weight and height growth charts. So, food molecules going into pathways 2 and 3 would get shut down so that pathway 1 could continue.

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

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

Left side of science notebook	Right side of science notebook
	

Key Ideas

Here is a final version of the Gotta-Have-It Checklist ideas students might use in their explanations:

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

8. Add to our Progress Trackers.

4 MIN

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



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

Alternate Activity

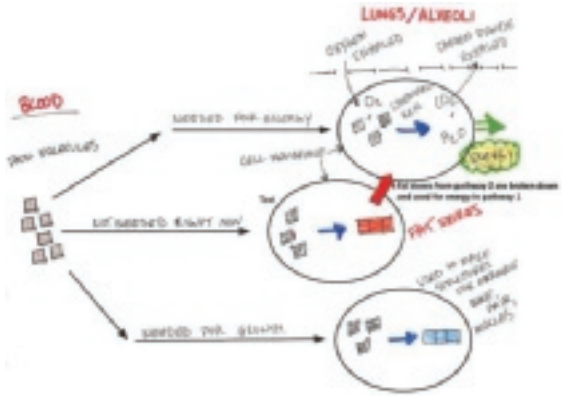
Instead of using the 3-column Progress Tracker in this lesson, you can choose to have students tape in their updated *Gotta-Have-It Checklist* in their notebooks in the Progress Tracker section for Lesson 13.

Below is one suggested representation for the Progress Tracker. Students will come back to their Progress Trackers again and add a second question.

Question	Source of evidence
How does a healthy body use food for energy needed now? Needed for growth? Not needed now? How did M'Kenna's body function differently?	• Evidence for all investigations in Lessons 1-12

What I figured out in words/pictures

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



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

9. How is M'Kenna now? (OPTIONAL)

3 MIN

Materials: *Who is M'Kenna, and what happened to her?*

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

Alternate Activity

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

LESSON 14

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

Previous Lesson

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

This Lesson

Investigation

1 DAY



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

Next Lesson

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

Building Toward NGSS

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

What Students Will Do

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

What Students Will Figure Out

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

Lesson 14 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Motivate needing to look at how other animals, besides humans, get energy to do the things they need to do.	A-B	Gotta-Have-It Checklist from Lesson 13
2	15 min	**RESEARCH ABOUT YOUR ANIMAL** Students read about other organisms and use their Gotta-Have-It Checklists to argue whether their animal gets energy in the same way as humans do.	C-D	*Investigating Other Animals*, computer access (optional), two pieces of chart paper, markers
3	8 min	**GALLERY WALK TO COMPARE ACROSS ORGANISMS**	E	*Peer Feedback Guidelines*, *Self-Assessment: Giving and Receiving Feedback*
4	12 min	**CONSENSUS DISCUSSION ABOUT OUR ANIMALS**	F	arguments on chart paper
5	3 min	**PROGRESS TRACKER: WHAT HAVE YOU FIGURED OUT?** Allow students to add what they have figured out to their Progress Trackers.	G	Progress Tracker
6	2 min	**NAVIGATION** Transition to the next lesson and assign home learning to look back at DQB questions.	H	*Let's Answer Questions from Our DQB!*
				End of day 1
		SCIENCE LITERACY ROUTINE Upon completion of Lesson 14, students are ready to read Student Reader Collection 5 and then respond to the writing exercise.		Student Reader Collection 5: *Built from Food.*

Lesson 14 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• science notebook • Gotta-Have-It Checklist from Lesson 13 • *Investigating Other Animals* • computer access (optional) • *Peer Feedback Guidelines* • *Self-Assessment: Giving and Receiving Feedback* • Progress Tracker • *Let's Answer Questions from Our DQB!*	• two pieces of chart paper • markers • arguments on chart paper	

Materials preparation (25 minutes)

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

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

Gather the classroom consensus model and Progress Tracker developed in Lesson 13. Prepare *Let's Answer Questions from Our DQB!* with questions from the Driving Question Board for students to evaluate. You can also update the handout started in Lesson 8 for Driving Question Board questions.

Online Resources



Lesson 14 • Where We Are Going and NOT Going

Where We Are Going

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

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

Where We Are NOT Going

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

LEARNING PLAN FOR LESSON 14

1. Navigation

5 MIN

Materials: science notebook, Gotta-Have-It Checklist from Lesson 13

Problematize the next lesson question.

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

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

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

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

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

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

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

Key Ideas

The Gotta-Have-It Checklist should have these key ideas:

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

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

2. Research About Your Animal

15 MIN

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

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

Additional Guidance

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

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

*** Attending to Equity**

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

Additional Guidance

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

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

Use the Gotta-Have-It Checklist to construct an argument in small groups. Place students in like-animal groups. For example, everyone who chose to research about dogs should sit together. Groups of no more than 3-4 students is recommended. Present **slide D**. Have students construct two arguments in response to these two questions:

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

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

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

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

Does your organism:

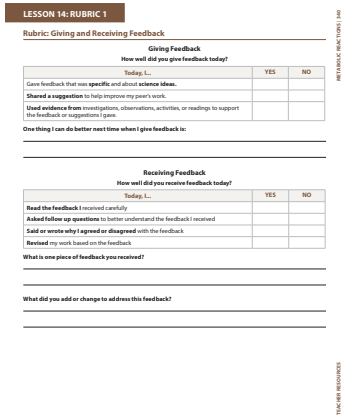
1. Obtain energy from eating food?
2. Have the same inputs and outputs of metabolic reactions as humans?
3. Have the same structures and body systems involved in these processes as humans?

3. Gallery Walk to Compare Across Organisms

8 MIN

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

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


LESSON 14: RUBRIC 1

Rubric: Giving and Receiving Feedback

Giving Feedback

How well did you give feedback today?

Today, I...	YES	NO
Gave feedback that was **specific** and about **science ideas.**		
Shared a suggestion to help improve my peer's work.		
Used evidence from investigations, observations, activities, or readings to support the feedback or suggestions I gave.		

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

Receiving Feedback

How well did you receive feedback today?

Today, I...	YES	NO
Read the feedback I received carefully		
Asked follow up questions to better understand the feedback I received		
Said or wrote why I agreed or disagreed with the feedback		
Revised my work based on the feedback		

What is one piece of feedback you received?

What did you add or change to address this feedback?

METABOLIC REACTIONS | 280

TEACHER RESOURCES

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

*** Supporting Students in Engaging in Argument from Evidence**
For additional ideas for peer feedback to support argumentation from evidence, refer to Ambitious Science Teaching Tools (See the **Online Resources Guide** for a link to this item.)

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

4. Consensus Discussion About Our Animals

12 MIN

Materials: science notebook, arguments on chart paper

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

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

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

*** Supporting Students in Three-Dimensional Learning**

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

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

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

Suggested prompts	Sample student responses
Let's think about this second question with our structure and function lens. Do all of our organisms have the same structures inside their bodies that work together to break down and burn food for energy?	*No, a lot of animals had different structures compared to humans. But it did seem like the structures were still doing the same functions!*
What's your evidence?	*For example, we found out that a shark needs oxygen and gives off carbon dioxide like humans, but it just uses gills instead of lungs to exchange those gases in the water.* *Also, a spider does chemical reactions to break down food, but it actually starts that process before it even eats! We humans have digestive enzymes in our mouths and other organs in our digestive system, but a spider squirts digestive enzymes on the food to break it down and then eats it.* *Many other examples are possible.*
Wow! So all animals take in food and oxygen, break it down, and rearrange it through chemical reactions, which make carbon dioxide and water and release energy that their cells can use; but they have different structures involved to do the same basic thing.	*Yeah! It's kind of crazy to think we are doing the same basic processes to get energy as a jellyfish or a spider!*

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

5. Progress Tracker: What have you figured out?

3 MIN

Materials: Progress Tracker

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

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

6. Navigation

2 MIN

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

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

Present **slide H**. Next, the class will revisit their Driving Question Board and celebrate all that they have figured out.

Assign reviewing the DQB questions for home learning. Have students evaluate which questions the class has answered from the DQB for home learning. Hand out a copy of *Let's Answer Questions from Our DQB!*, which you created to contain all of the student questions from the DQB, and have students tape it into their science notebooks. You may also have students add to the Lesson 8 version *Revisit Questions from Our DQB!* for which students evaluated their questions at the end of Lesson 8.

Have students mark questions that they think the class has answered by putting different symbols next to each question:

We did not answer this question or any parts of it yet: **o**

Our class answered some parts of this question, or the ideas we developed help me see how I could now answer some parts of this question: ✓

Our class answered this question, or the ideas we developed help me see how I could now answer this question: ✓+

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

Home Learning Opportunity



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

ADDITIONAL LESSON 14 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

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

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

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

SCIENCE LITERACY: READING COLLECTION 5

Built from Food

1 **Nutrition, Growth, and Disease**
2 **All-World Eating Team**
3 **Digesting Protein**

Literacy Objectives

- ✓ Translate information in text to personal experience.
- ✓ Support a position on the importance of eating a balanced diet.

Literacy Exercises

- Read varied text selections related to the topics explored in Lessons 12–14.
- Evaluate the reading selections according to provided prompts and criteria.
- Compare and contrast information gained from reading text with information gained from class investigation.
- Prepare an essay that explains why a balanced diet is important for health in response to the reading.

Instructional Resources

Student Reader



Collection 5

Science Literacy Student Reader, Collection 5
"Built from Food"

Exercise Page



EP 5

Science Literacy Exercise Page
EP 5

Prerequisite Investigations

Assign the Science Literacy reading and writing exercise *after* class completion of this lesson group:

- Lesson 12: Does this chemical reaction to burn food happen inside our bodies?
- Lesson 13: How does a healthy body use food for energy and growth, and how is M'Kenna's body functioning differently?
- Lesson 14: Do all animals do chemical reactions to get energy from food like humans?

Standards and Dimensions

NGSS

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

Disciplinary Core Ideas:

LS1.A Structure and Function

LS1.C Organization for Matter and Energy Flow of Organisms

Science and Engineering Practices: Asking Questions; Constructing an Explanation; Analyzing and Interpreting Data

Crosscutting Concepts: Systems and System Models; Structure and Function

CCSS

English Language Arts

RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

WHST.6-8.1.A
Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.

WHST.6-8.1.B
Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.

Core Vocabulary

Core Vocabulary: Core Vocabulary terms are those that students should learn to use accurately in discussion and in written responses. During facilitation of learning, expose students repeatedly to these terms. However, these terms are not intended for isolated drill or memorization.

diabetes **malnutrition**

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about any concepts in this exercise. Students will benefit from your modeling the use of these words without the expectation that students will use or explain the words themselves.

food insecurity **prevalence**

A Glossary at the end of the Science Literacy Student Reader lists definitions for Core Vocabulary and selected Language of Instruction.

1. Plan ahead.

Determine your pacing to introduce the reading selections, check in with students on their progress, and discuss the reading content and writing exercise. If you are performing Science Literacy as a structured, weekly routine, you might implement a schedule like this:

- Monday: Designate a ten-minute period at the beginning of the week to introduce students to the assignment.
- Wednesday: Plan to touch base briefly with students in the middle of the week to answer questions about the reading, to clarify expectations about the writing exercise, and to help students stay on track.
- Friday: Set aside time at the end of the week to facilitate a discussion about the reading and the writing exercise.

You'll proceed with the in-class lesson investigations during this week.

Exercise Page



EP 5

2. Preview the assignment and set expectations. (Monday)

- Let students know they will read independently and then complete a short writing assignment. The reading selection relates to topics they are presently exploring in their Metabolic Reactions unit science investigations.
- The reading and writing will be completed outside of class (unless you have available class time to allocate).
- Preview the reading. Share a short summary of what students can expect.
  - *In "Nutrition, Growth, and Disease" you will read about what happens to your body if you eat too much of one thing and not enough of another.*
  - *In the second selection, you'll find out what different animals eat and how they get their food.*

- *"Digesting Protein" discusses how to eat the right amount of protein to make efficient use of protein-rich foods in building lean muscle mass.*

- Distribute Exercise Page 5. Preview the writing exercise. Share a summary of what students will be expected to deliver. Emphasize that Science Literacy exercises are brief. The focus is on thoughtful quality of a small product, not on the assignment being big and complex.
  - *For this assignment you will be expected to generate an essay about the importance of a balanced diet.*
- Remind students of helpful strategies they can employ during independent reading. Offer the following advice:
  - *The reading should take approximately 30 minutes to complete.* (Encourage students to break reading into smaller sections over multiple short sittings if their attention wanders.)
  - *A good reading strategy is to scan through the collection first to see the titles, section headers, graphics, and images to see what the selections are going to be about before fully reading.*
  - *Next, "cold read" the selections without yet thinking about the writing assignment that will follow.*
  - *Then, carefully read the Exercise Page to understand the expectations for the writing part of the assignment.*
  - *Revisit the reading selections to complete the writing exercise.*
  - *Jot down any questions for the midweek progress check in class.* (Be sure students know, though, that they are not limited to that time to ask you for clarification or answers to questions.)

3. Touch base to provide clarification and address questions. (Wednesday)

Touch base midweek with students to make sure they are on track while working independently. You may choose to administer a midweek minute-quiz to give students a concrete reason not to postpone completing the reading until the last minute. Ask questions such as these, and have students jot answers on a half sheet of paper:

Suggested prompts	Sample student responses
How can a person have plenty to eat and still be malnourished?	*If you just ate one type of food that didn't have a balance of fats, carbohydrates, and proteins or had "empty calories," you could have plenty to eat but still have an unhealthy diet. Some foods offer no nutritional benefit, so you could still be malnourished.*
How does eating a balanced diet effect your health?	*People who get enough nutrients generally feel better, grow taller and stronger, and have fewer diseases.*
What are some ways that animals eat differently than humans do?	*Many animals eat only one type of food. Some eat other animals, and others eat only plants.*

Suggested prompts	Sample student responses
What do all animal eating habits have in common?	*All animals need to take in food from the environment to survive.*
Why is getting enough protein important in a balanced diet?	*Protein keeps your cells in good shape. It builds bone, muscle, and skin and repairs tissue.*

Ask a few brief discussion questions related to the reading that will help students tie the text content to students' classroom investigations.

Suggested prompts	Sample student responses
Why would it be good to find out what M'Kenna has been eating?	*The food anyone eats affects their health. By studying someone's diet, you can identify what nutrients and types of calories they might be missing.*
How could changing her diet help M'Kenna?	*Changing or adding foods could help find a remedy for her problems.*

- Refer students to the Exercise Page 5. Provide more specific guidance about expectations for students' deliverables due at the end of the week.
  - *The writing expectation for this assignment is to write a persuasive essay that argues the benefits of a balanced diet.*
  - *You will need to find credible sources to find information about what a balanced diet is and supporting evidence of the benefits of eating a balanced diet.*
  - *The important criteria for the work are that the argument is presented logically and includes supporting evidence.*
  - *Make the essay engaging so that people your age will be persuaded to eat balanced diet.*
- Explain that a great essay will be easy to read and understand and have evidence to persuade your readers.
- Answer any questions students may have relative to the reading content or the exercise expectations.

Exercise Page



EP 5

4. Facilitate discussion.

(Friday)

Facilitate class discussion about the reading collection and writing exercise.

The three reading selections in Collection 5 focus on what a balanced diet is, how animals eat, and how a balanced diet effects health and growth. The previous collection focused on calories and how many calories are taken in versus expended as fuel. It is important to eat a balanced diet to avoid malnutrition, which can occur when certain types of nutrients are absent from a person's dietary habits.

Student Reader



Collection 5

Nutrition is important for so many things, such as growth and development. It can also help prevent certain diseases. All animals have different ways that they eat, and they have different diets, too. But they all have one thing in common: they need to obtain food to survive. Protein is an important nutrient for maintaining good nutrition. People—and other animals—enough protein to fuel their cells and their bodies overall.

Pages 44–47 **Suggested prompts**	**Sample student responses**
What is the general purpose of the first selection, "Nutrition, Growth, and Disease"?	*This selection demonstrates that people who eat a balanced diet grow taller, live longer, and feel better than those who do not.* *An unbalanced diet can result in obesity, diabetes, poor growth, and poor health.*
What would happen if you only ate one food, even if it was good for you, like potatoes, eggs, or pineapple?	*You would starve your body of the full range of nutrition it needs for optimal health.* *You could become malnourished.* *You could become sick.*
What does diabetes have to do with nutrition?	*Many times, diabetes can be prevented through good nutrition.* *People who consume too much sugar, like carbohydrates, which put too much demand on the body to turn that food into glucose for the body to use, are at increased risk of diabetes.*
What does growth and height have to do with nutrition?	*Although your family genes affect how tall you will get, if you don't get enough nutrients from a balanced diet, you will not grow as well.*

Pages 48–51 **Suggested prompt**	**Sample student responses**
How does the second selection help you build knowledge on top of what you learned in the first selection?	*"All-World Eating Team" describes what and how different animals eat.* *Many animals eat just one type of food.* *Unlike humans, those foods provide what those animals need to live.* *Humans, on the other hand, need to eat a variety of foods to get all the nutrients that are needed to sustain us.*

SUPPORT—If you are using the recommended word envelope convention, check the envelope to see if it contains any words, phrases, or sentences that students need help understanding. Read key sentences aloud, and provide concise explanation.

SUPPORT—Some students may benefit from contrasting the words *nutrition* and *malnutrition*. Nutrition is the process of eating food that is necessary for health and growth. The prefix *mal-* changes the meaning to the opposite. Other words with the prefix are *malfunction* and *malpractice*.

CHALLENGE—Challenge interested students to find out how eating protein affects the body and then report their findings to the class.

EXTEND—Have students watch a video about the importance of protein in the diet. Follow up with a discussion about protein sources.

Pages 48–51 Suggested prompts	Sample student responses
Do all animals just eat other animals?	*Some animals, like cows and rabbits, just eat plants.* *Some animals, like dogs, bears, possums, and humans, eat both plants and animals.*
Compare how people eat to how all the animals in this selection eat.	*Animals eat alone.* *People eat meals in groups.* *Animals only eat one type of food.* *People eat a variety of foods.*

Pages 52–53 Suggested prompts	Sample student responses
What is the general purpose of the third article, "Digesting Protein"?	*This article debunks a myth that foods with protein build up in your body.* *It confirms that a balanced diet includes protein, fats, and carbohydrates.*
What animal and plant foods provide protein?	*meats, eggs, tofu, fish, beans, nuts, and seeds*
What would happen if you didn't get enough protein in your body for a long period of time?	*Because protein affects the cells, muscles, bones, and joints, pain or weakness could occur.* *People will notice low energy levels if they did not eat enough protein.*
How does food in the form of carbohydrates, fats, and proteins create metabolic reactions in your body?	*The food you eat breaks down in metabolic reactions in the digestive system into elements that your body needs to live and to grow.* *Food has an effect on every cell in your body.*

5. Check for understanding.

Evaluate and Provide Feedback

For Exercise 5, students should write a short persuasive essay arguing that a balanced diet is important for growth and health.

Use the rubric provided on the Exercise Page to supply feedback to each student.

LESSON 15

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

Previous Lesson

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

This Lesson

Putting Pieces Together

2 DAYS



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

Next Lesson

There is no next lesson.

Building Toward NGSS

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

What Students Will Do

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

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

What Students Will Figure Out

- We can answer many of our Driving Question Board questions!

Lesson 15 • Learning Plan Snapshot

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

Lesson 15 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• science notebook • *Let's Answer Questions from Our DQB!* • 5 sticky dots • Progress Tracker • *Brown Bear Hibernation Task* • *Modified Brown Bear Hibernation Task*		• Driving Question Board

Materials preparation (25 minutes)

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

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

Gather the classroom consensus models developed in Lessons 7, 13, and 14 and post them at the front of the room.

Online Resources



Lesson 15 • Where We Are Going and NOT Going

Where We Are Going

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

Where We Are NOT Going

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

LEARNING PLAN FOR LESSON 15

1. Navigation: Evaluate our DQB questions. 10 MIN

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

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

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

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

Then have students move into their Scientists Circle.

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

2. Revisit our Driving Question Board (DQB). 30 MIN

Materials: science notebook

Look for patterns using the sticky dots. In the Scientists Circle, focus on the questions that have the most amount of sticky dots.

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



Assessment Opportunity

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

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

3. Add to our Progress Trackers. 5 MIN

Materials: Progress Tracker

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

End of day 1

4. Demonstrate understanding on an assessment task. 37 MIN

Materials: *Brown Bear Hibernation Task*, *Modified Brown Bear Hibernation Task*

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

5. Quick Write: Reflect on our experiences. 8 MIN

Materials: science notebook

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

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

Additional Guidance

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

Teacher Resources

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Assessment System Overview

Each 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

When	Assessment and Scoring Guidance	Purpose of Assessment
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 (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, 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 Assessment Teacher Key	**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 Teacher Key - Sample Student Response Argument Rubric	**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.
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** Students 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.
After Students Complete Substantial, Meaningful Work	Peer Feedback Facilitation: A Guide	**Peer Feedback** There will be times in your classroom when facilitating students to give each other feedback will be very valuable for their three-dimensional learning and for learning to give and receive feedback from others. We suggest that peer review happen at least two times per unit. This document is designed to give you options for how to support this in your classroom. It also includes student-facing materials to support giving and receiving feedback along with self-assessment rubrics where students can reflect on their experience with the process. Peer feedback is most useful when there are complex and diverse ideas visible in student work and not all work is the same. Student models or explanations are good times to use a peer feedback protocol. They do not need to be final pieces of student work, rather, peer feedback will be more valuable to students if they have time to revise after receiving the peer feedback. It should be a formative, not summative type of assessment. It is also necessary for students to have experience with past investigations, observations, and activities where they can use these experiences as evidence for their feedback.

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

Lesson-by-Lesson Assessment Opportunities

Every 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.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
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). Ask questions that arise from careful observation of *M'Kenna's Doctor's Note* to clarify and seek additional information about what is going on inside the body of M'Kenna that is causing her symptoms (effect).	**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	Lesson-Level Performance Expectation(s)	Assessment Guidance
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.	**Analyzing and Interpreting Data; Structure and Function; Systems and System Models** While students are examining the illustrations of the organs of the digestive system, circulate among them to listen to group and/or pair 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. **Analyzing 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 of 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.
Lesson 3	Plan and conduct an investigation in order to produce data to determine whether food molecules can travel from one side of a system to the other side separated by a solid structure with properties similar to the walls of the small intestine.	**Planning and Carrying Out Investigations; Systems and System Models; Structure and Function** During the Plan Our Investigation section, while students write individually in their notebooks, walk around and look for them to make connections between the inside of the dialysis tube system as a representation of the inside of the small intestine. Therefore, students should place the food molecules inside the dialysis tube. If students struggle to connect their system to the small intestine have them revisit their Lesson 2 data that showed differences in food within the small intestine. At the end of day 1, look at Part 2 of *Dialysis Tube Investigation* to see students make their predictions about which molecule(s) will go through the structure of the dialysis tube system. Look at the connections between student predictions and the reasoning they use to justify their explanations. Student answers will vary based on their ideas from Lesson 2. If students struggle to connect their predictions with reasoning, prompt them to think about why they set up the pieces of the dialysis tube system in the way they did.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
	Argue from evidence to revise a model to show how the results of this investigation and graphs of different types of food molecules traveling through the small intestine explain how the structure of the walls impacts the function of the small intestine.	**Developing and Using Models; Structure and Function** When students make sense of the results (Part 6 of *Dialysis Tube Investigation*), look at questions 2 and 3 to see if students connect their results from the dialysis tube investigation. Students should add the idea of openings/gates to the dialysis tube structure and that there must be something different about the structure of food molecules that allows glucose to fit through but not starch. If students struggle with connecting the glucose moving through the dialysis tube to the openings, ask them if they have ever experienced one material going through a barrier of some kind while another material did not, such as when sifting sand. At the end of day 2, students argue from evidence with their partners about what to add to their models in their Progress Trackers. Look for students to argue that, because glucose went from the inside of the dialysis tubing to the outside of the dialysis tubing, this must imply that there are openings or gates in the dialysis tubing and, thus, the small intestine. Students will also argue from evidence that using the moleculecular representations of starch and glucose show that starch is the larger structured molecule, impacting it from functioning by moving through the gates of the small intestine. If students struggle with the use of evidence, you might provide sentence starters or fill in the blanks for the reasoning part. See the teacher reference for an example.
Lesson 4	Analyze and interpret data to determine patterns and limitations of the relative amounts of different molecules in food as it moves through the digestive system of a healthy person versus M'Kenna.	**Analyzing and Interpreting Data; Patterns** During the Follow the Graham Cracker section, while students are using the I^2 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?"

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 5	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.	**Analyzing and Interpreting Data; Cause and Effect; Patterns** After analyzing data from eating a graham cracker on *Analyze Data from Eating a Graham Cracker*, students record their analyses in their science notebooks. Look for students' ability to recognize the pattern in the data that shows that, as complex carbohydrates decrease in the mouth, glucose increases. In addition, students should note that the relative quantities of the other food molecules in the mouth do not change. Students should be able to argue that the relationships that they observe are correlations, but not causations. If students struggle to identify patterns in the data, consider providing additional support in reading the graph provided. If students struggle to distinguish between causal and correlational relationships in the data, consider taking the time to distinguish between causal and correlational relationships. **Planning and Conducting Investigations; Patterns** Students record their plans and findings from an investigation that they have planned and conducted on *Data Table for Chemical Reactions in the Mouth*. Prior to conducting the investigation, check student work to make sure that they have planned an investigation similar to the one provided. After conducting the investigation and recording their results, check student work 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.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 6	Analyze and interpret data to identify patterns in the amount that certain food molecules (complex carbohydrates, proteins, and fats) decrease and other food molecules (glucose, amino acids, and fatty acids) increase as they move through different organs in the digestive system. Analyze and interpret these data as evidence that the digestive system is a system of interacting subsystems composed of organs that each perform different functions.	**Analyzing and Interpreting Data; Patterns** Students will have the opportunity to use *Progress Tracker* to look for the idea that large food molecules are broken down into smaller food molecules through chemical reactions. This presents an opportunity to determine how well students understand and make connections to this key idea partially developed as part of Lesson 5. If students are struggling with this key idea, consider pulling the class together to interpret the multiple lines of evidence identified in Lesson 5 to support this claim. The multiple lines of evidence include: observations from eating a cracker, data analysis from eating a graham cracker, reading about digestion and amylase, and an investigation to determine if chemical reactions occur in the mouth. Consider suggesting a way to represent this idea to students by showing several large boxes attached to one another being broken down into separate boxes. Understanding that large molecules can be broken down into smaller molecules is central to students' understanding of what is taking place in the digestive system. **Analyzing and Interpreting Data; Structure and Function** Use the analysis and interpretation of data on *Table to Organize Food Molecules Data* in students' science notebooks to look for analysis and interpretation of the data that can serve as evidence for the claim that each organ in the digestive system performs a different function. If students are struggling to analyze the data, consider modeling analysis of the data with the whole class. Redirect student attention to the helpful tips for interpreting the bars in the graph found in *Food Molecule Data for a Healthy Person* and help students make sense of one organ in the digestive system. As students are analyzing the graphs, circulate and support students as they look for patterns that can help them explain why the amount of one type of molecule (e.g., protein) might be decreasing by the same amount that another type of molecule (e.g., amino acids) is increasing in the graham cracker in the mouth. **Analyzing and Interpreting Data; Patterns; Structure and Function** Use the Building Understandings Discussion at the end of the lesson to determine if students have come to key conclusions related to MS-LS1-3. First, students should have analyzed data to identify patterns in the functions of each of the organs in the digestive system. Second, students should have interpreted these data as evidence that the digestive system is a system of interacting subsystems that each perform different functions. If students struggled to analyze the data, consider returning to the data analysis and providing more scaffolding to support students in the analysis. If students struggle to make the connection that the digestive system is a system made up of interacting subsystems, consider physically showing how a piece of food moves through the different organs in the digestive system. Stop the food at each "stop" along the way (as indicated by the graphs) and then analyze each graph.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
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. Respectively provide and receive critiques about small-group models developed to explain how various subsystems in a healthy digestive system interact to move food through a series of chemical reactions to break down large food molecules. Engage in an argument from evidence to eliminate two of the five possible gastrointestinal conditions that could be causing the symptoms that M'Kenna is experiencing in her digestive system, based upon how they affect the body as a whole system.	**Developing and Using Models; Systems and System Models** Students will develop models throughout this lesson individually, in small groups, and as a whole group. Students should identify the following ideas in their models: • The digestive system is a long tube with different parts to it. • In one part of the digestive system, the small intestine, small food molecules are absorbed, and large food molecules aren't. • Absorption means that the molecules cross the lining of the small intestine. • Fiber is not digested at all and is excreted from the body. • Large food molecules can be broken down into smaller food molecules. • In another part of the digestive system, the mouth, some types of complex carbohydrates are broken down into smaller pieces through chemical reactions. • Other types of food molecules (proteins and fats) are broken down in other parts of the digestive system (stomach and small intestine). If students are missing ideas, prompt them to revisit their Progress Trackers or science notebooks for key ideas that they are missing. During small-group modeling time, there are suggested prompts to help students when 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. Finally, students should show the inputs, processes, and outputs of the digestive system.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
		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 *Key for 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.
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. 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** In the *Part 3: Argue from Evidence What's Causing M'Kenna's Symptoms*, students argue from evidence that M'Kenna's symptoms can be explained by her having celiac disease. Look for students to argue that M'Kenna has celiac because the villi in M'Kenna's small intestine cause her to have a reduced number of cells since taller villi in the small intestine cause there to be more cells, and this does not allow her body to absorb food molecules as effectively as a healthy digestive system. Students combine this evidence with the understanding that the data from her large intestine indicated that food molecules, other than fiber and water, remained in the large intestine after digestion, while in a healthy large intestine only fiber and water remain. While the assessment should be completed independently, some students might benefit from assistance with the organization of their writing. Additional guidance is provided in regard to how to support students with this organization. Then, students exchange written arguments with a peer and provide a critique of their argument based on the sufficiency of evidence provided. Look for students who attend closely to the strength of the argument and identify key pieces of evidence that support it. Provide a review for a small group of students or for the whole class about the key features of a strong scientific argument using *Argument Rubric - Part 3 - M'Kenna's Disease* for guidance. In Revisit the Driving Question Board, students select three questions from the DQB that they have made progress toward answering. They argue the answer to those questions using evidence that they have collected throughout the unit.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
		Analyzing and Interpreting Data; Structure and Function In Examine the Function of the Villi, students collect data from the NetLogo interactive simulation of the small intestine. Students organize data into a table and create graphical displays of the data to demonstrate that villi height increases the number of cells, which has a direct relationship to the rate of absorption of food molecules into the bloodstream. Circulate and observe students to determine whether they are drawing a connection between villi height and the rate of absorption of food molecules into the bloodstream. Listen for students who explain that the cause of the food molecules that remain in M'Kenna's large intestine are a result of her villi being flat and, therefore, having fewer cells. If students are not drawing a connection between villi height, number of cells, and rate of absorption, gather them into a small group and adjust the simulation together, making the villi height 0, then 5, then 10. After each adjustment, count the number of cells together, writing them down in a public space for comparison. Ask students what they notice about the data, guiding them to see that taller villi have more cells. Have students run three trials—one for each of these villi height adjustments—and add the rate of absorption to the data table. Ask students what they notice about the relationship between the number of cells and the rate of absorption. Scaffolding the activity in such an explicit manner should help students come to the conclusion that taller villi = more cells = higher rate of absorption. Some students may struggle to visualize a data table, and, therefore, have trouble initiating the task of creating a data table to organize their data. Additional guidance is provided to support students who are not constructing an organized data table. In Add to the 3-Column Progress Tracker, students use all that they have figured out to develop a model to represent what is happening in M'Kenna's digestive system as compared with a healthy digestive system. Look for students who incorporate the items in the bulleted list into their models in words and pictures. If students do not include an element, ask a targeted question to help students recall something that they figured out in this lesson. For example, if a student does not include something about villi height affecting the number of cells and, therefore, the rate of absorption of food molecules into the bloodstream, ask, "Where can I find information in your model about the villi? How did you show what you learned about the height of the villi from the NetLogo simulation?" This should remind students without giving away key learning.
Lesson 9	Ask questions to gather more information about how problems in one body system interact with other systems after revisiting M'Kenna's symptom list.	**Asking Questions and Defining Problems** Teachers can collect *Revisit 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.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
		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 we haven't figured out yet, ask them to think about which systems we have we have collected evidence to explain and which symptoms remain unexplained. At the end of the lesson, students individually fill out their Progress Trackers for Lesson 9. Look for students to explain that we have figured out why most of M'Kenna's digestive system symptoms occur (due to issues with absorption of food in her small intestine), but we can't yet explain how that is causing her symptoms in other body systems, such as brain fog, fatigue, and weight loss. If students struggle to make this connection between systems, have them walk over to the DQB and look at the clusters of questions that don't have any dots on them yet. If they are still not able to make the connection, take out *M'Kenna's Doctor's Note* and *Map M'Kenna's Symptoms to Her Body Systems* to see which symptoms and systems are still not explained.
Lesson 10	Analyze and interpret data using graphical displays and statistics to identify temporal relationships to provide evidence for how M'Kenna's pattern of body growth and weight have changed over time compared with typical children her age. Obtain, evaluate, and communicate information to determine the central ideas in an article to help determine where fat (matter) goes when people lose weight.	As a formative, pre-assessment for Lesson Set 2, use the Initial Ideas Discussion in the Navigation activity about what could be causing M'Kenna's weight loss to see if students could connect to what was figured out in Lesson Set 1 when she could not get enough matter inside her body because her villi in her small intestine are damaged. If students do not make this connection, that's OK. They will have the opportunity to do so later on. **Analyzing and Interpreting Data; Stability and Change** Students are introduced to using statistics in order to identify temporal relationships in M'Kenna's growth chart. Look for students to identify that M'Kenna's growth remained stable for about 11 years, and then began to slow down when she turned 13. If students don't make this connection, you can pull them into small groups to do a more guided data analysis. Also, you might pull different student work samples of their WIS/WIM statements and have the whole class look at what classmates have written. Next, students examine DEXA scans of a human and/or a dog that have lost weight. Look for students to identify that fat was lost over time. This should prompt students to begin to think about where the fat goes when someone loses weight. If students are identifying this, you might ask a question like, "If the animal weighed 60 pounds in this photograph, but 45 pounds in the next photograph, what is the difference in weight? Let's think about a 15-pound dumbbell you might lift at the gym—that's quite heavy! Where do you think all that weight went?"

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
	Plan and carry out an investigation to produce data to serve as the basis for evidence to answer the question, Where does matter go when people lose weight?	**Obtaining, Evaluating, and Communicating Information; Energy and Matter** After the students read the article *Children Need More Fat in Their Diets Compared to Adults* for the second time, they answer questions with a partner and discuss those questions as a whole class. During that discussion, look for students thinking about one way people use fat is to "burn" it, but what does burning fat really mean? Students should be wondering where the matter really goes when fat is burned. If this idea does not come out, ask if they have ever heard people say that they are "burning calories" when they exercise, and what do they think that means? **Planning and Carrying Out Investigations; Energy and Matter** During part 3 of the investigation, students will be answering the "Making Sense" questions to start to think through what happens to the matter when fat is burned. Look for students being able to make connections from their understanding of chemical reactions from a previous unit with the data they collected during this experiment. For students who are having difficulty with the "Making Sense" questions in Part 3, you could ask additional questions, such as: "What do the changes in the substance color, odor, or state of matter indicate about what happened?" and "Where did the matter in the vegetable oil/animal fat go?"
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?"

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
		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.
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?"

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
		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 and clarified after examining the data described above. Look for students who include specific data or refer explicitly to the data to write a clear claim. If students do not write a clear claim, provide a sentence stem as support, such as: "The parts of the body that use the most energy when active are ___. I know this because ___."
Lesson 13	Develop models of three possible pathways showing how food is rearranged in the body to create energy, store matter for later use, and use matter for growth within a body system. Construct an explanation to explain the relationships between differences in M'Kenna's digestive system and a healthy digestive system in order to predict symptoms (effects), such as M'Kenna's decreased growth rate.	**Developing and Using Models; Systems and System Models** Students work in small groups to develop models of three different pathways that food entering a body system could take: (1) how the body uses food for energy, (2) how the body uses food not needed right now, and (3) how the body uses food for growth. As groups develop these models, look for them to identify different matter inputs, such as food and oxygen, processes, such as digestion, storage, growth, and cellular respiration, and matter outputs, such as carbon dioxide, water, and fat. Models should also identify different energy flows; for example, in pathway 1, food is broken down and used for energy by the body right away. In pathways 2 and 3, energy from food, and molecules, is stored for later use or to be used in the growth of new tissues. Look for groups to generalize the processes for how healthy bodies use food in each of the three pathways. In pathway 1, models should indicate that food and oxygen enter the body system and are broken down to be used for energy. In pathway 2, models should indicate that excess food is used to create storage molecules, like fat and glucose stored in muscle and liver, which can be used later for energy or growth. In pathway 3, models should indicate that molecules from food can be rearranged to create different tissues in the body like muscle and bone.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
		If groups struggle to identify how food is used differently in each of the pathways, refer them back to their Progress Trackers for Lessons 10-12 when we figured out that the body needs food for growth and that food can be burned for energy. **Constructing Explanations; Cause and Effect** After developing a classroom consensus model, students write an explanation for how M'Kenna's body is functioning differently than a healthy body. In addition, students return to their Progress Trackers to update them with a 3-column entry. In this update, students use the model they built as a class to develop an explanation for how the systems in a healthy body work together to process matter and energy inputs, processes, and outputs. Students add to their explanations about how M'Kenna's digestive system is functioning differently and how her digestive condition contributes to the symptoms that she experiences in other systems of her body. Use this opportunity to look for students to identify the cause and effect relationship between decreased food absorption affecting M'Kenna's energy levels. Students should also explain the relationship between decreased food absorption causing M'Kenna to rely on stored food, or fat, leading to her slowed growth rate or decrease in weight. If students are struggling to make these connections, refer them back to their Progress Trackers for Lesson 12 when they figured out that, when we are active, our body needs more energy, which requires more food.
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	Lesson-Level Performance Expectation(s)	Assessment Guidance
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 2: ANSWER KEY

Key for Analyzing Endoscopy Images

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

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

Organ	What I notice from the illustrations	Observations of M'Kenna's endoscopy images	Is M'Kenna's image mostly similar or very different from the healthy person? If different, what are the differences?
Esophagus	The esophagus looks like a hollow tube. It has a wavy inside lining.	Very pink and smooth with red blood vessels. The tube seems to close off in M'Kenna but not in the healthy person.	Mostly Similar
Stomach	The stomach looks like an empty sack. It has a tube on both ends that connect it to the esophagus, and it looks like it might be connected to the small intestine.	M'Kenna's stomach is pale, and there are ridges on the inside lining. There are some smooth areas on M'Kenna's that are not on the healthy person.	Mostly Similar
Beginning of small intestine	The beginning of the small intestine is a hollow wavy tube. It has a very wavy inside lining. It looks like it might be connected to the stomach.	M'Kenna's seems lumpy and doesn't have many ridges. The color is more red and irritated looking.	Mostly Different. The healthy small intestine doesn't seem as red and irritated. There are ridges in the healthy patient that are not in M'Kenna. M'Kenna's seems very swollen.
Middle of small intestine	The middle of the small intestine looks the same as the beginning of the small intestine.	M'Kenna's is very pale and very smooth. The end seems to be pinched off.	Very Different. The healthy patient has lots of ridges, and it appears to be more moist than M'Kenna's.
Large intestine	The large intestine is also hollow, but it looks bigger and lumpier than the small intestine.	M'Kenna's is very pale and smooth with deep ridges and lots of blood vessels.	Mostly Similar

LESSON 3: ANSWER KEY

Key for Dialysis Tube Investigation

Which food molecule(s) are ***outside*** of the tube (Start)?	Which food molecule(s) are ***inside*** of the tube (Start)?
None	Starch and glucose
Which food molecule(s) do you think you will find ***outside*** of the tube (End)?	Which food molecule(s) do you think you will find ***inside*** of the tube (End)?
Answers will vary	Answers will vary
Explanation of why I made my predictions: Answers will vary. (E.g., "I think that starch and glucose will be found inside and outside of the dialysis tube because they both went down in the small intestine graphs of the graham cracker.)	
Part 3: What do iodine and Benedict's look like with just water?	
Color of Iodine and Water	Color of Benedict's and Water (after heating)
Brown	Blue
Part 4: What food molecules are outside of the tube after the investigation?	
Color of Outside Liquid with Iodine	Color of Outside Liquid with Benedict's (after heating)
Brown	Orange
Food molecules detected ***outside*** of the tube	
Glucose	
Part 5: What food molecules are inside of the tube after the investigation?	
Color of Inside Liquid with Iodine	Color of Outside Liquid with Benedict's (after heating)
Black	Orange
Food molecules detected ***inside*** of the tube	
Starch and glucose	

Part 6: Answer the Making Sense questions in your science notebook.

1. Did any of the food molecules that started off inside of the dialysis tube end up outside of the tube?

Explain what happened.

We started with starch and glucose inside of the tube. After the investigation, there was glucose inside and outside of the tube but only starch inside of the tube. The glucose was able to move through the tube to the outside, but something kept the starch from moving.

2. What do the class results tell us about the structure of the surface of the dialysis tubing?

There must be something about either the structure of the dialysis tube or the structure of the starch molecule that keeps the starch from going through to the outside of the tube.

3. What do these results tell you about what might be different about the structure of a complex carbohydrate molecule (like starch) compared to a sugar molecule (like glucose)?

(Answers will vary.) Maybe the starch is more complicated, maybe the starch is bigger, or maybe the shape of the starch is weird.

Name: _____ Date: _____

LESSON 5: ANSWER KEY 1

Key for Chemical Reactions in the Mouth Data Table

	Tube A	Tube B	Tube C	Tube D
Part 1: Diagram of Tube Label each tube with the substances you plan to add. 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.				
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	1. Rice 2. Water 3. Iodine 4. Mix The indicator should always be added last. The order of the food and water does not matter.	1. Rice 2. Amylase 3. Iodine 4. Mix The indicator should always be added last. The order of the food and amylase does not matter.	1. Rice 2. Water 3. Benedict's 4. Mix The indicator should always be added last. The order of the food and water does not matter.	1. Rice 2. Amylase 3. Benedict's 4. Mix The indicator should always be added last. The order of the food and amylase does not matter.
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

LESSON 7: RUBRIC

Rubric for Giving and Receiving Feedback

Giving Feedback

How well did you give feedback today?

Today, I...	YES	NO
Gave feedback that was **specific** and about **science ideas.**		
Shared a suggestion to help improve my peer's work.		
Used evidence from investigations, observations, activities, or readings to support the feedback or suggestions I gave.		

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

_____

_____

Receiving Feedback

How well did you receive feedback today?

Today, I...	YES	NO
Read the feedback I received carefully.		
Asked follow up questions to better understand the feedback I received.		
Said or wrote why I agreed or disagreed with the feedback.		
Revised my work based on the feedback.		

What is one piece of feedback you received?

_____

_____

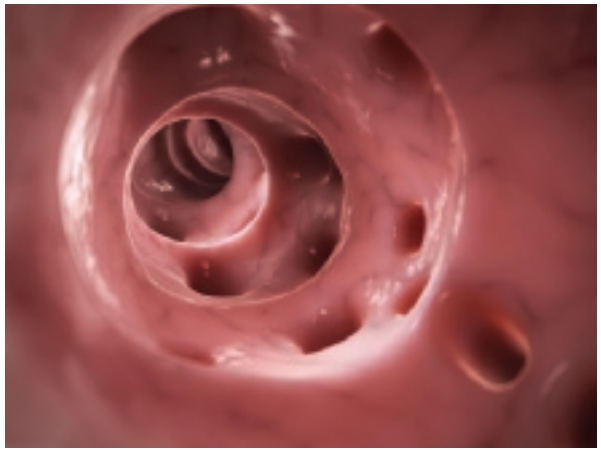
What did you add or change to address this feedback?

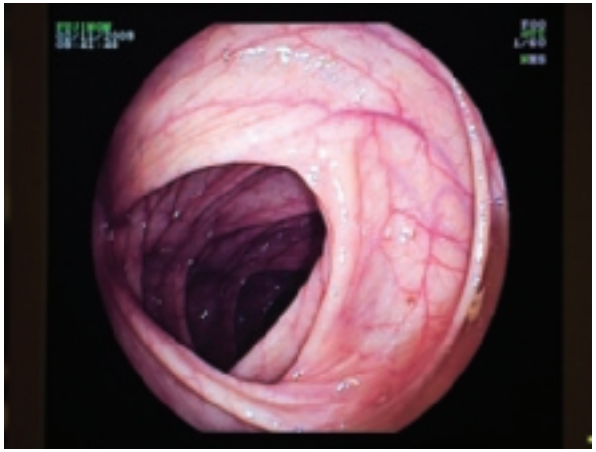
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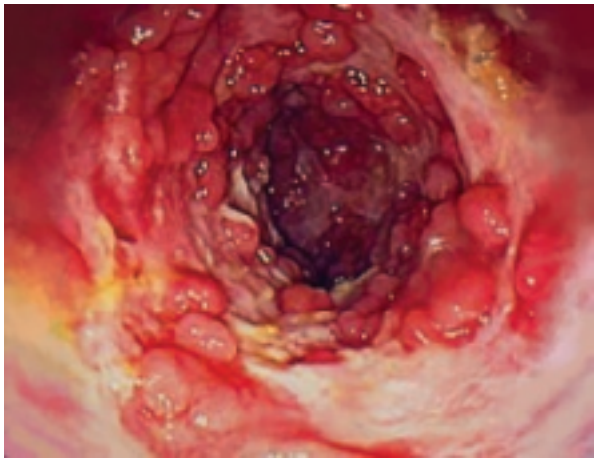
Task Parts 1 and 2: Eliminate Possible Conditions and Identify Missing Evidence

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

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

Gastrointestinal Condition	Image of Intestinal Lining	Symptoms	Cause(s)
Diverticular disease is the general name for a common condition that causes small bulges or sacs to form in the wall of the large intestine. Although these sacs can form anywhere in the colon, they are most common in the part of the large intestine closest to the rectum.	 Large Intestine	Painful abdominal cramps Nausea and vomiting Fever Chills Abdominal tenderness Constipation Diarrhea	**Diverticula,** which can range from pea-sized to much larger, are formed by increased pressure on weakened spots of the intestinal walls by gas, waste, or liquid. Diverticula can form while straining during a bowel movement, such as with constipation.

Gastrointestinal Condition	Image of Intestinal Lining	Symptoms	Cause(s)
If a person has **celiac disease** and eats foods with gluten, the immune system responds by damaging the small intestine. Gluten is a protein found in wheat, rye, and barley.	 Small Intestine	Diarrhea Bloating Gas Fatigue Weight loss Iron-deficiency anemia Constipation Depression	**Celiac disease** is an immune disease in which people can't eat gluten because it will damage their small intestine. It affects both males and females. People with this condition have flattened "villi," which are tiny finger-like structures on their small intestine. Villi can only be seen with a high magnification microscope.
Irritable bowel syndrome (IBS) is a common disorder that affects the large intestine. Signs and symptoms include cramping, abdominal pain, bloating, gas, and diarrhea or constipation, or both. **IBS** is a chronic condition that needs long-term management.	 Large Intestine	Abdominal pain and cramping Diarrhea Constipation Alternating constipation and diarrhea Gas and bloating Food intolerance Fatigue	**IBS** is thought to result from a combination of abnormal gastrointestinal tract movements, increased awareness of bodily functions, and a disruption in the communication between the brain and the gastrointestinal tract. More research is still being done to better understand the cause of IBS.

Gastrointestinal Condition	Image of Intestinal Lining	Symptoms	Cause(s)
Colitis is a chronic digestive disease characterized by inflammation of the inner lining of the colon. Infection and loss of blood supply in the colon can occur. Colitis affects only the large intestine and only the inside lining.	 Large Intestine	Not feeling hungry Weight loss Fatigue Dehydration Joint pain Canker sores Eye pain Anemia Skin sores Diarrhea Rectal bleeding Abdominal cramping Frequent and immediate need to empty the bowels	**Colitis** is an inflammatory bowel disease that causes long-lasting inflammation and ulcers or sores in the digestive tract. One type of **colitis** affects the innermost lining of the large intestine and rectum. Symptoms usually develop over time, rather than suddenly.
Crohn's disease is a chronic inflammation of the digestive tract, primarily the small intestine. The chronic disease means that sometimes people feel well and sometimes people do not notice symptoms at all.	 Small Intestine	Persistent diarrhea Rectal bleeding Urgent need to move bowels Abdominal cramps and pain Fever Loss of appetite Weight loss Fatigue Night sweats	**Crohn's disease** is an inflammatory bowel disease. No one knows exactly what causes Crohn's. It may be caused by a malfunctioning immune system, genetics, or environmental factors.

Gastrointestinal Condition	Image of Intestinal Lining	Symptoms	Cause(s)
Write your initial ideas about the information in the table here.			

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

- M'Kenna's Doctor's Note, which includes her symptoms
- M'Kenna's Endoscopy Images
- Progress Tracker
- Updated Model
- List additional evidence sources here:

3) Using the evidence you've collected, determine 2 of the conditions in the table that do not match what you believe is causing M'Kenna's symptoms. Write the condition(s) you identify in the first column of the table below. Then, add any evidence that supports your choice in the second column of the table. Finally, construct an argument to explain why the evidence you have selected serves as strong evidence that the condition is not causing M'Kenna's symptoms.

Condition	Reasons/Evidence this condition ***could not*** be what is causing M'Kenna's symptoms	Why is this evidence that the disease is not causing her symptoms?

Assessment Task Part 2: Identify Missing Evidence

4) Now that you have narrowed down the possibilities for what condition(s) could be the cause of M'Kenna's symptoms, revisit the "Causes" column of the Gastrointestinal Conditions chart above. Brainstorm ideas for what additional evidence you would need to determine which condition is most likely to be the cause of M'Kenna's symptoms. Write your ideas in the space below or on the back of this page. Be ready to share your ideas with the class.

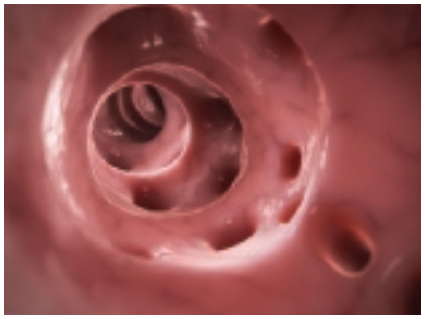
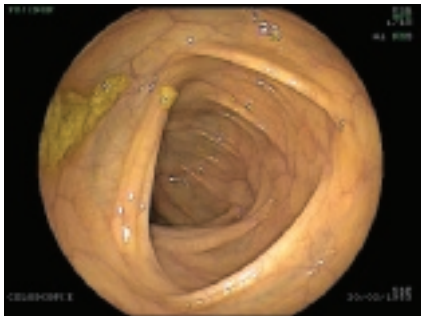
Key for Task Parts 1 and 2: Eliminate Possible Conditions and Identify Missing Evidence

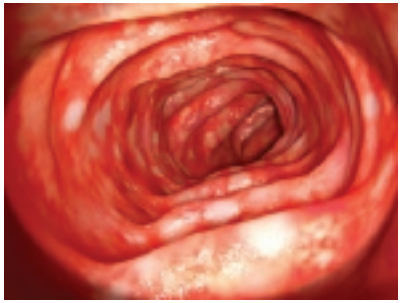
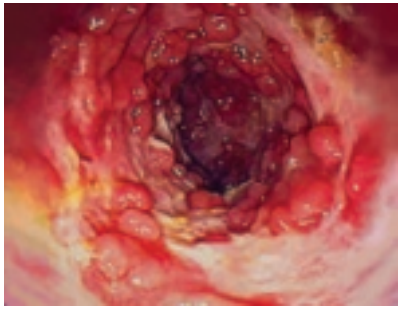
The bullet points in red below indicate the important ideas to look for in student responses. They do not indicate a preferred scoring scheme. You can choose how to score or grade the assessment.

Student Assessment

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

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

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If a person has **celiac disease** and eats foods with gluten, the immune system responds by damaging the small intestine. Gluten is a protein found in wheat, rye, and barley.	 Small Intestine	Diarrhea Bloating Gas Fatigue Weight loss Iron-deficiency anemia Constipation Depression	**Celiac disease** is an immune disease in which people can't eat gluten because it will damage their small intestine. People with this condition have flattened "villi," which are tiny finger-like structures on their small intestine. Villi can only be seen with a high magnification microscope.

Irritable bowel syndrome (IBS) is a common disorder that affects the large intestine. Signs and symptoms include cramping, abdominal pain, bloating, gas, and diarrhea or constipation, or both. **IBS** is a chronic condition that needs long-term management.	 Large Intestine	Abdominal pain and cramping Diarrhea Constipation Alternating constipation and diarrhea Gas and bloating Food intolerance Fatigue	**IBS** is thought to result from a combination of abnormal gastrointestinal tract movements, increased awareness of bodily functions, and a disruption in the communication between the brain and the gastrointestinal tract. More research is still being done to better understand the causes of IBS.
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Write your initial ideas about the information in the table here.

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

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

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

- Students could list any of the conditions here and find possible connections to why that disease might not be causing M'Kenna's symptoms.
- As long as students are making viable cause-and-effect connections between the evidence and the disease, any answers are fine here.
- One row is completed below to provide an example of what you might be looking for from the students.

Condition	Reasons/Evidence this condition ***could not*** be what is causing M'Kenna's symptoms	Why is this evidence that the disease is not causing her symptoms?
Colitis	M'Kenna's Endoscopy Images did not show damage to her large intestine.	Colitis only affects the large intestine, and in an endoscopy image of a colitis patient, you can see the damage. M'Kenna's large intestine was mostly normal.
	M'Kenna's Doctor's Note does not mention joint pain.	Joint pain is a common symptom of colitis. M'Kenna might not have colitis because she does not have this symptom.

Assessment Task Part 2: Identify Missing Evidence

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

- Any student ideas could be valuable, look for ideas that:
  - connect to the "Causes" section of the chart above,
  - provide information or evidence that the class hasn't encountered yet, and
  - help to distinguish between the diseases that students have not been able to rule out yet.

Argument Rubric - Part 3 - M'Kenna's Disease

Argument Rubric - M'Kenna's Disease Lesson 8

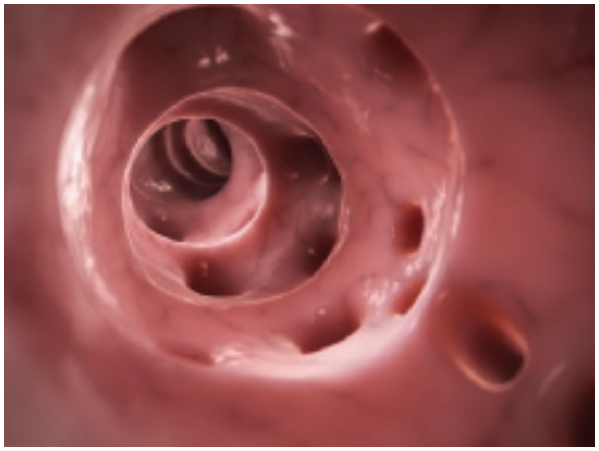
Claim	Category			Feedback
	Missing	Developing	Mastered	
• **There is a claim** that states that M'Kenna has celiac disease.				
Justification **Evidence or empirical data** that supports the claim includes:	**Category**			**Feedback**
	Missing	Developing	Mastered	
• M'Kenna's endoscopy images of her small intestine look differently than the healthy small intestine images				
• Graphs show that M'Kenna is breaking down all large food molecules except for all "other complex carbohydrate"				
• Graphs show M'Kenna has food molecules left in her large intestine and poop, that are not found in a healthy person				
• M'Kenna has flat villi in her small intestine				
Scientific principles or ideas that explain how each piece of evidence supports the claim (*reasoning*) includes:				
• Since there are structural differences in the small intestine images, this indicates there could be a difference of M'Kenna's function of her small intestine				
• Since small molecules are not being absorbed by the small intestine, they continue moving down her digestive tract and end up in her poop				
• The food molecules are being broken down in M'Kenna and in a healthy person because we see large food molecules in the graphs go down and small food molecules go up, but then in M'Kenna they all are not being absorbed because food molecules are still left in her poop and large intestine				
• Flat villi make it more difficult to absorb food so small molecules are left over in the process as food moves through the body. The villi are the cells of the digestive system in the small intestine where food is absorbed. When functioning properly, villi increasing the surface area in the small intestine where small food molecules can be absorbed (*structure/function*)				

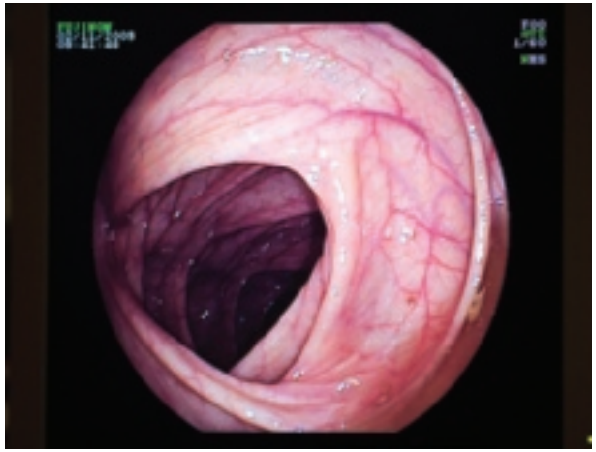
Rebuttal Clearly represents or describes the following:	Category			Feedback
	Missing	Developing	Mastered	
• a critique of the evidence of an alternate claim ◦ Not other diseases because the damage located in the small intestine ◦ The other small intestine diseases are not caused by damages to the villi structures ◦ Any other valid critique that relies on evidence				
• a critique of the reasoning of an alternate claim ◦ The disease M'Kenna has must be related to the small intestine because that is where we knew there was damage from the images we examined ◦ The disease M'Kenna has must be a result of or related to the damage of villi in the small intestine because we know that the damaged villi absorb small molecules less efficiently than normal villi which can explain why we see small molecules in M'Kenna's poop. ◦ Any other valid critique of reasoning that students propose				

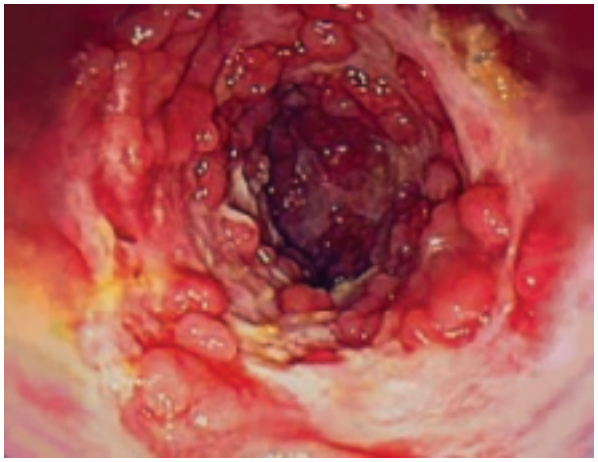
Name: _____ Date: _____

Part 3: Argue from Evidence What's Causing M'Kenna's Symptoms

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

Gastrointestinal Condition	Image of Intestinal Lining	Symptoms	Cause(s)
Diverticular disease is the general name for a common condition that causes small bulges or sacs to form in the wall of the large intestine. Although these sacs can form anywhere in the colon, they are most common in the part of the large intestine closest to the rectum.	 Large Intestine	Painful abdominal cramps Nausea and vomiting Fever Chills Abdominal tenderness Constipation Diarrhea	**Diverticula**, which can range from pea-sized to much larger, are formed by increased pressure on weakened spots of the intestinal walls by gas, waste, or liquid. Diverticula can form while straining during a bowel movement, such as with constipation.

Gastrointestinal Condition	Image of Intestinal Lining	Symptoms	Cause(s)
If a person has **celiac disease** and eats foods with gluten, their immune system responds by damaging the small intestine. Gluten is a protein found in wheat, rye, and barley.	 Small Intestine	Diarrhea Bloating Gas Fatigue Weight loss Iron-Deficiency Anemia Constipation Depression	**Celiac disease** is an immune disease in which people can't eat gluten because it will damage their small intestine. It affects both males and females. People with this condition have flattened "villi," which are tiny finger-like structures, on their small intestine. Villi can only be seen with a high magnification microscope.
Irritable bowel syndrome (IBS) is a common disorder that affects the large intestine. Signs and symptoms include cramping, abdominal pain, bloating, gas, and diarrhea or constipation, or both. **IBS** is a chronic condition that needs to be managed long term.	 Large Intestine	Abdominal pain and cramping Diarrhea Constipation Alternating constipation and diarrhea Gas and bloating Food intolerance Fatigue	**IBS** is thought to result from a combination of abnormal gastrointestinal tract movements, increased awarenes s of bodily functions, and a disruption in the communication between the brain and the gastrointestinal tract. More research is still being done to better understand the causes of IBS.

Gastrointestinal Condition	Image of Intestinal Lining	Symptoms	Cause(s)
Colitis is a chronic digestive disease characterized by inflammation of the inner lining of the colon. Infection and loss of blood supply in the colon can occur. Colitis affects only the large intestine and only the inside lining.	 Large Intestine	Not feeling hungry Weight loss Fatigue Dehydration Joint pain Canker sores Eye pain Anemia Skin sores Diarrhea Rectal bleeding Abdominal cramps Frequent and immediate need to empty the bowels	**Colitis** is an inflammatory bowel disease that causes long-lasting inflammation and ulcers or sores in the digestive tract. One type of **colitis** affects the innermost lining of the large intestine and rectum. Symptoms usually develop over time, rather than suddenly.
Crohn's disease is a chronic inflammation of the digestive tract, primarily the small intestine. This chronic disease means sometimes people feel well and sometimes people do not notice symptoms at all.	 Small intestine	Persistent diarrhea Rectal bleeding Urgent need to move bowels Abdominal cramps and pain Fever Loss of appetite Weight loss Fatigue Night sweats	**Crohn's disease** is an inflammatory bowel disease. No one knows exactly what causes Crohn's. It may be caused by a malfunctioning immune system, genetics, or environmental factors.

1. **Claim**. The condition that is most likely causing M'Kenna's symptoms is: _____.
2. **Write an argument to support your claim**. Use your work from Parts 1 and 2 in lesson 7 and use at least 4 pieces of evidence from the unit so far that support your claim that M'Kenna has the disease you chose and not the other diseases you examined. List each piece of evidence and answer the questions below.

Evidence #1:

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

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

Evidence #2:

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

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

Evidence #3:

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

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

Evidence #4:

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

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

LESSON 8: ANSWER KEY 1

Connecting the Structure of Villi to Their Function

Procedure

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

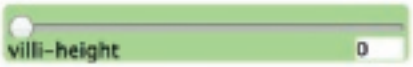
2. Adjust the "end-simulation-at" slider to be any value above 12, and keep it at that value for all simulation runs.



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



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



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



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



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

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

Create a data table on the next page record each of your results.

Data Table

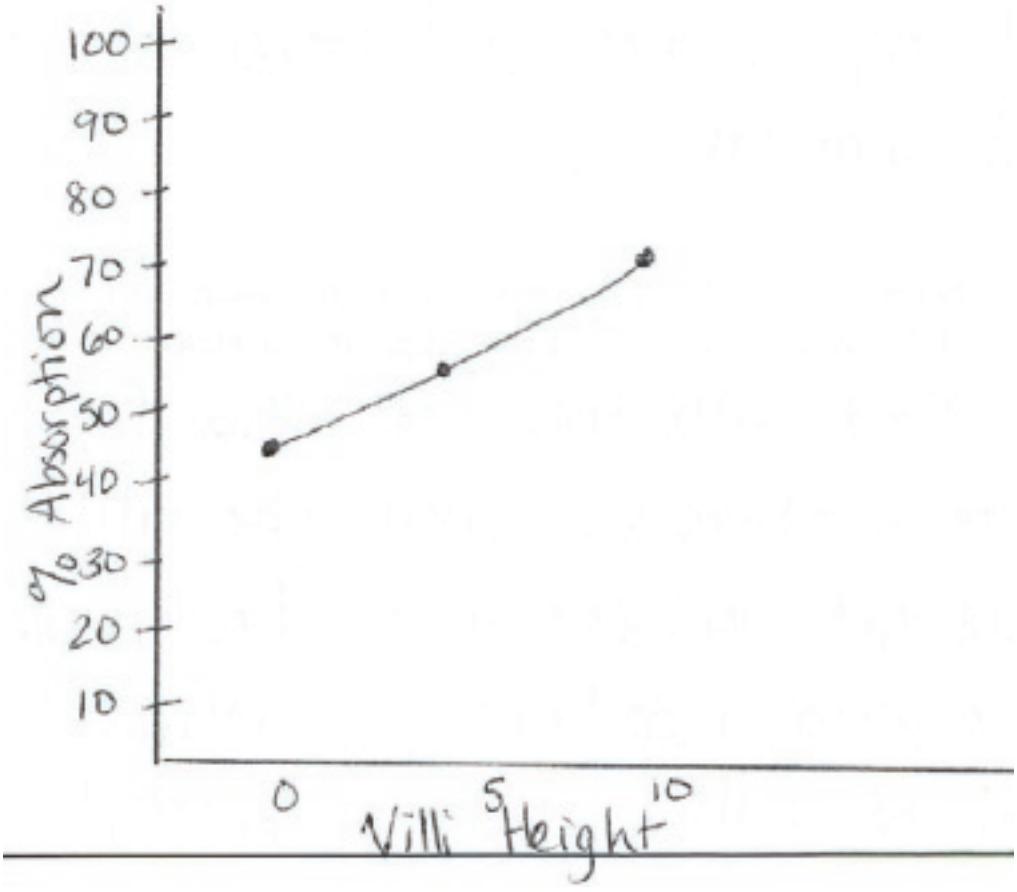
Create a data table in the space below, recording the following information for each trial you run:

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

Simulation #	Villi Height	# Cells	% Absorbed
1	0	35	43.6
2	5	74	58.2
3	10	119	71.8

Graphing Data

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



Making Sense

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

   As the villi got taller, the percentage of absorption increased.

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

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

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

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

LESSON 8: ANSWER KEY 2

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

This document provides a sample student response to the Lesson 8 individual assessment in an unstructured form.

We recommend using the argument rubric to assess your students.

1. Claim. The condition that is most likely causing M'Kenna's symptoms is: celiac disease.

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

Evidence #1:

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

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

Sample Student Response

It's difficult to eliminate diseases based on M'Kenna's symptoms alone from her doctor's note. Her symptoms such as diarrhea, fatigue, and weight loss could be caused by several of these diseases, so we needed more evidence. I have come to this conclusion using several additional sources of evidence. First, when we looked at M'Kenna's endoscopy images, we saw a difference between her images and a healthy patient's images mainly in the structure of her small intestine. Second, we also analyzed several graphs and came to the conclusion that her small intestine was not absorbing food molecules as a healthy digestive system should. One of the graphs shows that her food molecules are being broken down but the molecules aren't all leaving her body like they should. This indicates that her small intestine is the main organ involved in her condition. When we look at the list of possible conditions, this causes me to eliminate diverticular disease and colitis because those diseases mainly affect the large intestine, not the small intestine.

Also, we looked at microscopic images of what the small intestine should look like and there are tiny structures called villi that are there to increase the area that small food molecules can be absorbed into the body. They look like tiny fingers. M'Kenna doesn't have villi; her small intestine wall is flat. According to the evidence we've gathered, celiac disease is the only one which is caused by damage to the villi in the small intestine. This makes "celiac disease" most likely the cause of M'Kenna's condition.

LESSON 9: ANSWER KEY

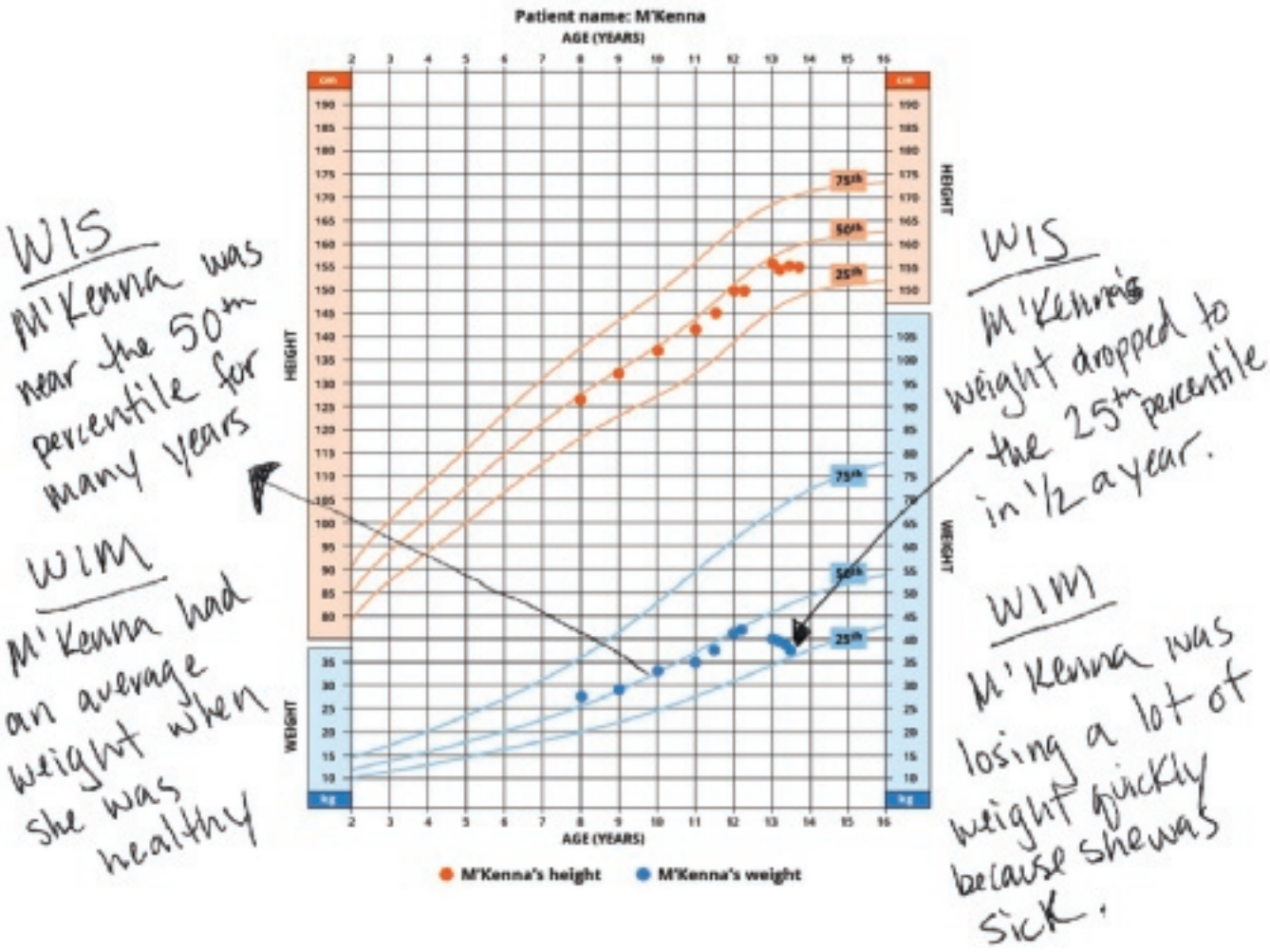
Key for Symptoms and Systems

Part 1: Which of M'Kenna's symptoms could be connected to what we've figured out?	
Symptom	Evidence and Reasoning
Nausea/Vomiting	*M'Kenna's body is not absorbing all of her food, so maybe some of it is coming out of her mouth.*
Abdominal cramps	*Her small intestine villi are damaged, so maybe that's why she has pain in her abdomen.*
Diarrhea	*M'Kenna isn't able to absorb food molecules as quickly as a healthy person, so more food molecules and water remain in her poop.*

Part 2: Which of M'Kenna's symptoms have we not found a connection to yet?	
Symptom	Noticings and Wonderings
Fatigue	*This seems like it is a whole body effect.*
Weight loss	*This seems like it is also a whole body effect.*
Muscle cramps	*This is happening in other parts of her body besides the digestive system.*
Brain fog	*What does this mean? How is her digestive system affecting her head?*
Rapid heartbeat	*This seems really important! We need to know more about how something wrong in her digestive system could cause heart problems.*
	All of these symptoms are happening outside of the digestive system!

LESSON 10: ANSWER KEY

Key: Patterns in M'Kenna's Weight



Focus on just M'Kenna's weight.

1. What was the pattern in M'Kenna's weight before she got sick (ages 8-12)?
   - About average, 50th percentile
2. How did M'Kenna's weight pattern change? If M'Kenna's weight continues on the new pattern, where do you expect her weight to be at age 14?
   - It dropped quickly and went close to the 25th percentile.
   - At age 14 her weight would be less than the 25th percentile, maybe just under 35 kg.
3. If M'Kenna was your patient and you saw this change in her weight pattern, would you be alarmed? Why or why not?
   - Yes, because this weight loss isn't normal for M'Kenna, and it's changing so quickly.

LESSON 14: RUBRIC 1

Rubric: Giving and Receiving Feedback

Giving Feedback

How well did you give feedback today?

Today, I...	YES	NO
Gave feedback that was **specific** and about **science ideas.**		
Shared a suggestion to help improve my peer's work.		
Used evidence from investigations, observations, activities, or readings to support the feedback or suggestions I gave.		

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

_____

_____

Receiving Feedback

How well did you receive feedback today?

Today, I...	YES	NO
Read the feedback I received carefully		
Asked follow up questions to better understand the feedback I received		
Said or wrote why I agreed or disagreed with the feedback		
Revised my work based on the feedback		

What is one piece of feedback you received?

_____

_____

What did you add or change to address this feedback?

_____

_____

Rubric: Engaging in Argument from Evidence

Claim	Category			Feedback
	Missing	Developing	Mastered	
• **There is a claim** that is relevant to the question, problem, or solution posed.				
Justification **Clearly represents or describes the following:**	**Category**			**Feedback**
	Missing	Developing	Mastered	
• evidence or empirical data that supports the claim				
• scientific principles or ideas that explain how each piece of evidence supports the claim (*reasoning*)				
Rebuttal **Clearly represents or describes the following:**	**Category**			**Feedback**
	Missing	Developing	Mastered	
• a critique of the evidence of an alternate claim				
• a critique of the reasoning of an alternate claim				

LESSON 15: RUBRIC

Bears Assessment Modeling Rubric

Component Clearly represents or describes the system (digestion and cells burning fat for energy) components and must include at least:	Category			Feedback
	Missing	Developing	Mastered	
• Bite of food				
• Small food molecules				
• Blood				
• Cells				
• Fat stores				
• Food molecules (role in making energy)				
• Lungs				
• Oxygen				
• Carbon Dioxide				
Interactions Between Components Clearly represents or describes the following:	Category			Feedback
	Missing	Developing	Mastered	
• the digestion of food chemically breaks down food from big molecules into small molecules				
• the digested food molecules are absorbed by cells and/or travel around the body through the blood				
• cells use the energy they need from food right away through a chemical reaction that uses oxygen from the lungs and releases carbon dioxide (matter/energy)				
• when there are extra food molecules, they are stored as fat that animals can use for energy later (matter/energy)				

Brown Bear Hibernation Task

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





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

Average Stats for an Adult Male Brown Bear	Fall - October Going into Hibernation	Winter During Hibernation	March - May Coming out of Hibernation
Body Temperature	100°–101°F	about 88° degrees F	100°–101°F
Breathing Rate & Heart Rate *One way to measure energy used.*	Normal	Very Slow	Normal
Heart Rate	40–50 beats per min	8–19 beats per min	40–50 beats per min
Weight	about 450 pounds	Not measured	about 250 pounds
Body Fat Percentage *Similar to DEXA scans—one way to measure how much fat the bear has stored.*	30%	Not measured	15%

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

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

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

Model

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

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

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

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

Modified Brown Bear Hibernation Task

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





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

Average Stats for an Adult Male Brown Bear	Fall - October Going into Hibernation	Winter During Hibernation	March - May Coming out of Hibernation
Body Temperature	100°–101°F	about 88° degrees F	100°–101°F
Breathing Rate & Heart Rate *One way to measure energy used.*	Normal	Very Slow	Normal
Heart Rate	40–50 beats per min	8–19 beats per min	40–50 beats per min
Weight	about 450 pounds	Not measured	about 250 pounds
Body Fat Percentage *Similar to DEXA scans—one way to measure how much fat the bear has stored.*	30%	Not measured	15%

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

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

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

   The **components** you should include in your model are:

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

   Some **interactions** you should include in your model are:

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

Model

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

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

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

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

LESSON 15: ANSWER KEY

Key for Brown Bear Hibernation Task

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





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

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Breathing Rate & Heart Rate *One way to measure energy used.*	Normal	Very Slow	Normal
Heart Rate	40-50 beats per min	8-19 beats per min	40-50 beats per min
Weight	about 450 pounds	Not measured	about 250 pounds
Body Fat Percentage *Similar to DEXA scans—one way to measure how much fat the bear has stored.*	30%	Not measured	15%

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

1. During hibernation, bears do not eat for 5 to 6 months in a row. How can the bear stay alive without eating for this long? Use patterns in the data table and science ideas developed throughout this unit to support your answer.
   - Even though the bears are not eating, their cells can still get the energy they need because, during hibernation, bears can use stored fat for energy.
   - Bears can use the stored fat and convert it to energy that their cells need through chemical reactions, which need oxygen, and then release carbon dioxide, water, and usable energy that cells can use.
     - Evidence to support this claim includes the decrease in body fat percentage (bears are burning body fat) and decreased weight (probably related to the decrease in body fat).
   - The stored fat can sustain them for the entire hibernation because they are sleeping and using very little energy—they don't use any energy to move around and are just sitting there. Evidence for this is that, during hibernation, all of the processes that the bear requires energy for are working a lot slower, like breathing and heart rate, compared to the fall or spring months. Even their body temperatures are lower compared to other times of the year.
2. To prepare for winter in the den, a bear will gain up to 30 pounds a week (in extra mass) by eating grass, roots, berries, fish, insects, and small animals. Using everything you've learned from the unit, develop a model that explains how a bear can gain so much weight so quickly. Some important components or interactions to include in your model are: food molecules, matter, energy, chemical reactions. Use extra sheets of paper if you run out of space.

   [The list of components and interactions appears in the modified version of the student assessment for students who might need additional support.]

   The **components** you should include in your model are:

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

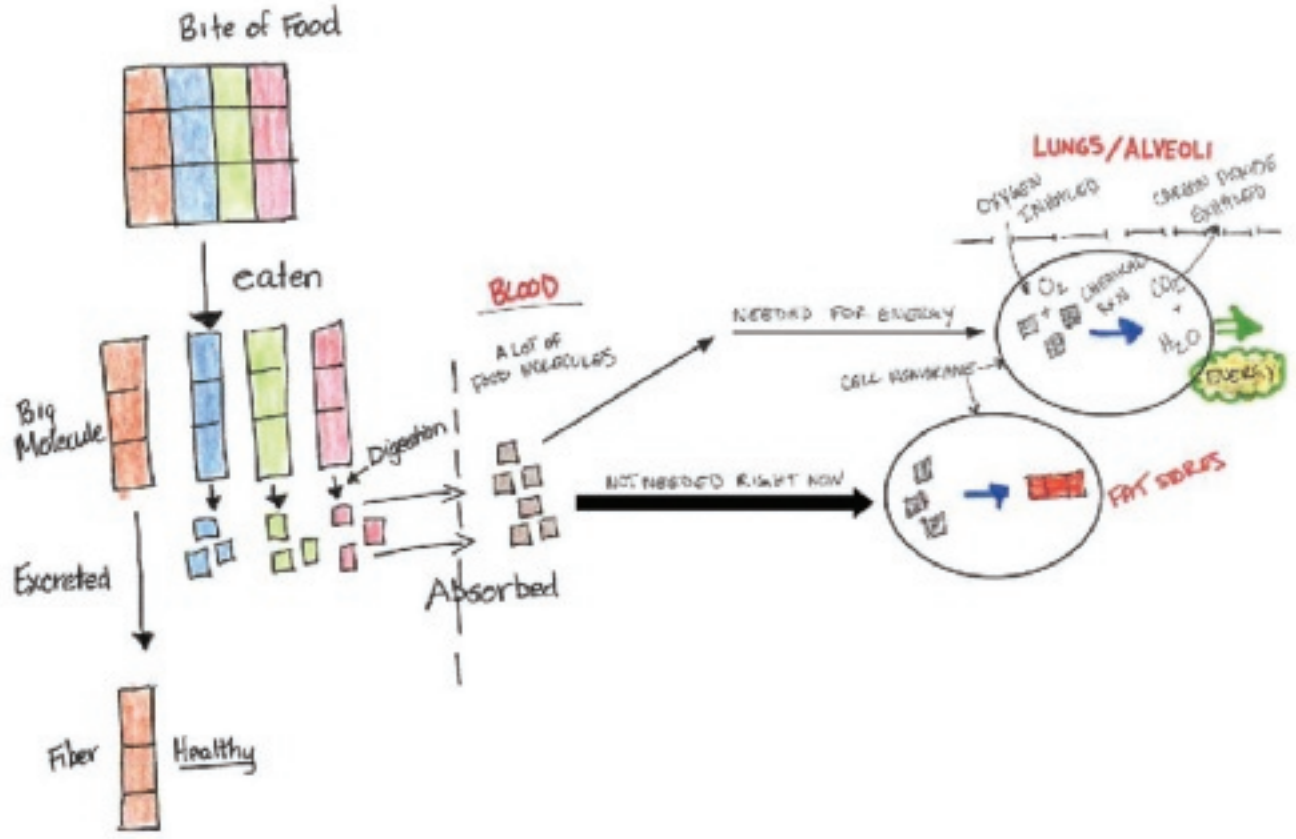
   Some **interactions** you should include in your model are:

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

   Model

   Use *Bears Assessment Modeling Rubric to* assess this question. The model below is included for your reference, and they were developed in prior lessons.

A bear takes in a lot of food. Those food molecules get broken down through digestion, and absorbed into the blood. Some of the food molecules are needed for energy. The extra food molecules not needed right now are converted as fat and stored for later. When this happens the bear gains weight.



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

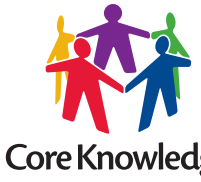
   Using your model above, explain where all the mass went when it was "lost."

   - The bear's mass wasn't actually lost but went into the air around it.
   - The bear had extra mass stored as fat.
   - Since the bear was not eating, the bear used the stored fat for energy.
   - Fat can be burned by the body. This means that the fat molecules go through a series of chemical reactions where the fat reacts with oxygen breathed in by the bear, and then, through chemical reactions, turns this into usable energy, carbon dioxide, and water, which the bear breathes out.
   - Since the bear used the fat for energy, the bear lost the weight of the fat, and it went into the air as carbon dioxide and water.

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

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

   - Prediction: There is more food available to bears in North Carolina than there used to be.
   - Model Supports: If a bear can eat more food, then more food is being broken down and absorbed into the blood. When bears are eating more food, they are using what they need right away for energy and then storing the rest as fat. This is shown in the "Not needed right now" pathway for food in the model. The stored fat is one reason bears are getting so big in North Carolina.



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Editorial Director

Daniel H. Franck

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Unit Development Team

Tara McGill, Unit Lead, Northwestern University

Michael Novak, Field Test Unit Lead, Northwestern University

Kate Cook-Whitt, Writer, Maine Mathematics and Science Alliance

Kathryn Fattalah, Writer, The Nora Project

Emily Harris, Writer, BSCS Science Learning

Lindsey Mohan, Writer, BSCS Science Learning

Jamie Noll, Writer, Northwestern University

Barbara Taylor, Writer, Charles A. Center at UT-Austin

Heather Galbreath, Pilot teacher, Lombard Middle School

Michael Clinchot, Teacher Advisor, John D. O'Bryant School of Mathematics and Science

Nicole Vick, Reviewer, Abingdon-Avon High School

Betty Stennett, Reviewer, BSCS Science Learning

Katie Van Horne, Assessment Specialist

Kelsey Edwards, Project Coordinator, Northwestern University

Barbara Hug, Unit Advisory Chair, University of Illinois at Urbana- Champaign

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Core Knowledge Foundation Science Literacy Subject Matter Expert

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Professor
School of Plant and Environmental Sciences
Virginia Tech
Blacksburg, Virginia

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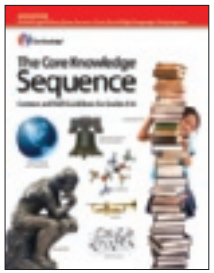
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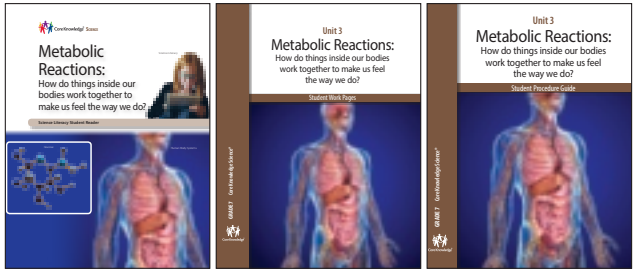
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