Matter Cycling and Photosynthesis:

Where does food come from, and where does it go next?

Science Literacy

Teacher Guide

Energy from the sun

Plant cell

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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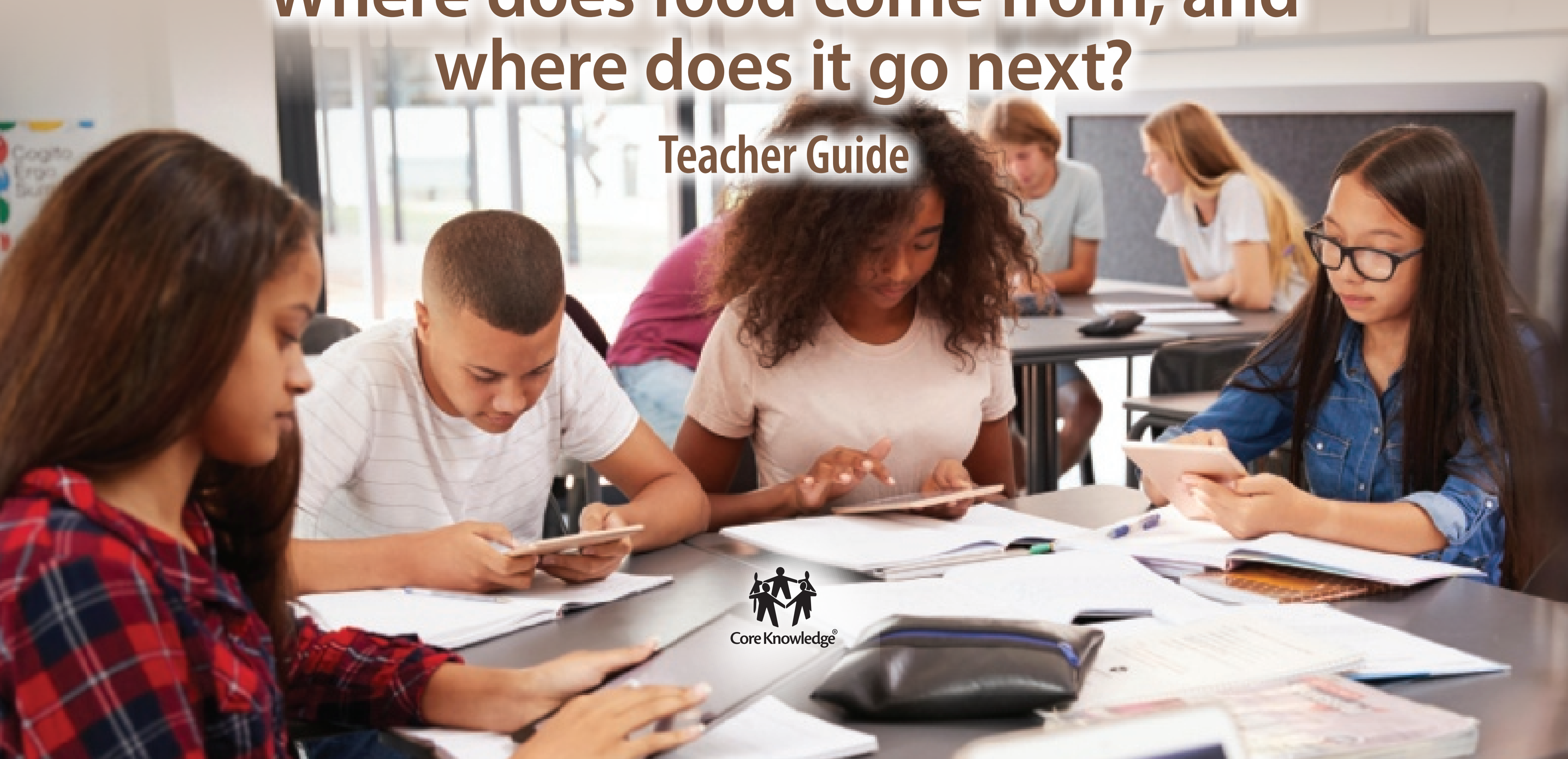

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BEFORE YOU BEGIN

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

Where does food come from, and where does it go next?

This unit on matter cycling and photosynthesis begins with students reflecting on what they ate for breakfast. Questions about where their food comes from lead them to consider which breakfast items might be from plants. Then students explore (and taste) a common breakfast food, maple syrup. They see that according to the label it is 100% from a tree. Students then see how some trees are tapped in the spring for their sap, and how water is boiled off, to leave only syrup. Students taste maple sap from the trunks of trees and compare it to the maple syrup they tasted earlier.

Students argue (based on the preceding unit) that they know what happens to sugar in syrup or other foods when they consume it—it is absorbed into the circulatory system and transported to all cells of their body to be used for growth or fuel. Students explore what else is in food, and discover that foods from plants they ate, like bananas, peanut butter, beans, avocado, and almonds, not only have sugars but proteins and fats, as well. This leads them to wonder about these molecules in plants: How are plants getting these food molecules? Why does a plant need food in the first place? Where does its food come from?

To figure out how plants could be making these food molecules and where plants get the matter and energy to do that, students conduct a series of investigations. Through these investigations, students:

- develop a model to track the inputs and outputs of plants
- carry out experiments to figure out how leaves and seeds interact with the gases in the air around them in the light and the dark
- develop and evaluate arguments from their evidence to figure out where plants are getting the energy and matter they need to live
- construct an explanation for the central role of photosynthesis in all food production, including synthetic foods
- obtain and communicate information to explain how matter gets from living things that have died back into the system through processes done by decomposers
- develop and use a model to explain that the major atoms that make up food (carbon, hydrogen, and oxygen) are continually recycled between living and nonliving parts of a system.

Focal Disciplinary Core Ideas (DCIs): LS1.C; LS2.B; PS1.A; PS1.B; PS3.D

Focal Science and Engineering Practices (SEPs): Developing and Using Models; Constructing Explanations and Design Solutions; Engaging in Argument from Evidence; Obtaining, Evaluating, and Communicating Information

Focal Crosscutting Concepts (CCCs): Systems and System Models; Energy and Matter

Building Toward NGSS Performance Expectations

MS-PS1-3: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

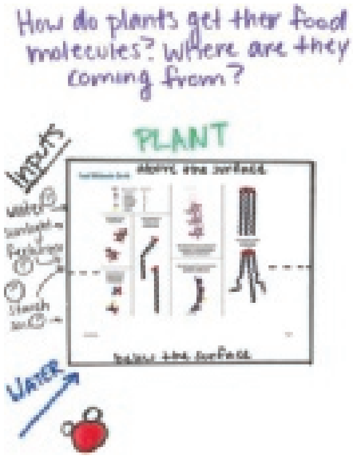
MS-LS1-6: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

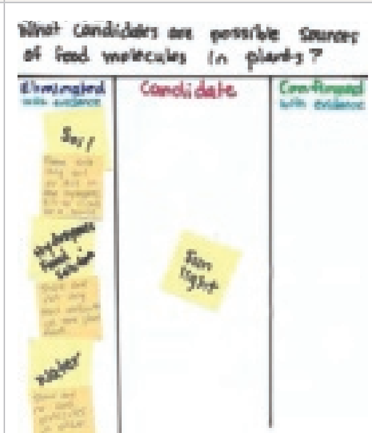
How students will engage with each of the phenomena

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

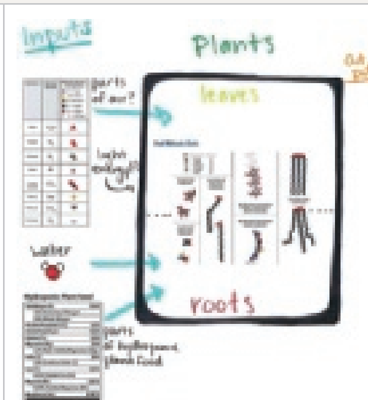
Where does food come from, and where does it go next?

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 1 **3 days** **Where does this stuff come from?** **Anchoring Phenomenon**	 *Students taste maple syrup, which comes from plants and contains food molecules. Nutrition labels show that all foods that come from plants contain food molecules.*	We brainstorm food we ate that we think come from plants, animals, or other sources. We taste maple syrup and maple sap—foods that we are surprised comes from plants and watch a video of sap being extracted from a tree. We review nutrition labels for the plant foods we ate. All the plants have some food molecules. We know we get our food from eating, but how do plants get their food? Where is the food in plants coming from? We develop a model to try to explain this and develop a Driving Question Board to guide future investigations. We figure out: • All plant foods we looked up nutrition information for have food molecules in them. Not all of the plants have the same food molecules (carbohydrates, fats, proteins), but all of them have some sugar. • There are different places that plants might get their food molecules from (i.e., water, sunlight, soil). • We have lots of questions about where the food in plants comes from and have ideas for future investigations to pursue that could help answer these questions.	

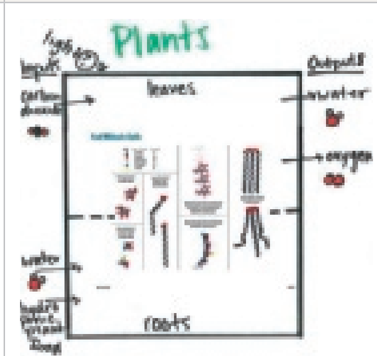
⇩ **Navigation to Next Lesson:** In this lesson, we figured out that plants have food molecules in them. This made us wonder "How do plants get their food molecules? Where are they coming from?"

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 2 **2 days** **Do plants get their food molecules by taking them in?** **Investigation**	 *Radishes can be grown in a hydroponic system.*	We use a hydroponic plant system and indicators of food molecules to investigate whether soil, plant food, water, or air could be potential sources of food molecules in plants. We develop a list of candidates coming into contact with the hydroponic plants both below and above the surface that light is shining on. We figure out: • Plants can grow without soil. • Water and hydroponic plant food do not have food molecules inside them according to food labels and food indicator experimental results. • Parts of food molecules might be found in water and hydroponic plant food.	

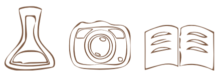
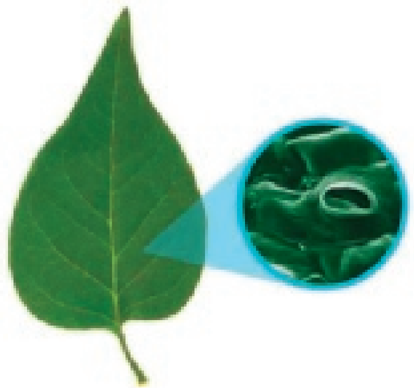
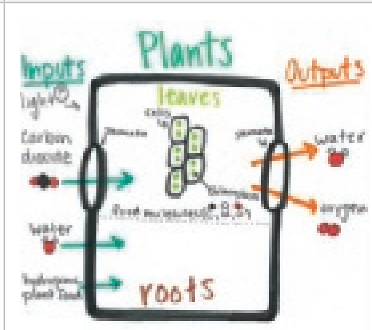
⇩ **Navigation to Next Lesson:** We figured out that inputs of the hydroponic plant system below the surface do not contain whole food molecules and can't be sources of food molecules. We wonder what inputs above the surface of the plant system could be sources of food molecules. We want to look more closely at the atoms and compare what food molecules and inputs to the plant system are made up of.

LESSON 3 **1 day** **What other inputs could be sources of food molecules for the plant?** **Problematizing**	 *Air, light, water, and hydroponic plant food do not contain whole food molecules but we notice that there are similarities in the parts of these candidates and the parts of food molecules.*	We revisit the composition of air and light to look for possible sources of food molecules. After looking at air and light (in addition to water and hydroponic plant food) we figure out none of our initial candidates contain whole food molecules. We realize that we might have to adjust our question and look to find whether plants could be putting together parts of food molecules, instead of directly taking in whole food molecules. We figure out: • Air and light do not contain whole food molecules (carbohydrates, protein, or fats) that can be taken in by plants. • Air, hydroponic plant food, and water contain the same atoms that food molecules contain. These are parts of food molecules that could be taken in by plants.	

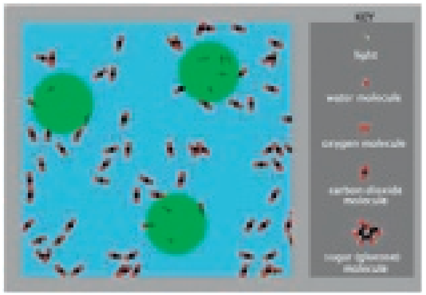
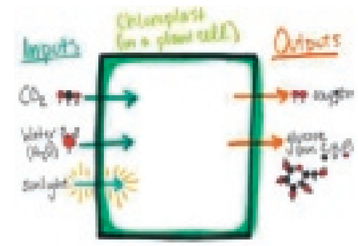
⇩ **Navigation to Next Lesson:** We figured out that no whole food molecules are going into the plant. This made us wonder if parts of food molecules could be coming into the plant above the surface.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 4 **2 days** **Are any parts that make up food molecules coming into the plant from above the surface?** Investigation	 *When spinach leaves are exposed to light, the level of carbon dioxide decreases and the level of water increases. When dandelion leaves are under constant light levels, the level of carbon dioxide decreases while water and oxygen levels increase.*	We conduct an investigation and produce data showing carbon dioxide decreasing and water increasing in the air surrounding plant leaves exposed to light. We analyze and interpret secondhand data, confirm carbon dioxide and water patterns, and discover that oxygen levels are increasing around the plant. This sparks questions about how these gases are getting into and out of the leaves. We figure out: • Carbon dioxide enters plants through the leaves. • Since carbon dioxide is the only input containing carbon, it is the source of carbon in food molecules. • Plants also release water and oxygen from their leaves.	

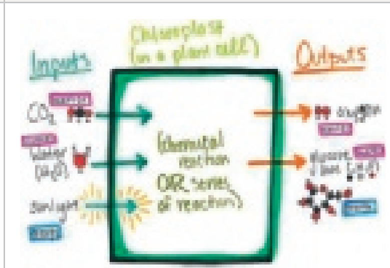
⇩ **Navigation to Next Lesson:** In this lesson, we figured out that plants leaves take in carbon dioxide and give off water and oxygen. This made us wonder, "How do these gases get in and out of plant leaves?"

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 5 **1 day** **How are these gases getting into and out of leaves?** **Investigation** 	 *Microscopic images and a video of plant cells show openings on the outside of a leaf and later structures inside a leaf.*	We observe the surface of real leaves along with microscopic leaf images and a video. We see small openings on the leaf surface and discuss how these could allow plants to "breathe," by letting gases in and out. Inside the leaves, we see moving green circles inside repeating structures. We gather information from a reading that the repeating structures are plant cells, and the green circles, or chloroplasts, are moving in response to light. We discuss how light and chloroplasts fit in our plant model and review the other inputs and outputs. We discuss how a simulation could help us figure out what exactly is happening inside plant leaves. We figure out: • Leaves have small openings on the leaf surface that allow gases like carbon dioxide, oxygen, and water to enter and exit the leaf. • Leaves are made of cells. • Plant cells have chloroplasts in them that move in response to light.	

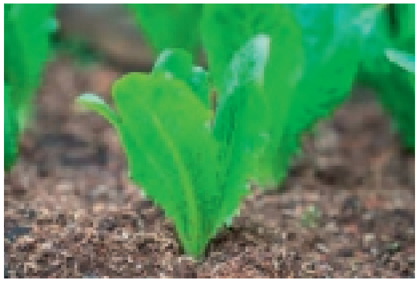
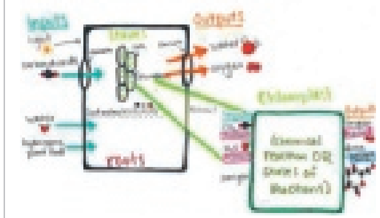
⇩ **Navigation to Next Lesson:** We figured out that plants have microscopic structures that allow gases to enter and exit the leaf. We also figured out that plant cells have chloroplasts that respond to light, but we're not sure why. This is difficult to visualize, which makes us want to use a simulation and try different inputs and outputs to understand what exactly is happening inside leaves.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 6 **2 days** **How are all these things interacting together in this part of the plant?** Investigation	 *Results from NetLogo Computer Simulation of Photosynthesis*	We use a computer simulation to explore how water, carbon dioxide, light, and chloroplasts interact in a plant cell. We use the simulation to carry out an investigation into how changing the amount of one of these inputs affects the outputs of the plant cell. We use the evidence we collect to argue that decreasing the amount of water, carbon dioxide, light, and chloroplasts decreases the amount of oxygen and sugar produced by the plant cell. We also argue that removing any one of these inputs prevents the plant from producing oxygen or sugar. We figure out: • Water and carbon dioxide molecules, along with light, interact in chloroplasts in plant cells, where they are used to make oxygen and sugar molecules. Each of these inputs is needed to produce these outputs. • In this process, molecules of water and carbon dioxide are broken apart and the atoms that make them up (carbon, hydrogen, and oxygen) are rearranged to form new substances. • As plants get more inputs, more oxygen and sugar are produced.	

⇩ **Navigation to Next Lesson:** We know that the matter from the inputs in plants interact in the chloroplasts where they are used to make oxygen and sugar molecules. We wonder about the role of light. We know it is needed for this chemical reaction to occur, but it doesn't contain matter, so what is it really doing?

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 7 **1 day** **Why do plants need light?** **Investigation, Problematizing**	**Carbonated Water**  **Nutrition Facts** Serving Size: 1 cup **Amount Per Serving** **Calories** 0 *Food labels show how much energy can be provided for humans. Sparkling water and water food labels do not contain calories and thus no energy can be used for most living things.*	We know sunlight is needed for plants to make food, but we aren't sure what it's doing. We think sunlight gives plants *energy*, but so far our models only account for matter. We investigate the role of sunlight by examining food labels to figure out how much energy water, carbon dioxide, and glucose can provide for the body. We argue from evidence that since glucose (an output of plants) provides energy for our bodies in the form of calories, but inputs of plants, water and carbon dioxide, do not have energy in the form of calories, the energy must be coming from some other input. The sunlight must be the source of the energy for plants to rearrange the Cs, Hs, and Os through chemical reactions. We figure out: • Water and carbon dioxide don't provide energy from food (measured in calories) for the body, but glucose does. • Plants must use sunlight as an input for energy so they can do the chemical reactions to make glucose.	

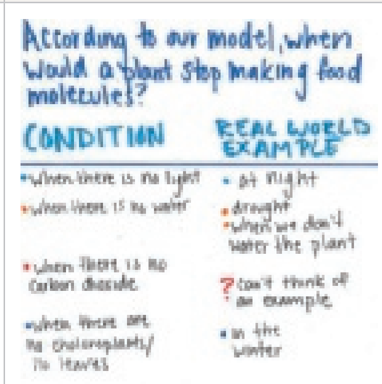
⇩ **Navigation to Next Lesson:** We figured out glucose provides bodies energy but carbon dioxide, water, and oxygen don't. We wonder if our models can explain where plants get energy to make food molecules.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 8 **2 days** **Where are plants getting food from?** **Putting Pieces Together**	 *A lettuce plant has food molecules that we can eat to provide us with matter and energy. A scientist can survive inside a sealed container with just plants.*	This lesson marks the end of the first lesson set. We develop a Gotta-Have-It Checklist to highlight the key ideas that we figured out in Lessons 1–7. On day 2, students take an individual assessment, applying what we have learned to explain new phenomena. We revise our consensus model by drawing and explaining what we figured out in Lessons 1–7 to explain how plants get food molecules. Our models include key inputs and outputs and differentiate between matter and energy. We figure out: • Plants use energy from the sun to make sugars (food) from carbon dioxide and water. Plants release oxygen as an additional output in this process. This process is called photosynthesis. • During the process of photosynthesis, energy is transferred from the sunlight to the plant. • All plants make their own food molecules through the process of photosynthesis. • Photosynthesis occurs in the chloroplasts of plant cells.	

⇩ **Navigation to Next Lesson:** We put the pieces together to explain that plants do chemical reactions using the inputs of carbon dioxide, water, and light to make glucose and oxygen. This made us wonder if this is what is happening when the maple tree makes sap and how plants that don't have all their inputs could survive.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 9 **1 day** **Where do the food molecules in the maple tree come from?** **Problematizing**	 *Maple trees during sugaring season without leaves*	We apply our models to try to explain how maple trees can produce sap in the winter, but our models predict that plants only make food molecules when leaves are present and sugar comes out of maple trees when leaves aren't there. We realize that our models can't yet explain how food molecules can be found in plants when all the inputs or structures needed are gone. We develop initial explanations for how food molecules can be found in plants when leaves aren't present. Then we add new questions to our Driving Question Board (DQB). • Maple trees are tapped in early spring before there are any leaves. • Maple trees have sap, or food, even in the winter when there aren't leaves on the tree. • People have been tapping trees for sap for a long time. • Besides maple trees, there are other trees that sap can be collected from and made into syrup.	

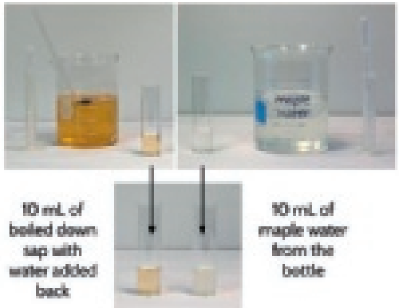
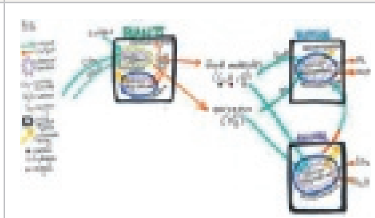
⇩ **Navigation to Next Lesson:** We figure out that maple trees have food (sap) in them even when there are no leaves on the tree. This makes us wonder whether trees can make food when they don't have leaves and if they do have leaves can they make food in the dark?

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 10 **2 days** **Why don't plants die at night?** Investigation	 *When spinach leaves are in the dark, carbon dioxide and water levels increase. When dandelion leaves are in the dark, the level of oxygen decreases while water and carbon dioxide increase.*	We use our model to predict when plants don't make food molecules and wonder why plants don't die at night. We conduct an investigation and produce data showing that plants release carbon dioxide and water when in the dark. We analyze and interpret second hand data and discover that plants take in oxygen in the dark. We argue that photosynthesis doesn't happen in the dark, but now we are curious about what is happening. We wonder, are plants breathing like us? We compare our findings to humans and theorize that maybe plants burn stored food through cellular respiration when they can't make food molecules through photosynthesis. We figure out: • In the dark, plants do not do photosynthesis. • Instead, they do some kind of chemical reaction that takes in oxygen and releases carbon dioxide and water (cellular respiration).	

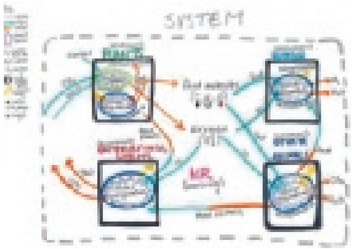
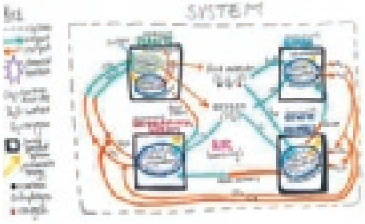
⇩ **Navigation to Next Lesson:** We figured out that in the dark plant leaves take in oxygen and release carbon dioxide and water. This made us wonder if plants burn stored food through cellular respiration when they cannot do photosynthesis.

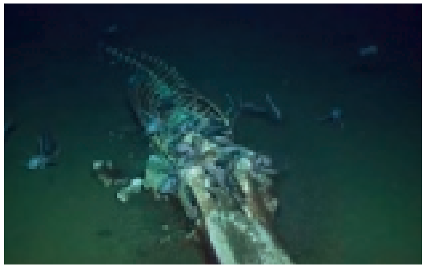
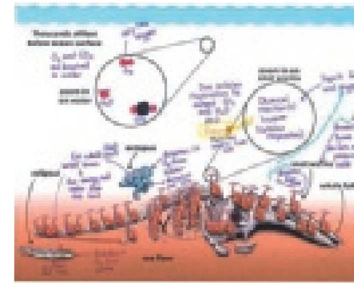
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 11 **3 days** **Why don't plants die when they can't make food?** **Investigation**	 *While bean seeds are sprouting, they use energy from stored food molecules and release carbon dioxide before they have green leaves that can do photosynthesis.*	We plan and carry out an investigation to see whether plants without leaves are doing cellular respiration. We use the results to argue from evidence that the food plants make is able to provide them energy (just as in humans). We read about where this happens in plant and animal cells and what plants do with extra food they produce from photosynthesis. We use the ideas from this and the evidence we collected to construct an explanation of what is happening to a maple tree in a time-lapse video filmed over many years. We figure out: • Plants do cellular respiration. This is how their cells (and our cells) get energy to survive and grow. • If plants make sugar (through photosynthesis) faster than their cells use it for energy (through cellular respiration), they store up that extra food by converting it to starches (or fats). These can be used later for fuel or building blocks. • Plants use their stored food as building blocks by reassembling the atoms in that food to make new substances.	

⇩ **Navigation to Next Lesson:** We figured out that the maple tree is not producing syrup for us to eat for breakfast, but is producing it so it can use it as an input for cellular respiration so it can have energy and matter to live and grow. Now we want to revisit our breakfast food poster and see if we can explain where our breakfast foods come from.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 12 **3 days** **Where does the rest of our food come from?** Investigation	 *When sap is heated it turns into syrup. Food is harvested from plants or animals. Some of it we eat relatively intact, while the rest is changed in some manner before we eat it (e.g., ground, boiled, mixed with other substances).*	We obtain information from ingredients lists for common processed foods and argue that they are made of matter from plants and/or animals. We obtain information from nutrition facts and data about animal diets and argue that animals have food molecules in them that come from eating plants or other animals that once ate plants. We argue that processed foods are made of matter from plants and/ or animals. We figure out: • Everything we eat contains matter that came from either plants or animals. • Some foods we eat have been processed either physically or chemically, but we can still trace them back to originally coming from plants. • Most animals, including humans, eat plants, other animals that once ate plants, or both. • Most animals, including humans, use the food molecules they eat to build up larger molecules for growth, to get energy by burning glucose through cellular respiration, or to store for later use.	

⇩ **Navigation to Next Lesson:** We can now trace where all our food comes from back to plants. But, we don't use all parts of all the plants, so we wonder what happens to the parts of the plants that we don't use or eat.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 13 **2 days** **What happens to food that doesn't get eaten?** Investigation	 *Dead plants and animals decrease in size in a system with decomposers. Decomposers live in systems all over the world.*	In this lesson, we watch videos of decomposers that recycle matter and energy from dead plants and animals. We examine data (for changing inputs and outputs of the system) from bread mold (a decomposer) in the light and dark. We read about decomposers in systems around the world and revise our model to include decomposers as a living part of the system. We figure out: • Many decomposers take in oxygen and food molecules and give off carbon dioxide and water. • Decomposers recycle dead plant and animal matter and energy back into the system. • Decomposers use matter for food that humans (and many animals) cannot use for energy and matter.	
⇩ **Navigation to Next Lesson:** In this lesson, we figure out that decomposers recycle dead plant and animal matter back into the system. This makes us wonder if we can apply what we figured out to other systems with decomposers in our community.			
LESSON 14 **2 days** **Where does food come from, and where does it go next?** Putting Pieces Together	 *A single piece of matter (an atom) can be traced as it moves from one component to another in a system.*	We share photographs and pictures of decomposers we have seen in our own lives. We revise our consensus model to include arrows representing the continuous cycling of matter and energy. We create a Gotta-Have-It Checklist from our final revised consensus model using what we figured out from each investigation. We figure out: • The outputs of living things become the inputs of other living things and part of the nonliving components of the system. • Systems consist of living (producers, consumers, and decomposers) and non-living (air and water) components where atoms are continuously recycled between these components.	
⇩ **Navigation to Next Lesson:** In this lesson we figured out how atoms are cycled through different levels of a system. 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 Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 15 **2 days** **Where does food come from, and where does it go next?** **Putting Pieces Together**	 *A whale dies at the surface of the ocean. Over time its remains fall to the seafloor and become a feast for a myriad of living things, including worms that can burrow into bones and obtain food.*	We revisit the DQB and discuss all of our questions that we have now answered. Then we demonstrate our understanding by individually taking an assessment. Finally, we reflect on our experiences in the unit.	
LESSONS 1–15 **29 days total**			

TEACHER BACKGROUND KNOWLEDGE

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., wearing 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 via the **Online Resources Guide**.

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 set-up, 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 phenomenon?

"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 develop and use a model to explain the cycling of matter and flow of energy in a system comprised of living and nonliving components. This model includes mechanisms for both photosynthesis and cellular respiration. Their model traces the paths of carbon, hydrogen, and oxygen atoms through the ecosystem as living things produce and/or use them as food. The model tracks the flow of energy into the ecosystem through sunlight and its conversion to energy that can be used by living things. Students' models build on their ideas from 7.3: *How do things inside our bodies work together to make us feel the way we do?* (Inside Our Bodies Unit). In that unit, they figured out that food contains particular types of molecules (sugars, fats, proteins), and that chemical reactions in animal's bodies break down these molecules and form new molecules that support growth and/or release energy, and can be stored for later use. This unit takes up the additional question of how and why plants have these molecules that animals can use and focuses on how these molecules move between the living and nonliving parts of the ecosystem.

In this unit, students' investigations are motivated in an anchoring phenomenon of trying to figure out where their breakfast food (like maple syrup and sap they taste) come from. In the first lesson set, students conduct investigations into what is in food that comes from plants. Surprised to find out from food labels that plants contain carbohydrates, proteins, and fats, students are motivated to see if any of their candidates (water, air, soil, hydroponic plant food/fertilizer) are possible sources for these food molecules in plants. Students investigate these candidates with indicators and look at the labels to see if they contain food molecules. Their tests show that plants can grow without soil, and that the water and hydroponic plant food that plants take in do not contain any food molecules. This raises the question of whether air or light might have food molecules. Students analyze air and water and determine that none of their candidate sources for food molecules for plants contain whole food molecules. They revisit their candidates and see that some of the atoms in food molecules are similar to those within their candidates, such as in hydroponic plant food and water. Students analyze and interpret data from leaves in closed systems to figure out that plants are in fact taking in carbon dioxide but also give off water and oxygen. They argue from evidence about the role of water since it is both an input and an output of plants. This makes them wonder how gases get in and out of leaves. By critically reading scientific text, they figure out there are microscopic structures in leaves to let gases in and out but also other structures called chloroplasts that respond to light. Students plan an investigation with a computer simulation to analyze what is going on inside leaves. Students figure out that the matter from the inputs in plants interact in the chloroplasts where they are used to make oxygen and sugar molecules. They next focus on the role of light. Students have evidence that light is needed for this chemical reaction to occur, but also know that light does not contain matter that can be used in the reaction. Students figure out that light provides the energy needed for chemical reactions to happen in the chloroplasts, and carbon dioxide and water provide the matter needed to make glucose and oxygen. Students put the pieces they have figured out together to explain that plants do chemical reactions using the inputs of carbon dioxide, water, and light to make glucose and oxygen. This made them wonder if this is what is happening when the maple tree makes sap. They also question how plants that don't have all their inputs could survive.

In the second lesson set, students figure out that maple trees have food (sap) in them even when their leaves have fallen off. This raises the question of whether trees can make food without their leaves or while it is dark. They conduct an investigation and determine that plants release carbon dioxide and water and take in oxygen when in the dark. They wonder if plants burn stored food like the process of cellular respiration they figured out animals do. They plan and carry out an investigation to test whether plants without leaves (i.e., sprouting seeds) are doing cellular respiration. They argue from their evidence that the food plants make provides energy for them (just as in animals) and then construct an explanation of what is happening to a maple tree in a time-lapse video filmed over five years. Students figure out that the sap the maple tree produces works as an input for cellular respiration so it can have energy and matter to live and grow through the winter. It just also happens to be useful for humans to make into syrup. They revisit their breakfast food and consider the items they were "not sure" about. Using ingredients lists for common processed foods and data about animal diets, students argue that their food, including processed foods, are made of matter from plants and/or animals and that animals have food molecules in them that come from eating plants or other animals that once ate plants.

Students consider what happens to the parts of the plants that animals (including people) do not use or eat. Students explore how decomposers recycle matter and energy from dead plants and animals. They investigate decomposers in systems around the world and revise their model of how matter and energy move between living and nonliving parts of the system to include decomposers, producers, and consumers as living parts of the system. Students then revise their consensus model to show how the outputs of one component of the system can become the inputs for other parts. They explain how atoms can be continually cycled through a system as energy flows. Finally, students apply their model and construct an explanation of the matter cycling and energy flow for the inputs and outputs of an aquatic system.

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

- **MS-LS1-6:** Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
- **MS-LS2-3:** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- **MS-PS1-3:** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

Partial NGSS Performance Expectations (PEs) addressed by this unit:

- **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. (Specifically, chloroplasts and mitochondria.)

The unit expands students' understanding of matter cycling and photosynthesis, which include these Grade 6-8 DCI elements:

LS1.C: Organization for Matter and Energy Flow in Organisms

- Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

LS2.B: Cycle of Matter and Energy Transfer in Ecosystems

- Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem.
- Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments.
- The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

PS1.A: Structure and Properties of Matter

- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

PS1.B: Chemical Reactions

- Substances react chemically in characteristic ways. 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.

PS3.D: Energy in Chemical Processes and Everyday Life

- The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. (secondary)

The placement of this Unit 7.4 and associated units are shown in the Scope and Sequence document.

What should my students know from earlier grades or units?

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, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).
- Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.

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 Chemical Processes and Everyday Life

- Cellular respiration in plants and animals involve 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.

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

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).

PS1.B: Chemical Reactions

- Substances react chemically in characteristic ways. 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.
- The total number of each type of atom is conserved, and thus the mass does not change.

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:

- Asking questions and defining problems
  - Formulate questions that can be investigated and predict reasonable outcomes based on patterns such as cause-and-effect relationships.
- Developing and using models
  - Develop and/or use models to describe and/or predict phenomena.
  - Develop a diagram or simple physical prototype to convey a proposed object, tool, or process.
- Planning and carrying out investigations
  - Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
- 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.
- Constructing explanations and designing solutions
  - Use evidence (e.g., measurements, observations, patterns) to construct a scientific explanation or design a solution to a problem.
- 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.
- Obtaining, evaluating, and communicating information
  - Compare and/or combine across complex texts and/or other reliable media to acquire appropriate scientific and/or technical information.
  - Determine the main idea of a scientific text and explain how it is supported by key details; summarize the text.
  - Combine information in written text with that contained in corresponding tables, diagrams, and/or charts.
  - Use multiple sources to generate and communicate scientific and/or technical information orally and/or in written formats, including various forms of media and may include tables, diagrams, and charts.
  - Use models to share findings or solutions in oral and/or written presentations, and/or extended discussions.

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.
  - A system can be described in terms of its components and their interactions.
- Energy and Matter: Flows, Cycles, and Conservation
  - Matter is made of particles.
  - Matter flows and cycles can be tracked in terms of the weight of the substances before and after a process occurs. The total weight of the substances does not change. This is what is meant by conservation of matter. Matter is transported into, out of, and within systems.
  - Energy can be transferred in various ways and between objects.

What are some common ideas that students might have?

Students may come to this unit with prior knowledge and experiences that can be leveraged to your advantage. Some of these ideas include the following:

- Students might come into the unit thinking they understand how plants get food, namely, plants “make” their food using energy from the sun. Students might even call that process “photosynthesis.” However, this unit pushes students to go a level deeper. Where exactly are plants getting the inputs from to make their food? We—and plants—can’t just make stuff out of nothing. So where are the inputs coming from to make the food molecules like carbohydrates, proteins, and fats that we find in the foods we eat that come from plants?
- In previous units, students should have become familiar with the idea that matter cannot spontaneously appear or disappear. They will bring the idea that since food molecules are not entering the plant, then plants must be making them from other inputs that have the same atoms in them.

- In previous units, students should have seen cells under the microscope and should be familiar with the idea that animals and humans are made of cells.
- Students will bring in ideas that gases can enter into and out of cells through permeable membranes and that chemical reactions take place in human cells.
- Students will need to recall previous knowledge that all matter (and thus atoms) in our world is conserved and cannot be created or destroyed.

Remember not to assume from words or representations in students' models that they have an understanding of how plants get their food on a deep mechanistic level.

- A very common partial understanding is that plants get their matter to grow from the nutrients in the soil. This is why, instead of just eliminating soil and plant food from the class "candidate list" by using the hydroponic system, we also look for more evidence by testing the hydroponic water with food indicators. This drives the point that the major source of food molecules is not soil and plant food. Plants take in small amounts of atoms from the hydroponic plant food like nitrogen, phosphorus, and sulfur, but they are not the main source of building blocks to make plants grow. The main source comes from CO_2 in the air.
- Students may have ideas that sunlight is a form of matter that can be used by the plant to make food.
- Students will likely have intuitive ideas that sunlight gives plants energy, though students may not necessarily know how matter and energy interact.
- Students may think that processed foods are made of chemicals or stuff that isn't natural. They will figure out that the main ingredients in processed foods are actually from plants and that some ingredients also come from animals. However they will also figure out that chemically processed synthetic foods also come from plants.
- Students may have ideas that when food rots it is the food that is causing the changes and not separate, initially unobservable organisms living on the food.

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

This is the fourth 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:

- If taught before Unit 7.1 or at the start of the school year, supplemental teaching of classroom norms, setting up the Driving Question Board, and asking open-ended and testable questions would need to be added. (These supports are built into 7.1.)
- This unit is designed to come 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. Without these ideas, the questions raised make no sense to students, and they don't have what they need to develop the disciplinary core ideas. If not being done in the standard sequence, teachers would need to make sure there are other ways students have developed these foundational ideas, reflected in the PEs MS-PS1-1: Develop models to describe the atomic composition of simple molecules and extended structures and 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. Students will also need an understanding that all matter is made of particles, which is foundational ideas for these PEs. MS-PS1-5: Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.
- The unit is also designed to come after the extension of chemical reactions to living things that occurs in Unit 7.3. If students have not done that unit before taking this unit on, they will need to develop the idea that there are chemical reactions in living things, reflected in the PE 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.
- Supplemental teaching of PEs 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 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 living things are made of cells and those cells have structures for specific jobs. This unit will add to that knowledge by looking at the role of chloroplasts and mitochondria.

What are prerequisite math concepts necessary for the unit?

In Lesson 6 students use a NetLogo simulation to discover the relationship of how the inputs within the plant interact and affect the amounts of outputs and represent the process of photosynthesis in a plant.

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.SP.B.5.B Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.
- 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 input/output 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 selection. 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 scenario to pique interest, launch discussion, and begin to frame expectations.

Instructional Resource

Student Reader

Preface

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

No Prerequisite Investigations

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

Science and Engineering Practice: Asking Questions and Defining Problems

Crosscutting Concepts: Cause and Effect; Energy and Matter

CCSS

English Language Arts

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.

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.

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.

nutrient
science literacy
phenomenon
social media

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 Matter Cycling and Photosynthesis 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 about the Maui creation myths is written at approximately Lexile 1100–1200, 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."

Student Reader

Preface

Pages 2–3 **Suggested prompts**	**Sample student responses**
How would you summarize the "scene" referred to in the title?	*It explains how the Disney film* Moana *is related to Polynesian mythology, which contains both fiction and ancient scientific knowledge about nature that could still be valid today.*
In the film, Maui bragged that he can "explain every natural phenomenon." What is a "natural phenomenon"?	*something people can observe in nature, which includes all aspects of their daily lives*
What do scientists do to understand a natural phenomenon?	*They make observations, collect data, interpret data, and draw conclusions.* *Sometimes they do experiments to collect their data.*
The reading says, "nutrients that are released by the decomposing eel." You have likely heard this word used many times. But what exactly are nutrients?	*substances your body needs to grow* *substances used by living things for growth and energy*
Plants need sunlight, too. Is sunlight a nutrient?	*No, all definitions of* nutrients *imply that they are matter.*
How would you design an investigation to test the idea that plants grow faster and larger when eel guts are buried in the soil?	*We could take two pots of the same soil, add eel guts to one but not the other, sprinkle some seeds on both, and place the pots outdoors in the same location. Then we could check how fast and large the sprouts grow over time.*
What questions do YOU have about this Maui myth, other ancient people and nature, or nutrients in general that could be answered with an investigation?	*Did the Polynesians only bury eels, or did other kinds of fish work just as well?* *Did it have to be the fish guts, or could they bury the head, tail, and bones instead?* *Do farmers today use fish to fertilize their crops?* *Are dead plants also good for growing plants? Is this why people make compost?*
If you want to learn more about how ancient Polynesians explained natural phenomena, what reliable sources could you use?	*Ask a reference librarian for sources.* *Find books on specific cultures.* *Search online for university (.edu) and museum (.org) web pages about the topic.* *Find and read science magazine articles about ancient stories and the related science.*

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 2–3 Suggested prompts	Sample student responses
Should your sources for science information include social media?	*It depends. If you are asking these questions of your friends or followers and none of them are scientists, the information you get will not be reliable. But, if you follow scientists, science museums, or other experts, you could ask them questions, and the information will be more reliable.*
Can a person be scientifically literate and still enjoy films and books about ancient myths? Explain.	*Yes. You can use scientific thinking to explain things and solve problems in the real world and still enjoy stories because they make you feel happy, scared, or connected to other people.*

KEY IDEA—Point out that, without an investigation into the claim made by Maui that fish remains support the growth and survival of plants, there isn't really a way to draw a scientific conclusion. 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 to the topic of how nutrients from once-living organisms are recycled by plants at the end of the unit.

LESSON 1

Where does this stuff come from?

Previous Lesson *There is no previous Lesson*

This Lesson

Anchoring Phenomenon

3 DAYS

We brainstorm foods we ate that we think come from plants, animals, or other sources. We taste maple syrup and maple sap, foods that we are surprised come from plants and watch a video of sap being extracted from a tree. This motivates us to review nutrition labels for the plant foods we ate. All the plants have some food molecules like carbohydrates, proteins, or fats. We know we get our food from eating, but how do plants get their food? Where is the food in plants coming from? We develop a model to try to explain this and come up with questions to form a Driving Question Board (DQB). We brainstorm investigations to figure out the answers to our questions.

Next Lesson *We will investigate possible sources of food molecules such as carbohydrates, proteins, and fats inside plants using a hydroponic plant system and a list of potential candidates. We will do a lab with food indicators to confirm or eliminate each candidate.*

Building Toward NGSS

MS-LS1-6, MS-LS2-3, MS-PS1-3

What Students Will Do

Develop an initial model to describe the inputs of the system where plants get food molecules (matter).

Ask questions that arise from careful observation of food-related phenomena that the class can investigate to explain how plants get matter and energy to make food molecules.

What Students Will Figure Out

- All plant foods we looked up nutrition information for have food molecules in them. Not all of the plants have the same food molecules (carbohydrates, fats, proteins), but all of them have some sugar.
- Plants might get their food molecules from different sources (i.e., water, sunlight, soil).
- We have lots of questions about where the food in plants comes from.
- We have ideas for future investigations to pursue that could help figure out these questions.

Lesson 1 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	10 min	**EXPLORE THE FOOD WE ATE TODAY** Brainstorm what students ate today and categorize the foods into three bins: (1) 100 percent from plants; (2) mixture, not sure, or from some other source; and (3) 100 percent from animals. Taste a food that came from a tree—maple syrup.	A–D	1 plastic spoon, 3 oz plastic cup containing about 15 mL maple syrup, chart paper, markers
2	10 min	**WHERE DOES MAPLE SYRUP COME FROM?** Show a video of where maple syrup comes from. Share out patterns students noticed from tasting the maple syrup and watching the video.	E–F	computer with projector and sound to show the Maple Tree Tapping - Unit 7.4 Matter Cycling & Photosynthesis Lesson 1 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**), Patterns We Noticed chart, markers
3	5 min	**TASTE MAPLE SAP** Taste maple sap and record noticings and wonderings in students' science notebooks.	G	3 oz plastic cup containing about 15 mL maple water
4	7 min	**RECALL WHAT HAPPENS TO THE FOOD WE EAT** Recall what happens to the food we eat as it travels through our bodies. We connect this information to what we learned previously in our metabolic reactions unit.	H-I	*Food Molecule Cards*
5	11 min	**PREDICT WHICH FOOD MOLECULES ARE IN PLANTS** Work in small groups to combine and categorize the foods listed at the beginning of class. Then make predictions about which food molecules are in the foods that come from plants.	J	*What's in the foods we eat that come from plants?*, chart paper, sticky notes (or index cards and tape), colored markers, markers
6	2 min	**READ ABOUT BREAKFAST FOOD AROUND THE WORLD** Generalize out more about the plants containing food molecules phenomenon by having students take home a reading about foods from plants around the world.	K	*Reading: What do kids around the world eat for breakfast?*
				End of day 1
7	2 min	**NAVIGATION** Students recall their predictions about which food molecules are in the foods we eat that come from plants.	L	

Part	Duration	Summary	Slide	Materials
8	10 min	**INVESTIGATE WHAT IS IN FOOD THAT COMES FROM PLANTS** Investigate what's in the foods we eat that come from plants by working in small groups to look up their nutrition labels. Build our Related Phenomena poster as a whole class. Analyze our class data to look for patterns in our findings.	M	*Nutrition Labels: What is in food?*, chart paper, colored markers, Related Phenomena poster
9	5 min	**DEVELOP INITIAL MODELS OF HOW PLANTS GET FOOD MOLECULES** Develop an initial model of how plants get food molecules and where the food molecules come from.	N	*How Plants Get Food Initial Model*
10	7 min	**COMPARE INITIAL MODELS OF HOW PLANTS GET FOOD MOLECULES** Pairs of students compare models, and then students do a short gallery walk to compare three other models.	O-P	*How Plants Get Food Initial Model*
11	5 min	**REVISIT CLASSROOM NORMS** Have students review the classroom norms and set expectations for their work together on a consensus model. Prompt students to pick one norm to focus on for today.	Q	*How Plants Get Food Initial Model*, chart paper, markers, Discussion Norms poster, space for chairs in a Scientists Circle
12	18 min	**DEVELOP A CONSENSUS MODEL OF HOW PLANTS GET FOOD MOLECULES** In a Scientists Circle, conduct a whole-group consensus discussion around the questions, "How do plants get their food molecules? Where are they coming from?"	R	*How Plants Get Food Initial Model*, chart paper, markers, Discussion Norms poster, space for chairs in a Scientists Circle
13	2 min	**NAVIGATION** Use ideas from the consensus model to develop questions we can investigate.	S	
				End of day 2
14	7 min	**DISCUSS QUESTIONS TO POST ON DRIVING QUESTION BOARD** Provide question stems to help students work on and share their questions from last time to prepare to post them on the DQB.	T	sticky notes (or index cards and tape), marker
15	23 min	**BUILD THE DRIVING QUESTION BOARD** Develop the DQB with contributions from all students in the class.	U	sticky note with question, sticky notes (or index cards and tape), markers, chart paper
16	15 min	**DEVELOP IDEAS FOR INVESTIGATIONS** Develop ideas for investigations using contributions from all students in the class.	V	chart paper, markers, Ideas for Investigations poster
				End of day 3

Lesson 1 • Materials List

	per student	per group	per class
Lesson materials Student Procedure Guide Student Work Pages	• science notebook • 1 plastic spoon • 3 oz plastic cup containing about 15 mL maple water • *Food Molecule Cards* • *What's in the foods we eat that come from plants?* • *Reading: What do kids around the world eat for breakfast?* • *Nutrition Labels: What is in food?* • *How Plants Get Food Initial Model* • sticky notes (or index cards and tape) • marker • sticky note with question	• 3 oz plastic cup containing about 15 mL maple syrup • chart paper • sticky notes (or index cards and tape) • colored markers • markers	• chart paper • markers • computer with projector and sound to show the Maple Tree Tapping - Unit 7.4 Matter Cycling & Photosynthesis Lesson 1 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) • Patterns We Noticed chart • Related Phenomena poster • Discussion Norms poster • space for chairs in a Scientists Circle • Ideas for Investigations poster

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.

Laminate the *Food Molecule Cards* or place in sheet protectors. This is the same reference used in Unit 7.3: *How do things inside our bodies work together to make us feel the way we do?* (Inside our Bodies Unit). It is helpful to have this reference sheet laminated because students can use dry-erase markers to mark up the models of food molecules in Lessons 2 and 3. This reference sheet will also be frequently pulled out in later lessons.

Test the video of where maple syrup comes from (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**). Make sure you can hear the audio.

Prepare class posters: Initial Notice and Wonder chart, Patterns We Notice, *What's in the Foods We Eat That Come from Plants? (Related Phenomena)*, Consensus Model, DQB, and Ideas for Future Investigations. Determine where to set up the DQB so that students can gather around it.

Print *Nutrition Labels: What is in food?* for each group of students or have students pull it up on a device. It is multiple pages and you can reuse one set for all of your classes.

Day1: Maple Syrup and Sap Tasting

- **Group size:** Ideally the lab is completed in groups of 4.
- **Setup:**
  - Maple Syrup: Pour about 15 mL (about a tablespoon) of maple syrup into 1 small (3 oz) plastic cup per group. Make sure each person has a clean spoon.
  - Maple Sap: Pour 15 ml (about a tablespoon) of the maple water into a cup for each student.
- **Notes for during the lab:** Remind students not to share or to re-dip their spoon in the maple syrup after they have tasted it. Make sure students are using clean cups.
- **Safety:** Be sure to check for any food allergies to maple syrup and sugar intolerance and that you are using 100% maple syrup and sap. Follow your school's policy for safe food handling. Wear gloves when pouring cups and ensure that there is no sharing of spoons or double dipping.
- **Disposal:** Can be disposed of in standard trash receptacles.
- **Storage:** Store in a cool dry place. Make sure to check the expiration date.

Lesson 1 • Where We Are Going and NOT Going

Where We Are Going

In this lesson, students are introduced to the anchoring phenomenon of a maple tree producing sap that humans can drink (eat). By the end of the lesson, students figure out that their agreed-upon inputs for plants include water and perhaps sunlight, which leaves the class wondering, so then where did the food molecules in plants come from? This lesson elicits students' initial ideas about the system of how a plant can come to have food molecules such as carbohydrates, proteins, and fats, inside of it.

Students may come to this unit with prior knowledge and experiences that can be leveraged. Students might come into the unit thinking they understand how plants get food, namely, plants "make" their food using energy from the sun. Students might even call that process "photosynthesis." However, this unit pushes students to develop a conceptual model for this process. Where exactly are plants getting the inputs from to make their food? We—and plants—can't just make stuff out of nothing. So where are the inputs coming from to make the food molecules like carbohydrates, proteins, and fats that we find in the foods we eat that come from plants? Where do these food molecules go after they are made in the plant? How can the matter in animals, processed food, and synthetic food, be traced all the way back to plants? What happens to the matter when living things die?

Throughout this unit, students will be reminded of what they figured out in the Inside our Bodies Unit about the inputs and outputs of chemical reactions that happen to food molecules inside the body, related to these two NGSS performance expectations:

- 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.

Where We Are NOT Going

As students share their ideas, you may hear them say plants get what they need to grow from soil, rocks, or fertilizer. Although plants take in minerals from the soil, the amount of these minerals is very small compared to carbohydrates, proteins, and fats that make up most of a plant's structures. Encourage students to share their thinking, but avoid pushing back on any of these ideas at this point in the unit. Subsequent lessons will draw upon students' prior knowledge regarding inputs plants need to make food molecules. Over the course of the unit, students will notice that there are atoms that are in all the food molecules and in all of the inputs. These observations will be used to support students figuring out that carbon is an important atom in the cycle of plant growth and the food we eat. Students will see that carbohydrates, fats, and proteins all have a large amount of carbon in the structure, so carbon atoms make up the majority of a plant's mass. Plants get carbon from carbon dioxide in the atmosphere, not from carbon in the soil. The cycling of nitrogen is beyond the NGSS boundary for middle school and found in the high school grade band. Additionally, the biochemical mechanisms of photosynthesis are beyond the assessment boundary for the NGSS PE MS-LS1-6.

LEARNING PLAN FOR LESSON 1

1. Explore the food we ate today.

10 MIN

Materials: science notebook, 1 plastic spoon, 3 oz plastic cup containing about 15 mL maple syrup, chart paper, markers

Explore what students ate today. Show **slide A**. Begin by asking students to recall what they ate that day for breakfast or lunch. Ask students to Stop and Jot (on a new page) in their notebooks the list of foods they ate.

Science Notebook

This is the first use of the science notebook for the unit. You may need time to organize a new section in the notebook. How to set up the section will vary depending on how you've structured the components of your notebooks, such as the table of contents and how to note the start of a new unit. It is recommended to have students do the following:

- Reserve a blank page at the start of the unit where students will write the unit question on day 4 of this lesson.
- After the title page, reserve 2 pages (4 pages front-to-back) for the table of contents (unless all tables of contents are at the front of the notebook).
- Reserve 10 pages (20 pages front-to-back) for the Progress Tracker pages.
- After the Progress Tracker pages, begin numbering pages (start with 1) so everyone begins the first investigation of the unit on the same page number.

Remind students that the notebook is their tool for recording their observations, evidence, and ideas to share with the classroom community. They should see it as a space to brainstorm and record their thinking as well as a place to show how their thinking changes as they learn more.

Have students Turn and Talk to a student next to them about where the food originally came from—before it got to the grocery store, cafeteria, or vending machine. Listen for categories to emerge, such as plants and animals.

Additional Guidance

In this Turn and Talk, students are likely to say the food we eat comes from a factory or farm. While students talk to their partners, encourage them to think about the question, "But what originally made the food?" There is no need to go public with these responses because we don't want the class to get sidetracked into food processing.

Ask students where the food we ate came from. Show **slide B**. Ask students do a Stop and Jot by drawing three bins in their science notebooks: "100% from plants," "Mixture/Not Sure/Other," and "100% from animals." Then categorize the foods they listed above into these three bins. Tell students not to worry too much about the categorization at this point. If they are 100 percent sure a food is from a plant or animal, they should put it in the respective category. If they have doubts, they should place it in the Mixture/Not Sure/Other category.

*** Attending to Equity**
Some students might not realize that trees are a type of plant. Make sure you check that all students are making the connection that trees are plants too. If students are not making the connection ask them to name different types of plants they have encountered in their lives.

Additional Guidance

While students are working, check to see if there are foods in the “100% from plants” column that have fat in them. At least one student in the class needs to have something from plants that contains fat (used later in the lesson). Examples of plant foods that contain fat are avocados, peanut butter, almonds (or any nuts), olives, or beans.

Taste the maple syrup. Show **slide C.** Have students make a Notice and Wonder T-chart for maple syrup in their science notebook.

Say, *I recently ate a food that I was surprised came 100 percent from a plant. It was maple syrup. Has anyone tried maple syrup before? I brought in some samples so we can all have a taste. While you are sampling the syrup, record any noticings and wonderings that you have in the T-chart in your science notebook.**

Safety Precautions

Check for food allergies or sugar intolerance before allowing students to taste the maple syrup or maple water (sap). Make sure that syrup you are sampling is 100% pure maple syrup with no other added ingredients.

Alternate Activity

To make this phenomenon even more locally or culturally relevant, you could search the internet for plant-based syrups (or other products) from saps produced in your state or region, such as agave, birch, corn, or palm. If you find one to include, it is recommended that you also change to a local phenomenon, in the next activity.

Give students samples and show food labels of maple syrup. Allow students to taste the maple syrup.

- Hand out a clean spoon to each student.
- Ask students to wait to put the spoon in their mouths.
- Provide a 3 oz plastic cup with about 15 mL of maple syrup for each group of students.
- Instruct students to use a clean spoon to take a small amount of syrup to taste.

Record maple syrup noticings and wonderings, individually. Show **slide D.** While students are tasting the syrup, show the food labels on the bottle of syrup. Students can include ideas from these labels in the Maple Syrup Notice and Wonder chart in their science notebooks. As students record their noticings and wonderings in their science notebooks, walk around the room and quietly ask probing questions.

Suggested prompt	Sample student response
Think back to our previous Inside our Bodies Unit. Did food labels include any food molecules you recognized from studying M’Kenna’s case?	*Yes!*

Suggested prompts	Sample student responses
Which food molecules do you recognize?	*We recognize sugars (maybe carbohydrates), fats, and proteins.*
What did you notice about the food molecules found in maple syrup?	*I noticed that there seems to only be carbohydrates and sugar in maple syrup.*
What are you wondering about?	*I wonder why sugars are listed underneath carbohydrates.*
Why do you think sugars are listed under total carbohydrates?	*I'm not sure.* *I thought they were separate things.* *I've heard that sugars are types of carbohydrates, so that's why they are under the category "total carbs."* *Remember how we said there were different types of carbohydrates in M'kenna (such as complex carbohydrates like starch and fiber/cellulose and simple carbohydrates such as glucose).*
So, I hear you saying that there are carbohydrates and sugars in the maple syrup that came from the tree.	*Yes! The label says everything in the syrup came from the tree—they just took a little water out of it. The maple syrup tasted really sweet and sugar is listed on food labels.*
What is going into the system that gives this output of this really sweet food? Where is syrup coming from?	*It is in the tree.* *Maybe it is like fruit that also tastes sweet?* *It's kind of weird now that we think about it! We need to know more about where the syrup came from.*

Additional Guidance

If your students did not complete the Inside our Bodies Unit prior to this, but did complete different unit(s) of study that covered rearranging food through chemical reactions to support growth and/or release energy and the atomic composition of molecules, modify this framing and slide D to refer to those experiences that students had in place of the Inside our Bodies Unit, referenced in the slide.

Listen for student noticings and wonderings about why sugar is under the larger category of "Total carbs." We will refer to carbohydrates in general later and want to make sure students realize that sugar is a type of carbohydrate. This is an idea that students worked explicitly in the Inside Our Bodies Unit when figuring out what happens to food inside the body.

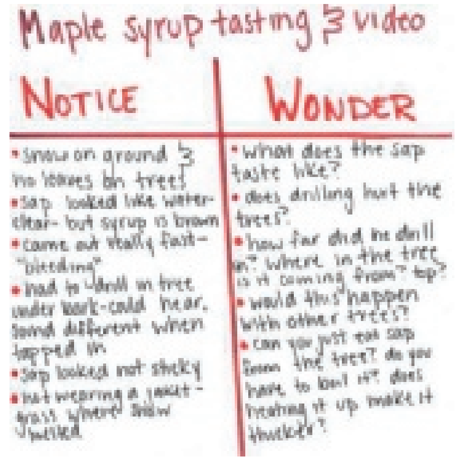
Additional Guidance

During this discussion (and other discussions during the unit) it may be helpful to record initial questions on a piece of chart paper for the class to see. Students may choose to repurpose some of these questions for the DQB on day 3.

2. Where does maple syrup come from?

10 MIN

Materials: science notebook, computer with projector and sound to show the Maple Tree Tapping - Unit 7.4 Matter Cycling & Photosynthesis Lesson 1 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**), Patterns We Noticed chart, markers



Say, *It seemed odd that this food came from a tree! What does that really mean? Is it from the fruit of the tree? From its leaves? Roots? I have a video showing where it comes from, and I was surprised at what it showed. Let's check out the video together.*

Watch the video of where maple syrup comes from. Show **slide E**. Instruct students to use the same Notice and Wonder chart in their science notebooks. Students should record in their Maple Syrup tables what they notice and any wonderings they have after watching the video. Show the video Maple Tree Tapping - Unit 7.4 Matter Cycling & Photosynthesis Lesson 1. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) You might want to play the video clip more than once.

Share out noticings and patterns we noticed. Show **slide F.** Have students go public with any patterns they noticed or important noticings during the maple syrup tasting and the video of tapping a maple tree. Record students' responses on the Patterns We Noticed chart.

Suggested prompts	Sample student responses
What patterns do you notice from the maple syrup tasting and the video of tapping a maple tree?	*The syrup tasted really sweet.*
	In the video, it looked like it was winter or spring because there was some snow on the ground and no leaves on the tree.
What did you notice about the inputs and outputs of the system?	*The maple syrup was brown, but the stuff coming out of the tree was clear.*
	The maple sap looked like water.
*What are you wondering about now?**	*We're not sure. Maybe maple sap tastes like water or maybe it's a little sweet?*
	Could we taste it?

*** Supporting Students in Engaging in Asking Questions and Defining Problems**
Initial questions about a phenomenon are intended to clarify what information is known and not known, and, as is often the case, there are more questions than answers when scientists begin their investigations. Develop a safe and supportive space for students' uncertainty, and focus on the need to ask and answer questions in order to address the uncertainty that may require the entire unit to resolve.

3. Taste maple sap. 5 MIN

Materials: science notebook, 3 oz plastic cup containing about 15 mL maple water

Say, *I was also curious about the maple sap that comes directly from the tree and I was able to get some samples. Would you like to try a taste of it?*

Taste the maple sap (maple water). Show **slide G.** Have students set up their Maple Sap T-charts while you pass out samples to taste. The manufacturer calls it "maple (drink) water," but it is the same as the maple sap dripping out of the tree that we saw in the video.

- Provide a 3 oz plastic cup with about 15 mL of "maple water" for each student.
- Students should record their observations and questions about the tasting and the nutrition label in their science notebooks.

4. Recall what happens to the food we eat. 7 MIN

Materials: science notebook, *Food Molecule Cards*

Stop and Jot about what happens to the food we eat. Show **slide H.**

Say, *Close your eyes. Think about the sugar in the maple sap we just drank. We put it into our mouths, and then what happens to it in our body? Where does it go? Recall what we learned about chemical reactions in the body and visualize what will happen to that food over the next 24 hours as it moves through our bodies. Stop and Jot in your science notebook what you think happens.*

Additional Guidance

This matter cycling and photosynthesis unit is explicitly connected to the *Inside our Bodies Unit*. Students need to recall what they learned about chemical reactions in the body that break down food and cellular respiration as they visualize what happens to the maple syrup we put in our mouths. Students should have worked with the food molecule cards for carbohydrates, proteins, and fats.

Share out initial ideas as a whole group. Have students go public with their thoughts about what happens to the food we eat and drink.

Key Ideas

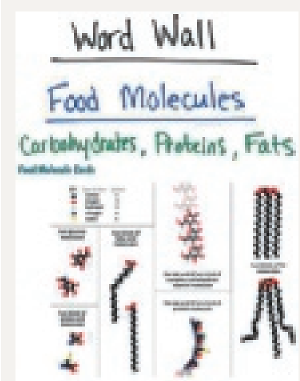
Purpose of this discussion: Give students a chance to (1) reflect on what they already know about food molecules and chemical reactions from previous units and (2) connect that plants, like animals, can have food molecules inside of them.

Listen for these ideas:

- The investigations students did to figure out what happened to the matter and energy of the food molecules over time when they investigated M'Kenna's case during the Inside our Bodies Unit (such as burning duck fat and oil, measuring carbon dioxide changes in a system, etc.)

*** Attending to Equity**

When new scientific words, like food molecules, 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. You can assign a student to create an entry for the word wall. Paste a copy of the *Food Molecule Cards* onto the word wall entry. Here is one possible representation:

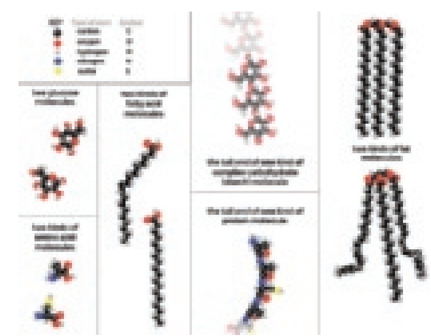


This will engage students in retrieving ideas from the previous unit and remind the class that chemical reactions occur within systems of living things to transfer matter and energy.

Suggested prompts	Sample student responses
Think about what happens to the sugar from the maple sap we just drank. What did we learn during the Inside our Bodies unit about what happens to the food we eat as it goes through our body system?	*It enters my body through my mouth, down my esophagus, and into my stomach. Then it moves into my small intestine and passes through the wall into my blood. My blood takes the little pieces of food to the cells in my body.*
What is the food used for in our cells?	*Our cells use it for building blocks to grow, for energy to do the things our body needs to do like move, breathe, think, etc., or food molecules can be stored for later use.*
What do our bodies do to the food in order to be able to use it for energy?	*Our bodies have to break it down into smaller pieces through chemical reactions. Sometimes food is rearranged into different molecules inside our bodies. Some of the molecules leave our bodies as waste, like some gases.*
Can someone say more about the molecules that are inputs to our bodies and the molecules that are outputs from our bodies?	*We saw in the Inside our Bodies Unit that we take in (input) food molecules (like carbohydrates, proteins, and fats) with oxygen and give off (output) carbon dioxide and water.*

Summarize, *So we learned in the Inside our Bodies Unit that when we eat food, it gets broken down and that we use it for energy, for growth, or for later use by storing it. We also learned what food was made out of. What molecules is food made out of again? Maybe we should take out our Food Molecule Cards from our last unit to double check.*

Food Molecule Cards



Reexamine the *Food Molecule Cards* from the Inside our Bodies Unit. Show **slide I.** Instruct students to take out their *Food Molecule Cards* from the Inside our Bodies unit or you can also have the reference *Food Molecule Cards* ready to hand out to students for convenience, which contains the same image of *Food Molecule Cards* from the Inside our Bodies Unit.*

Suggested prompts	Sample student responses
What is food made out of according to our Food Molecule Cards?	*Basically food is made up of carbohydrates, proteins, and fats.*
And what primarily makes up those food molecules?	*They are all mostly made up of carbon, hydrogen, and oxygen atoms.*
	We notice that all of the food molecules are made of mostly carbons in the center of their structure with oxygens and hydrogens, and a few other atoms like sulfur and nitrogen (in amino acids and proteins).

Summarize, *So basically all food is mostly made up of these molecules that have carbon, hydrogen, and oxygen. We just ate some food from a tree, which is a type of plant. According to the nutrition label, the maple sap and syrup had sugar—a type of carbohydrate—in it.*

Suggested prompts	Sample student responses
I understand that we get our food molecules like carbohydrates from eating, but how did the maple tree get its carbohydrate molecules?	*Accept all responses. Possible responses might include: air, water, soil, eating just like us, sunlight, or making food molecules.*
Now that I'm thinking about it, it's kind of weird; we get food molecules from eating, but where are other plants getting their food molecules from?	*Answers will vary. Accept all responses.*
So, do the other foods we listed that come from plants have food molecules in them too?	*yes; no; maybe* *I have looked at food labels for other foods and they had food molecules.*

Say, *Let's go back to the list of foods we ate and see if we can organize them into categories before we try to figure out what is in each of them.*

5. Predict which food molecules are in plants. 11 MIN

Materials: science notebook, *What's in the foods we eat that come from plants?*, chart paper, sticky notes (or index cards and tape), colored markers, markers

Combine and categorize the foods our group ate into 3 bins. Distribute half a piece of chart paper to each group. These posters will be reused in Lesson 12. Show **slide J**. Explain the following:

With your group:

- Look at your original list of foods that you individually categorized as 100% from plants, Mixture/Not Sure/Other, or 100% from animals. This time, you will break down the ingredients to make sure you are putting things that we are 100% sure come from the plants and animals into these categories.
- Write each food from your individual list on a sticky note using a marker.
- Work in small groups to combine all the sticky notes with foods you ate into three groups: 100% from plants, Mixture/Not Sure/Other, and 100% from animals. (Make sure to get rid of any repeats within your group).

Individually:

- Use your 100% from plants category to make a prediction: "Which food molecules would we find in these plant foods?"
- Record your predictions on the handout, *What's in the foods we eat that come from plants?*

We will walk through an example before your small groups get to work.

Say, *So let's say I had pizza for lunch. Instead of calling pizza a mixture, I'm breaking it down into the crust, tomato sauce, cheese, and olives. Crust—I'm not sure—part of it might be from a plant, but I'm not totally sure, so I'm putting it in the Mixture/Not Sure/Other category. Tomato sauce I'm sure comes from tomatoes, which are plants, and cheese is from milk, which comes from animals, and olives grow on trees, which are plants too.*

While students are working, check to make sure that at least one small group has a food in the "100% from plants" category that contains fat, such as nuts, avocado, beans, or milk. If you do not see one, you could ask, *Does anyone like peanut butter cups? Did anyone eat one for dessert?* Work with students to put the peanut butter in the 100% from plants category, even if the chocolate gets put in the Mixture/Not Sure/Other category.

If there are still no foods that might contain fat on the list, add one from yourself. Go to a small group and ask if you could join their group list. For example, say *I had almonds in my cereal this morning, could I join your group list and put my food from plants up with yours?*

Distribute *What's in the foods we eat that come from plants?* and have students tape it into their notebook.

Make predictions about which foods from plants have different food molecules in them. Use the group 100% from plants category to make a prediction: "Which food molecules would we find in these plant foods?" Students individually record these foods and their predictions about the molecules in the data table on *What's in the foods we eat that come from plants?*. Students might wonder why "carbohydrates" on the nutrition labels contain both sugars and dietary fiber. See the suggested prompts below.

Suggested prompts	Sample student responses
Ask if any students noticed that many food labels contain an additional category under "total carbohydrates" besides sugars called "dietary fiber." What do we remember from Inside our Bodies Unit about dietary fiber?	*Isn't fiber the stuff that mostly comes out in our poop?*
So most of the dietary fiber we eat comes out of our bodies. Does anyone recall what fiber is made out of?	*Yeah, I think fiber is sugars linked up somehow.*

Say, *So fiber is made up of smaller sugars, but the way the sugars are connected, our bodies can't break them down (unlike starches, which are made up of smaller sugars too, but our bodies can break down starches). OK, so now when we refer to "carbohydrates" we are including both sugars and fiber in "total carbohydrates." Let's make sure to look for the different types of carbohydrates, and proteins and fats tomorrow.*

Alternate Activity

You can assign students to research their predictions about what food molecules are in each of their plant foods for home learning, instead of doing it in class during day 2. Students would need to look up the nutrition labels of their foods and mark which food molecules (carbohydrates, proteins, fats) are actually in each food that comes from plants.

6. Read about breakfast food around the world.

2 MIN

Materials: *Reading: What do kids around the world eat for breakfast?*

Introduce the *What do kids around the world eat for breakfast?*. Show **slide K.**

Say, *Before we investigate our food from plants to see what food molecules they have, let's take some time to see if people around the world also eat food from plants! You will each read about a student in another country and what they eat for breakfast.**

Suggested prompts	Sample student responses	Follow-up questions
Why might it be important for us to look at foods from around the world?	*Accept all responses.*	*Can anyone else add to that?*
Why might it be important for us to look at foods that are personally relevant to us?	*Accept all responses.*	*Say more about what you mean by _________.*

Home Learning Opportunity

On *Reading: What do kids around the world eat for breakfast?* students will read about kids in different countries and what they eat for breakfast. In the next class students can add these foods to their group's list to investigate which food molecules are in plant food.

End of day 1

*** Attending to Equity**
This is an opportunity for students to leverage their own experiences with food in the classroom and emphasize that each individual has contributions to make to their community of learners. It is through differences in thinking and experiences 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. If students are interested in breakfast food from countries or places not listed in *Reading: What do kids around the world eat for breakfast?*, have them make a list of breakfast foods and they can predict what food molecules might be in the food. Then you can print out or show the nutrition label in class with their group.

7. Navigation

2 MIN

Materials: science notebook

Recall where we left off in the last class by using the navigation routine. Show **slide L.**

Suggested prompts	Sample student responses
We left off last class making predictions about which food molecules are in the foods we eat that come from plants and breakfast foods around the world. What were some of our predictions?	*Accept all answers.*
What did we want to do to figure out our predictions?	*We want to look at nutrition labels for the other food we ate like we did for the maple syrup and sap.*
I have nutrition labels from many different types of plants that we said we ate. Can someone remind me what we want to look for when investigating our predictions about what is in the food we eat and food from around the world that comes from plants?	*We want to look for the food molecules we saw in the food that M'Kenna ate.*

Alternate Activity

Students may be interested in adding the foods from around the world reading to their group's list. If so, provide them with sticky notes and markers to add the new foods to their 3 bins. There are food labels in *Nutrition Labels: What is in food?* for each of the foods students read about in *Reading: What do kids around the world eat for breakfast?*.

Additionally, if students are interested in a food that is not listed, have 1-2 devices around the room where students can do an internet search for the nutrition label for that food.

Say, *Let's use those labels to look up the foods on our lists and record our findings!*

8. Investigate what is in food that comes from plants.

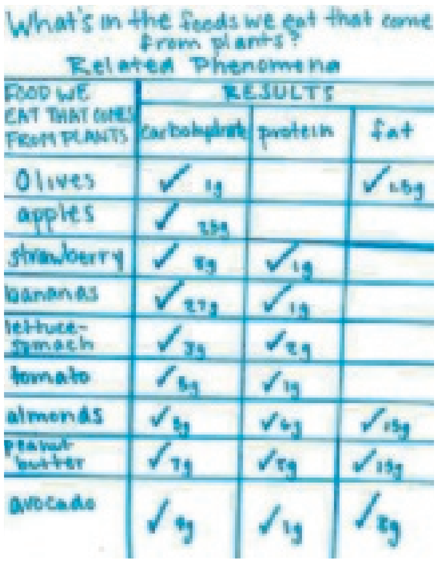
10 MIN

Materials: science notebook, *Nutrition Labels: What is in food?*, chart paper, colored markers, Related Phenomena poster

Record results from the *Nutrition Labels: What is in food?* investigation. Show **slide M**. Distribute *Nutrition Labels: What is in food?* to each group. Each group should write down the foods they have decided to investigate on *What's in the foods we eat that come from plants?*. Then instruct students to find each food they need in the *Nutrition Labels: What is in food?* Each group can divide the foods among their small-group members to research since each small group should have the same list of foods. Once they have found the food, students record whether or not the food has carbohydrates, fats, or proteins in the "Results" section of the table on *What's in the foods we eat that come from plants?*.*

*** Supporting Students in Engaging in Asking Questions and Defining Problems**
Encourage students to Stop and Jot down any questions that bubble up for them during this lesson. They will be building a DQB at the end of Lesson 1, and we don't want to them to forget any productive questions that arise.

Have a representative from each small group record the findings of what food molecules are in two to three foods the group ate. Representatives from each group will do this for the whole class on the Related Phenomena poster titled What's in the Foods We Eat That Come from Plants?



Analyze class data recorded on the Related Phenomena poster.

Suggested prompts	Sample student responses
What patterns do you see in the foods we eat that come from plants?	*Basically every plant food listed has some carbohydrates in it.* *Some foods like bananas have food molecules we didn't predict.* *A few of the plants have fats in them too, like peanut butter, almonds, and avocados.*
Is there anything surprising in the patterns you see?	*We were kind of surprised to see food molecules like proteins in bananas or fats in peanut butter. What does a plant need fat or protein for? What are these food molecules doing in plants? Are plants somehow "eating" like we do to get these food molecules?*

Alternate Activity

The *Nutrition Labels: What is in food?* is many pages long. You can have one packet per group and reuse these from class to class. If you are unable to print this, make sure to provide at least one Wi-Fi-enabled device per group for students to access the *Nutrition Labels: What is in food?* digitally.

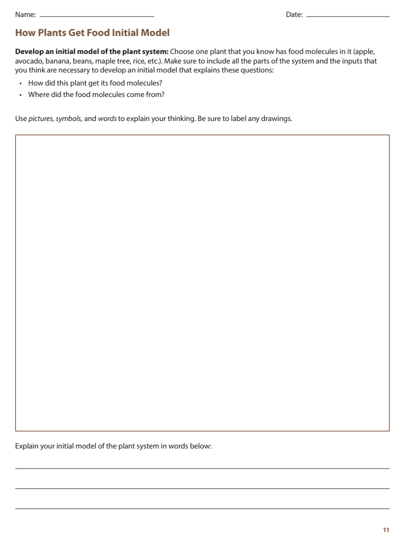
9. Develop initial models of how plants get food molecules. 5 MIN

Materials: *How Plants Get Food Initial Model*

Say, *We learned that we get our food molecules from eating, but how do plant systems get their food molecules? Where are the food molecules in plants coming from? Let's try to figure this out by drawing a model of our initial ideas.*

Develop an initial model of the plant system.* Show **slide N** and explain the following:

- Hand out one copy of *How Plants Get Food Initial Model* to each student.
- Tell students to choose one of the plants we've investigated so far on our list of Related Phenomena (e.g., maple tree, banana, avocado, beans, apple, or one of the plants they read about last night).
- Have them work individually to develop an initial model of the system to explain the following:
  - How did this plant get its food molecules?
  - Where did the food molecules come from?*



Name: ______________ Date: ______________

How Plants Get Food Initial Model

Develop an initial model of the plant system: Choose one plant that you know has food molecules in it (apple, avocado, banana, beans, maple tree, rice, etc.). Make sure to include all the parts of the system and the inputs that you think are necessary to develop an initial model that explains these questions:

- How did this plant get its food molecules?
- Where did the food molecules come from?

Use *pictures, symbols,* and *words* to explain your thinking. Be sure to label any drawings.

Explain your initial model of the plant system in words below:

* Supporting Students in Developing and Using Systems and System Models

Systems and systems models are a focal crosscutting concept for this unit. A system is an organized group of related objects or components. Here we refer to those objects or components as parts. Scientists use models to understand and predict the behavior of systems. The first step in modeling a system in order to understand it is to figure out the important parts of the system. This allows scientists to study how the parts interact to produce the emergent behavior of the system as a whole. Help students set up their initial models as systems models by identifying the important parts of each system and thinking about how those parts work together (interact).

* Supporting Students in Engaging in Developing and Using Models

Tell students it's OK if they don't know the "right" answer when drawing models. At this stage, there are no "correct" ideas to think or questions to ask. All ideas and questions are welcome. The goal of making an initial model is to make their thinking visible to others. Have students try to put any ideas they are thinking down on paper. They can use pictures, symbols, and words. Make sure they label any drawings.

10. Compare initial models of how plants get food molecules. 7 MIN

Materials: science notebook, *How Plants Get Food Initial Model*

Share initial models of the plant system for how plants get food molecules. Show **slide O**. Students should make a table in their notebooks to record similarities and differences and title it "Comparing our models".

Have students explain their own model to an elbow partner at their table.

- Each student talks for one minute.
- Then students record in their science notebooks similarities and differences they notice about the ideas represented.

To help focus students' model comparison on the relevant components, instead of superficial features, share some examples and some non-examples of productive comparisons.*

Have students do a quick gallery walk. Show **slide P.**

- Have students leave their models at their seats.
- Ask students to move so they stand at another student's model. Tell them they only have 10 seconds to do this.
- 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 get ideas flowing for building the consensus model in the next step.

*** Supporting Students in Engaging in Developing and Using Models**
Describe examples and non-examples by using a productive comparison. For example, a similarity might be that both students put water going into their plants. If one student colored the water blue and another student didn't color the water at all, that is a difference. But this difference might not be as helpful for understanding as the differences between students' ideas.

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, say *Table A students, stand at another student's model at Table B. Table B students, stand at another student's model at Table C.*

Assessment Opportunity

Students' *How Plants Get Food Initial Model* can be collected and used as a formative pre-assessment. They can help identify what science ideas students are bringing to the table and where students are at in their development of the practice of modeling. This is a great opportunity to see the resources your students are bringing into this unit.

11. Revisit classroom norms. 5 MIN

Materials: science notebook, *How Plants Get Food Initial Model*, chart paper, markers, Discussion Norms poster, space for chairs in a Scientists Circle

Revisit classroom norms to prepare for a whole-class consensus discussion. Show **slide Q**. Have all students sit together in a Scientists Circle and bring their science notebooks and *How Plants Get Food Initial Model* with them.* Have chart paper ready to develop a consensus model with the questions "How do plants get their food molecules? Where are they coming from?" at the top.

*** Attending to Equity**
This is an important opportunity to emphasize that each individual has contributions to make to their community of learners. It is

Scientists Circle

Your students may be familiar with the Scientists Circle from a previous unit. Remind students of the norms for participation and the logistics for forming and breaking down that space. A Scientists Circle includes these important features:

- students sitting so they face one another to build a sense of shared mission and a community of learners working together
- celebrating progress toward answering students' questions and developing more complete explanations of phenomena
- focusing on where students need to go next and how they might go about the next steps in their work

Take this opportunity to remind the class how we listen to one another, press on one another's ideas, and ask questions of one another, and that it's OK to disagree with ideas but it's important to be respectful. You can use **slide Q** to remind students of the classroom norms (if you have developed your own set of norms, replace this slide with your norms).

Additional Guidance

Based on the work done in the previous unit, evaluate how well your students did with the classroom norms guiding their work. If students did well with some norms, celebrate that now. If they need additional work on other norms, focus their attention on those norms. Spend a few minutes discussing the norms again and having students share (1) what a given norm would look like if everyone were following it and (2) what it would sound like. Then tell students that the class will practice the norm they chose today as they work on their consensus model.

Remind students of the Communicating in Scientific Ways sentence starters. Direct students to the *Communicating in Scientific Ways* poster or handout. 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. Examples include these:

Think of an idea, claim, prediction, or model to explain your data and observations:

- My idea is …
- I think that …
- We could draw it this way … to show ...

Give evidence for your idea or claim:

- My evidence is …
- The reason I think that is ….

Other examples could come from (1) listening to others' ideas and asking clarifying questions, (2) agreeing or disagreeing with others' ideas, and (3) adding on to others' ideas.

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.

12. Develop a Consensus Model of how plants get food molecules.

18 MIN

Materials: science notebook, *How Plants Get Food Initial Model*, chart paper, markers, Discussion Norms poster, space for chairs in a Scientists Circle

Conduct a whole-class consensus discussion to build a consensus model. Show **slide R.** During the consensus discussion, first help students generalize their models to apply to all plants, rather than to their individual plant choices.*

Tell students that the goal of this discussion is to figure out areas of agreement and disagreement in our initial models. Emphasize that knowing where we agree and disagree will help us identify questions we want to try to answer and ideas for investigations we want to pursue.*

Key Ideas

Purpose of this discussion: See if we can agree upon the important parts and inputs of the system that we think could be how plants come to have food molecules inside of them.

Listen for these ideas:

- Accept all responses.
- Possible parts of the system include:
  - plant (with different parts such as roots or leaves) and parts of the plant below and above the surface of the ground
  - air/environment around the plant
  - sun
  - soil
  - food molecules inside the plant
  - inputs going into the plant, such as water, food, or air

Additional Guidance

If students bring up sunlight as energy, don't ignore—write "sun/sunlight" and put up "energy" with a question mark. No need to push for it, but if it comes up say, *We are going to focus on where plants get the matter for the food molecules first and then we will come back to figuring out the energy piece.*

Suggested prompts	Sample student responses
Let's start by discussing one of our differences. Did we all draw a model for the same plant?	*No, that was one of the differences we saw when comparing models.*
Which one did you draw?	*I drew a banana/apple/maple tree ...*

*** Strategies for This Consensus Discussion**

As an instructor, you have two goals for guiding the consensus discussion, in addition to the goals listed on **slide R**. Your first goal is to help students: (1) build a positive culture where putting their ideas out in the public classroom community is valued and (2) to generate a variety of initial ideas to identify that there is a lot we don't understand yet. Highlight any areas of disagreement. Be careful not to favorably respond to any one idea over others to not "give away" the answer.

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

Although it will take a bit more time, help students generalize their specific examples to apply to all plants. When modeling, scientists have to continue mapping specific examples to a more generalized version of what's occurring. Allowing students to do this work here will help them more broadly develop their practice of modeling.

*** Supporting Students in Developing and Using Systems and System Models**

Students may have been listing various components of the plant system. It is OK to start pushing them to describe if any of the matter is moving into the plant as

Suggested prompt	Sample student response
*So maybe we should just draw one of them? But then that doesn't represent all our ideas … . Hmm, how could I represent all of our different plants?**	*Hmm, maybe you could just draw a circle or square or something generic to represent all the plants.*

an input for food molecules. You can also ask students if there are any components of the system or inputs that are invisible to us with just our eyes that might be important in the system.

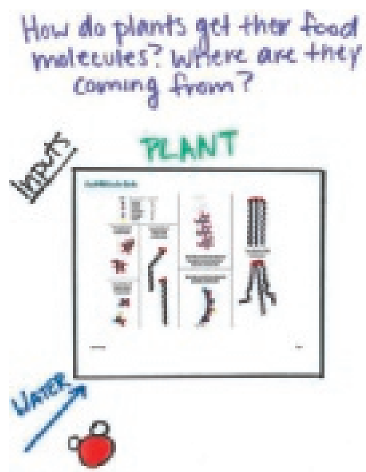
Say, *So even though we all chose different plants to draw, we can combine our ideas to represent all plants.*

Suggested prompts	Sample student responses
Was there anything we all had in common in our models?	*We saw water in everyone's models.*
Did anyone else see water in everyone's models?	*yes*
Was that water going into the plant?	*Yeah, I had it going into the plant through the roots in the soil.*
	I had water coming down from rain.
	I had it coming from the air.
OK, so some students had water come from different places, but everyone had water going from outside the plant to inside the plant in some way. Did I get that right?	*Yeah, that seems right.*

Say, *I'm going to write the word "input" at the top to represent things we agree are going into the plant. I'll write "water" with an arrow under the input list, but I'll put some question marks around how it's going into the plant because we all didn't have it entering in the same way. Is there anything else we agree on? Does everyone agree that there were food molecules inside your plants?**

Look for these three key components in the model: plant, food molecules, water. See the image for an example of what the model might look like at this point.

Other areas of agreement might include sunlight and that parts of plants are "above the surface" or "below the surface." It's OK if these areas don't surface at this time.

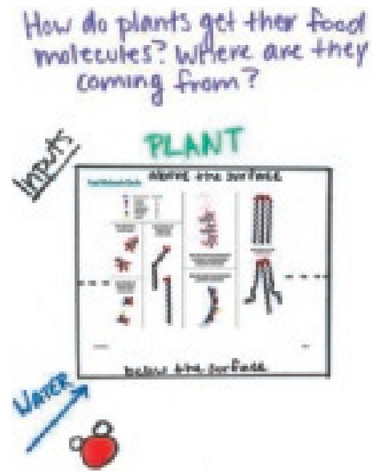


*** Strategies for This Consensus Discussion**
Don't worry about fleshing out every similarity or difference. For example, you can say to the group, *So it sounds like some people have X, but not everyone is totally convinced yet. So let's put it up with a question mark. Does everyone agree that we're not totally in agreement about X? Consensus can mean we agree that we're not in consensus.*

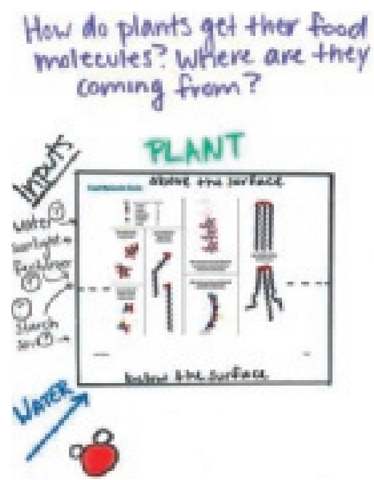
Suggested prompt	Sample student response
(If students say "leaves" or "roots" are something everyone had, try to push whether this statement is correct.) Did all students really have these specific parts in their models?	*Well, we all didn't have them in our models, but we think all plants might have some roots and/or leaves.*

Suggested prompt	Sample student response
Maybe we can agree that there are parts of plants above and below the surface exposed to light. (Put a dotted line with the labels "above the surface" and "below the surface" on the model.) Do we all agree on this?	*Yeah, we can agree that there are parts of plants above and below the surface exposed to light.*

If you haven't already, write "food molecules" on a sticky note and put it in the middle of the model or you can tape a copy of *Food Molecule Cards* right onto the consensus model. Tell students this placement represents the idea that we think food molecules could be found above and below the surface. Try not to get too many specific examples on the consensus model that don't apply to all plants. If they do come up, include them with a question mark.



Summarize, *On our models, we have several areas with question marks. We agree that there are food molecules in the plant either above the surface, below the surface, or in both places. We also agree that water (maybe sunlight too) is going into the plant, but how are the plants getting food from those things? What questions do you now have about how plants get food molecules?*



Additional Guidance

It might be helpful to help students problematize why it seems so strange that there are food molecules inside plants. Ask questions like, *In order for plants to get protein, do we need to cut up some chicken or hamburger and put it around the soil?"* (No!) *So then how* does *the plant get protein inside it?*

13. Navigation

2 MIN

Materials: science notebook

Record new questions. Show **slide S**. Have students write down new questions they are now thinking about for how and why plants get food molecules. They should write them in their science notebooks before they leave class or on a separate paper to be collected. They should come to the next class prepared to share those questions with others. If you are short on time this can be done as home learning.

Let the class know that at the next session we will share out all of our questions and build a DQB to help figure out what's going on with these food molecules inside plants.

Assessment Opportunity

You can read students' questions as a formative assessment prior to the next class and then again later in the unit to see how students' questions are developing. Look for students to be asking how and why questions about how plants come to have food molecules or other related phenomena.

End of day 2

14. Discuss questions to post on Driving Question Board.

7 MIN

Materials: science notebook, sticky notes (or index cards and tape), marker

Return to the questions students generated earlier and develop new questions. Say, *Last class, we brainstormed a lot of questions about how plants get their food molecules and other similar phenomena. Today, we're going to post our plant-food related questions to our Driving Question Board and begin thinking about how we're going to investigate to figure out what's happening in the system for plants to have food molecules in them.*

Share questions with a partner. Show **slide T**. Pull out their questions from the last class or their home learning.

- They should write one or two questions on sticky notes with large, **BOLD** writing so everyone can see. They should write only one question per sticky note.
- Share their questions with one partner in the circle.
- Remind students that the questions do not all have to start with how or why, but they should be questions that (1) we can answer through investigation and (2) will help us explain how these plant systems work the way they do.

Collaboration

As students learn to go public with their ideas, it can help to stimulate and support their individual thinking by sharing their questions with one person first, before having to go public with their questions in the large group. If your class is very comfortable sharing ideas in public already, you can omit this step in the lesson.

15. Build the Driving Question Board.

Materials: science notebook, sticky note with question, sticky notes (or index cards and tape), markers, chart paper

Gather students in a Scientist Circle around the consensus model you created. Show **slide U.** Find a place where all students can gather around the DQB. Place the Initial Class Consensus Model poster in the center of the DQB. Students should bring their science notebooks and their sticky notes (or index cards with questions).

Make sure you provide extra markers and sticky notes (or cards) around the perimeter of the circle.

Remind students that our goal today is to capture all of our questions by building a DQB. We can build the DQB on chart paper so we can move it around the class as needed. On a large piece of chart paper or in a part of the room that can stay up for the duration of the unit write the questions, "How do plants get their food molecules? Where are they coming from?"

Say something like, *it looks like you have a lot of really good questions about where the food molecules come from in the trees that produce maple syrup, in other foods we eat, and from making our models about how and where plants get their food molecules. It is important that we hear everybody's questions, and we might find that we have similar questions. We need to listen closely so we can link our questions.*

Create the DQB.

1. The first student comes up to the DQB with their index card, faces the class, and remains standing. The student reads their question off the card and then posts it on the DQB near the section of the consensus model or related phenomena it is most related to. *(Note: If the model is off to the side, students can post the note/card in a new space on the board/chart paper.)*
2. The students who are listening should raise their hands if they have a question that relates to the question that was just read aloud.
3. The first student selects the next student whose hand is raised.*
4. The second student reads their question and says why or how it relates to the previous question. Then the student places their question near the question it most relates to and selects the next student.*
5. This process continues until everyone has had a chance to post a question. If no one has a question that relates to the one before it, the class can decide to start a new thread.

Organize questions into groups. As students share, questions will naturally start clustering into similar parts of the model system or similar types of questions. If you are using the class consensus model as the backdrop for the DQB, ask students to post questions about specific parts of the system near that part of the consensus model. 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 overarching question or category label.

Ask, *What bigger questions do the questions in this cluster help answer? Or how could we categorize the questions in this cluster? How do all of these questions fit together?*

Here are some possible examples:

- **Soil:** What's in the soil? Does soil have protein? Can plants live without soil?
- **Water:** Why do I only have to water my houseplants for them to live? Does water go into a plant's leaves or just the roots?

*** Attending to Equity**
Having the student who volunteered and posted a question pick the next student to share (from those whose hands are raised) is a great way to turn over the pacing and cadence of this group work to the students. Reuse this technique in future Scientists Circle discussions to encourage increased student agency in the classroom learning community. When you do this, take a seat with the students in the circle to position yourself as an equal member of the learning community who is listening, making sense of questions, and trying to figure this out. If you have questions that you want to share with the group, raise your hand and wait for someone to call on you.

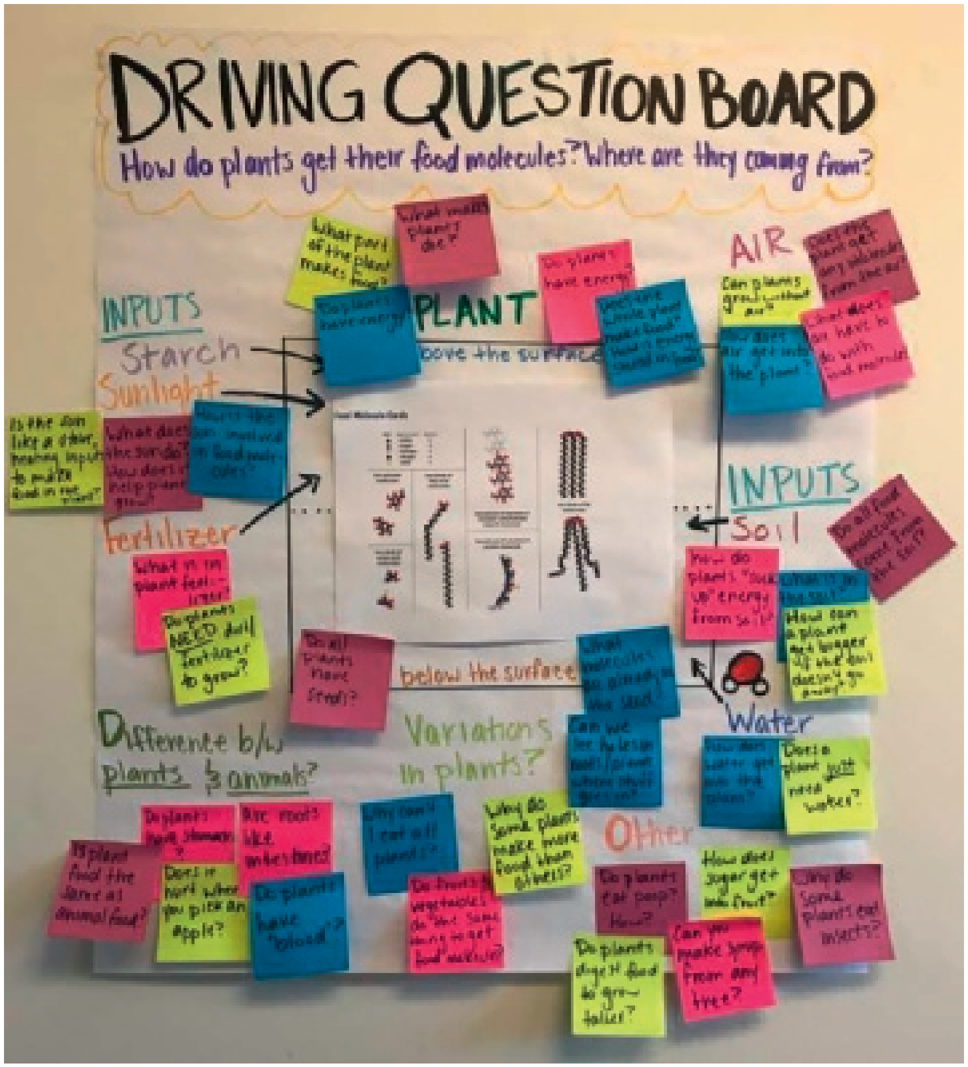
*** Supporting Students in Developing and Using Systems and System Models**
Systems and systems thinking is a focal crosscutting concept in this unit and has been in four of the prior units. As students ask questions, have them reflect on any parts of the plant food system that have few or no questions posted on the DQB. Prompt students to generate more questions in this space so that each important part of the system is to be investigated.

- **Plants:** What's inside plants? Do plants need to eat as we do? Why did the maple tree have sugar flowing out of it? How do plants survive in the winter? Why do plants need fats, anyway? Do plants have fats because they get too many nutrients? Do plants need proteins because they move with muscles as we do?

Say, *So many of our questions are connected. They all work together to answer our driving question, "How do plants get their food molecules? Where are they coming from?"*

Remind students that we can revise this driving question as we figure out things in future lessons or find that we have new sub-questions we need to add to the board.

An example of one such driving question board is shown here:



16. Develop ideas for investigations. 15 MIN

Materials: science notebook, chart paper, markers, Ideas for Investigations poster

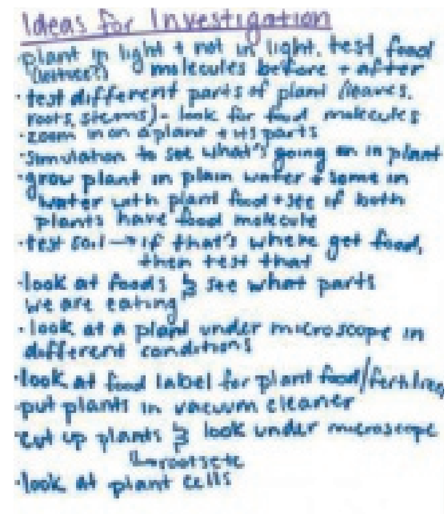
Stop and Jot Ideas for Future Investigations. Present **slide V.** Have students return to their seats or move somewhere they can work individually. Give students 5 minutes to brainstorm their own ideas for investigations that we could do to answer our questions. As students are doing this, create a new poster, titled Ideas for Investigations**.** Put this right next to the DQB.

In the last 10 minutes of the period, have students reconvene in a Scientists Circle around the poster so all can see it. Giving the students an option to stand (or sit) at this point might be desirable, as long as everyone can see the poster and the structure of an open circle is maintained so everyone can make eye contact.

Tell students that you are going to record their ideas and that you want everyone's idea to be represented. A suggested way to ensure that all students' ideas are shared and get up on the board follows.

Say, *To make sure we have your idea(s) up here, I will pass a marker to the first person on the edge of the circle. The student with the marker should share one idea they have. I will write it up and number it. Once that student sees that I have almost finished writing it, that student should pass the marker to the student next to them. The second student then shares an idea. If the idea is on the poster already, the student should say which idea is similar and how it is similar. I will then put another tally mark next to that idea. In this way, the marker is passed all around the circle and all students have a chance to have their thinking represented on this poster.*

If you have additional ideas that don't end up on the poster, feel free to raise your hand after we have heard once from everyone in the class (after the marker makes it all the way around the circle). If we run out of time, let's pick up here in the next class. And if you think of new ideas as we go, feel free to jot them down. We should always be thinking of ways we can add to this list.



Additional Guidance

Help to elicit student ideas for investigations by doing the following:

- Put up the Ideas for Investigation poster next to the DQB to jot down these new ideas. As students are sharing their ideas, underline repeated statements to keep track of common ideas among students.
- Encourage students to think about their questions and see if they have an idea to investigate a specific question or group of questions.
- Emphasize that the list is what we want to do that we think might help us answer our questions and that we may not do all these things, but we will do similar-type investigations. We can add to this list and our DQB throughout the unit as we go.

In large classes, you may run out of time before all students share out an idea. You can have students brainstorm ideas with a partner instead. Resuming this same activity right where you left off is a natural point to launch the next lesson. So plan to finish this up, if needed, right before the start of the next lesson.

Navigate to the next lesson. Once this Ideas for Investigations poster is built, help students realize (and get excited) that they created a joint mission and proposed action plan to guide the work of our learning community for weeks to come as we conduct investigations to figure out how plants get their food molecules.

Say, *Wow! We have accomplished so much. We now have a broad mission to accomplish as a class, thanks to all the questions you shared and how you connected them. So let's take a moment to think about how starting with one specific investigation idea could help us make progress on our questions. It seems like we have some ideas about the components of the plant system that we want to investigate. We also have a group of questions around the inputs that plants use and where these food molecules come from. It feels like this would be a productive place to start in trying to figure out more about where food molecules come from.*

Additional Guidance

Show slide W. Remind students to keep their science notebooks organized by writing a title on each page and updating their table of contents. They can do this when they have extra time at the beginning or end of class or during homeroom or homework time.

ADDITIONAL LESSON 1 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

CCSS.ELA-Literacy.SL.6.1.c: Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion.

When the class is building the DQB, if a student forgets to explain why or how their question is linked to someone else's question, press that student to try to talk through their own thinking. This is a key way to emphasize the importance of listening to and building off one another's ideas and to help scaffold student thinking.

Don't worry if some questions are raised that do not lead to productive investigations. Over time students will get better and better at forming testable questions in the scope of the driving question. This type of activity gives them practice at doing that.

If students can't figure out which question to connect theirs to, encourage them to ask the class for help. After an idea is shared, ask the original presenter if there is agreement and why, and then post the question.

Today's activities rely on students communicating and articulating their thinking. One tool that may support classroom discussion is the Communicating in Scientific Ways sentence starters. This 1-page document can be blown up and printed as a class poster, printed on 8.5-×-11 paper, and posted near students' desks and/or scaled-down and taped into students' science notebooks. To support discussion, reference the sentence starters on the poster and encourage students to use those sentence starters to help them communicate. The sentence starters can be especially useful for helping students engage in scientific talk, particularly students who may feel reluctant to contribute.

LESSON 2

Do plants get their food molecules by taking them in?

Previous Lesson

We brainstormed foods we ate that came from plants and reviewed their nutrition labels. All the plants had food molecules like carbohydrates, proteins, and fats in them. We know we get our food from eating, but how do plants get their food? Where is the food in plants coming from? We developed models to try to explain this and came up with investigations to figure out the answers to our questions.

This Lesson

Investigation

2 DAYS

We use a hydroponic plant system and indicators of food molecules to investigate whether soil, plant food, water, or air could be potential sources of food molecules in plants. We develop a list of candidates coming into contact with the hydroponic plants both below and above the surface that light is shining on.

Next Lesson

We will revisit the composition of air and light to look for possible sources of food molecules. We will then look at air and light (in addition to water and hydroponic plant food) and we will figure out none of our initial candidates contain food molecules. We will realize that we might have to adjust our question and look to find whether plants could be putting together parts of food molecules, instead of directly taking in whole food molecules.

Building Toward NGSS

MS-LS1-6, MS-LS2-3, MS-PS1-3

What Students Will Do

Plan and carry out an investigation collaboratively by identifying controls to produce data as evidence to determine whether hydroponic plant food contains food molecules as inputs.

Engage in argument from evidence to support or refute possible inputs of where plants get their food molecules from, such as hydroponic plant food or soil.

What Students Will Figure Out

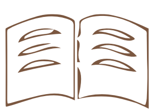
- Plants can grow without soil.
- Water and hydroponic plant food do not have food molecules inside them according to food labels and food indicator experimental results.
- Parts of food molecules might be found in water and hydroponic plant food.

Lesson 2 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	6 min	**NAVIGATION** Review what we agreed on in the last class from our consensus model and generate next steps to pursue.	A-B	Progress Tracker, Related Phenomena poster, consensus model
2	7 min	**EXPLORE PLANTS GROWING IN CLASS** Look at photos of plants that the teacher had started growing from seeds.	C-D	Photos of Plants Growing in Class, seeds of plants in the hydroponic system (radishes and spinach) inside their own paper cup to pass around for the class (optional)
3	5 min	**CREATE OUR LIST OF CANDIDATES** Create a list of candidates for the source of food molecules in plants.	E	chart paper, sticky notes or index cards, colored markers, tape
4	10 min	**ANALYZE THE HYDROPONIC SYSTEM** Make observations of the hydroponic system in order to eliminate soil as a candidate.	F-H	candidates list, tape, sticky notes or index cards
5	7 min	**ANALYZE THE HYDROPONIC PLANT SETUP** Analyze how the hydroponic plant system is assembled and maintained.	H–I	*Details of the Hydroponic Plant System*, candidates list, sticky notes or index cards, tape
6	10 min	**INVESTIGATE HYDROPONIC PLANT FOOD** Examine the hydroponic plant food label to determine whether it is a source for food molecules.	J-L	*Food Molecule Cards*, candidates list, bag of hydroponic plant food
				End of day 1
7	10 min	**NAVIGATION** Develop a protocol to test hydroponic plant food with food indicators. Then carry out experiments in class.	M	
8	25 min	**INVESTIGATE HYDROPONIC PLANT FOOD WITH FOOD INDICATORS** Students test the hydroponic plant food water using food indicators.	N-Q	Food indicator lab
9	10 min	**BUILDING UNDERSTANDINGS DISCUSSION ABOUT WHETHER FOOD MOLECULES ARE FOUND IN HYDROPONIC PLANT FOOD SOLUTION** Make sense as a class of what the results of the food indicator experiments tell us about whether hydroponic plant food water contains food molecules.	R-S	Progress Tracker, candidates list, sticky notes or index cards, tape

Part	Duration	Summary	Slide	Materials
10	5 min	**EXIT TICKET: FOOD MOLECULES FROM BELOW SURFACE INPUTS** Students complete an exit ticket to answer the question, “Were any of the below the surface inputs sources of food molecules?”	T	notecard
				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: *Plants, Food, and Plants’ Food*

Lesson 2 • Materials List

	per student	per group	per class
Food indicator lab materials	• *Which food molecules are in the hydroponic plant food?* • gloves • goggles • microcentrifuge tubes (4 per group) • science notebook • tape	• *Lab experiment using food indicators to test hydroponic plant food* • water (20 mL) in a plastic cup with pipette • 2 wooden stirrers to crush food • permanent marker • paper towels • plastic forceps to pick up food sample • materials for groups A–D found in advance preparation section	
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• Progress Tracker • Photos of Plants Growing in Class • science notebook • *Details of the Hydroponic Plant System* • *Food Molecule Cards* • notecard		• Related Phenomena poster • consensus model • seeds of plants in the hydroponic system (radishes and spinach) inside their own paper cup to pass around for the class (optional) • chart paper • sticky notes or index cards • colored markers • tape • candidates list • bag of hydroponic plant food

Materials preparation (4 hours spread over 1 month to prepare and maintain hydroponic plant system, for food indicator lab 40 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.

Hydroponic plant setup. Start setting up the hydroponic plant system **at least 1 month** before beginning the unit to ensure that your plants are ready for Lesson 2. For step-by-step instructions, please see *Details of the Hydroponic Plant System*. The small bag of plant nutrients that comes with the kit is more than enough for growing your plants. Some of the remainder of the nutrients may be needed for the lab in this lesson when students test whether fats, carbohydrates and proteins are found in these nutrients. After opening the small bag of plant nutrients, close and store it for use in this lesson. Watch this series of videos for help setting up the hydroponics system:

- Hydroponic kit setup overview.
- Hydroponic kit inserting the plugs.
- Hydroponic kit placing sowed seeds.
- Hydroponic kit placing under lights.
- Hydroponic kit troubleshooting when plants don't grow. (See the **Online Resources Guide** for links to these items. **www.coreknowledge.org/cksci-online-resources**)

Note: Putting the hydroponic planting boxes in a window does not provide enough light to grow the plants from seeds in time for the lesson. Put the plants under the grow lights as soon as you sow the seeds in the net cups with the clone collars.

Laminate *Food Molecule Cards*. It is helpful to have this reference sheet laminated because students can use wet-erase markers to mark up the models of food molecules. If you do not laminate it, print off a grayscale copy of *Food Molecule Cards* for students to mark up. This is the same reference used in Unit 7.3: *How do things inside our bodies work together to make us feel the way we do?* (Inside our Bodies Unit).

Day 2: **Food indicator lab**

- **Group size:** This lab prep is for day 2 of the lesson. These directions assume 8 groups of students, so 2 groups of students would test for each type of food. You can reuse the food indicators in cups as stock solutions for each class.
- **Setup:** Prepare the food to test. Slice the radishes and potatoes. Cut the beans into smaller pieces.
  1. Prepare items to be used in each group. These can also be reused in each class:
     - water (20 mL) in a plastic cup with pipette
     - permanent markers to label the microcentrifuge tubes
     - *Lab experiment using food indicators to test hydroponic plant food*
     - 2 utensils to crush food (e.g., wooden coffee stirrers)
  2. Prepare 4 stations, 1 for each food molecule indicator, so they are ready for groups to collect data. Watch this video for preparation tips video. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) See the list for each group below.
     - **Group A**, testing for complex carbohydrates

    - small slices of potatoes (as their control)
    - iodine (20 mL) in a plastic cup with pipette
    - additional foods students may want to test if time allows (i.e., cooked rice, banana)
    - microcentrifuge tubes (4 per group)
    - plastic forceps
  - **Group B**, testing for simple carbohydrates
    - small slices of radishes (as their control)
    - coffee cup with lid
    - Benedict's solution (20 mL) in a plastic cup with pipette
    - tool to scoop microcentrifuge tubes out the hot water (e.g., a spoon)
    - additional foods students may want to test if time allows (i.e., apple, banana)
    - microcentrifuge tubes (4 per group)
    - plastic forceps
  - **Group C**, testing for fats (lipids)
    - small cup of oil (as their control)
    - pipette
    - paper bags (white or brown)
    - additional foods students may want to test if time allows (i.e., a different type of oil)
  - **Group D**, testing for proteins
    - Small pieces of white beans (as their control)
    - Biuret (20 mL) in a cup with pipette (reused in each class)
    - additional foods students may want to test if time allows (i.e., mashed chickpeas)
    - microcentrifuge tubes (4 per group)
    - plastic forceps

3. Boil water in an electric kettle. Turn it on in the beginning of class so it is near boiling right before pouring it into a coffee cup with a lid for groups testing with Benedict's solution (simple carbohydrate group).
4. Watch this video to see how students should prepare microcentrifuge tubes when using solid pieces of food. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)
5. Watch this video to see how to do Benedict's test with coffee cups. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

- **Notes for during the lab:** Though there are food samples suggested here to use to test for different food molecules, students may want to test foods from their breakfast list. If some students finish earlier than others, they may try testing a second substance using the food indicators.
- **Disposal:** When students finish testing the food substances with the indicators, they may dispose of the microtubes, brown paper, and wooden stirring rods in the wastebasket. The containers of indicators with labeled pipettes, the extra food samples, the coffee cups and the tool to remove tubes from hot water can be re-used from class to class. In addition the plastic forceps can be cleaned and re-used from class to class.
- **Safety:** Even though students will not eat the foods used in this lab, be sure you are aware of any students who might be at risk of an allergic reaction from interacting with these foods, and plan groups accordingly. Also, the lab group(s) testing for simple carbohydrates (Benedict's solution) will need to use hot water (almost boiling) for the indicator to work. Students should use disposable coffee cups to carefully transport the hot water from the kettle to their lab station.
- **Storage:** Store chemicals in a locked closet at room temperature.

Lesson 2 • Where We Are Going and NOT Going

Where We Are Going

This lesson addresses Disciplinary Core Ideas related to the organization for matter and energy flow in organisms. The molecular models for food are being used because the ideas being built in this lesson will lead up to being able to track the movement of molecules into and out of living things at the atomic level. Shifting to viewing the continuous recycling of atoms deepens students' understanding of the role of photosynthesis in the cycling of matter at the middle school level. Plants make their own food. The source of matter to make their food does not chiefly come from nutrients in soil, fertilizers such as hydroponic plant food, or water. There is no source of carbon found in these inputs, so in the next lesson, we argue plants need to assemble food molecules by pulling parts from other molecules that the plant takes in.

Where We Are NOT Going

A very common partial understanding is that plants get their matter to grow from the nutrients in the soil. This is why, instead of just eliminating soil and plant food from the class "candidate list" by using the hydroponic system, we also look for more evidence by testing the hydroponic water with food indicators. This drives the point that the major source of food molecules is not soil and plant food.

Plants take in small amounts of atoms from the hydroponic plant food like nitrogen, phosphorus, and sulfur, but they are not the main source of atoms that plants use to make food molecules. The main source comes from CO_2 in the air and water, H_2O. In Lesson 3 students will dive deeper into the composition of air to make predictions about potential candidates of food molecules or parts of food molecules. Be sure to not give this away until those lines of evidence for those ideas are established in those future lessons.

LEARNING PLAN FOR LESSON 2

1. Navigation

6 MIN

Materials: Progress Tracker, Related Phenomena poster, consensus model

Help students recall what they figured out in the last class by using the Progress Tracker.

Introduce the Progress Tracker. **Present slide A**. Have students draw a T-chart directly in their science notebooks in the section set aside for Progress Trackers. Explain that as we investigate where our food comes from and where it goes next, we are going to keep track of how our model changes and develops over time in our Progress Tracker.

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

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

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

Question	What I figured out in words/pictures
Where does this stuff come from?	• All the plant foods we looked up so far have food molecules in them. Not all plants have the same food molecules (carbs, fats, proteins), but all of them have some sugar. • We agree water and possibly sunlight go into plants.

Present slide B. The goal here is to help students think through and come to an agreement on what question makes sense to focus on today, which is, "Do plants get their food molecules by taking them in?" In other words, do plants need to "eat" their food molecules like we do? You can also pull out the Driving Question Board (DQB) to reference if someone wrote a question similar to, "Do plants need to eat?" We want students to think about what's weird about the fact that plants have food molecules inside them.

Say, *It's kind of weird plants have food molecules inside them because we can't figure out where they came from. And plants don't seem to eat like we do.*

Suggested prompt	Sample student response
To make sure we are all on the same page, tell me what we found inside all the food items from plants that we checked?	*Food molecules were inside every plant. Some plants had more types and amounts than others, but every plant has some kind of food molecule in it.*

*** Attending to Equity**

This example Progress 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. This is an opportunity for students to express their understanding and reasoning in their own way. Encourage students to express what they've learned using a mode that makes sense for them. For some emergent multilingual students, encourage them to use space to make sense in the language that they feel most comfortable using. The individual Progress Tracker is a space for students to be creative and to synthesize learning in their own words. It is not supposed to follow a prescriptive plan or structure and should be a low-stakes opportunity for students' to make sense of what they are learning without the worry and anxiety that comes with knowing their work will be graded. Use the Progress Tracker for formative assessment only.

Suggested prompts	Sample student responses
Where do you think plants get these food molecules? What's weird about the fact that plants have food molecules inside them?	*We don't know where they get them. It's kind of weird because we can't figure out where they came from. And plants don't eat like we do.*
(If students don't bring up the idea of plants "eating" or taking in food, ask this question:) So how do we get our food molecules?	*We get them by eating.*
So do you think plants have to do the same thing? Are plants "eating" their food molecules too? Do they take them in somehow?	*Maybe? Don't plants have "plant food"? Could they be getting their food molecules from the soil?*
Those are great questions! So let's figure this out next. People in our class had that question on our Driving Question Board too. Are plants eating their food molecules somehow? Maybe they are coming from the soil? We know they don't have mouths like us, so our question is more like, "Do plants get their food molecules by taking them in?"	*Yeah, let's do it!*

Additional Guidance

Where your teaching objective would typically be in your classroom, you could write the question, "Do plants get their food molecules by taking them in?" The objective of the class is to figure out the answer to this question.

2. Explore plants growing in class.

7 MIN

Materials: Photos of Plants Growing in Class, seeds of plants in the hydroponic system (radishes and spinach) inside their own paper cup to pass around for the class (optional)

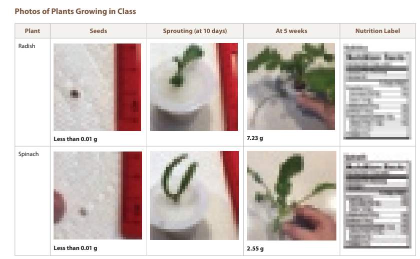
Have student pairs analyze the pictures and data from the plants growing in the hydroponic system.

Suggested prompts	Sample student responses	Follow-up questions
I have some plants in the back of class that might help us figure out our question. If the plants I have can help us figure out where all plants get their food molecules from, what should we make sure is inside my plants?	*food molecules*	*Right, so we should make sure to look at their nutrition labels too.*
What food molecules should we look for?	*carbohydrates, proteins, fats*	

Say, *Here are some pictures of what the plants looked like.* Show **slide C**. Hand out copies of Photos of Plants Growing in Class. Next, ask students to work with an elbow partner and analyze the photos, seeds, and nutrition labels and answer the questions on the handout.

If you have extra seeds from germinating the plants, you can hand out the actual seeds for students to pass around and look at. These can be put in cups for students to observe.

Show slide D. Conduct a whole-class discussion about the plants growing in class. Have students share the ideas they recorded in a whole-class discussion.



Photos of Plants Growing in Class

Plant	Seeds	Sprouting (at 10 days)	At 5 weeks	Nutrition Label
Radish	Less than 0.01 g		7.23 g	
Spinach	Less than 0.01 g		2.55 g	

Key Ideas

Look for these patterns that students should notice:

- According to the food labels, all the plants have food molecules in them. All three plants have carbohydrates, and spinach has a little protein too.
- The seeds seem way smaller than the fully grown plants. There seems to be a lot of food in the plant (like the red balls of the radishes and sugar beets) that wasn't there to start with.
- By "matter" we mean the "stuff" that makes up things in our world that has mass and takes up space.

Summarize, *So now that we're convinced that there is a lot of food in the plant that wasn't there to start with, it seems even more reasonable to think that the plant must be getting this food by "eating" or taking it in somehow! Looking at our consensus model, the only inputs that we have so far that are candidates for the source of the material or matter that make up food molecules is water, the sun, and maybe soil.*

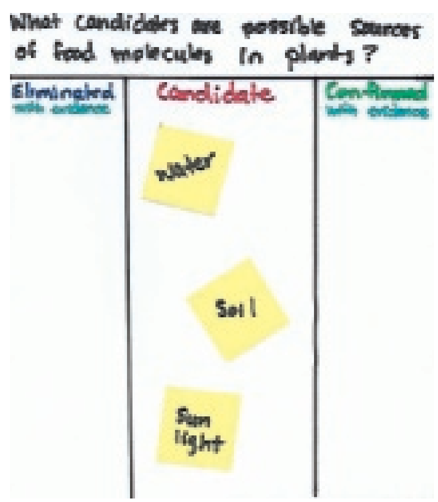
3. Create our list of candidates.

5 MIN

Materials: chart paper, sticky notes or index cards, colored markers, tape

Make a list of candidates to keep track of potential inputs into the plant. Present **slide E**.

Create a poster with the question, "What are the possible sources of food molecules in plants?" on top. Below the question, have three columns: Possible Candidate, Eliminated, Confirmed Input. See example.



Say, *In order to move the candidates into the confirmed inputs on our model we need to gather evidence to convince ourselves which way to move them. And since we're figuring this out together and generalizing to include all plants, it's our job to convince each other with evidence. We can't have just one person decide to move a candidate to the eliminated or confirmed side; if that one person feels strongly about moving something, it's that person's job to help convince all of us one way or another.**

Ask the class, *Who are our candidates so far?* Have students write each potential candidate, such as water, soil, and the sun, on a separate sticky note or index card and place them in the "Possible Candidate" column. Use tape to secure the sticky notes if they are falling off the chart paper.**

*** Attending to Equity**
When setting up the candidate list, it's important to emphasize that if one person feels strongly about moving something, it's that person's job to help convince all of us one way or another. In this way, the learning community sees each student as someone who should be engaging in the intellectual work of eliminating or confirming candidates.

*** Strategies for This Initial Ideas Discussion**
If more ideas such as "plant food" or "rocks" come up as candidates for below the surface inputs, it's OK to put them up too. Once you lift up the lid of the hydroponic system and show it to students, we will be able to take off extraneous inputs like soil or other sources, because there are only two inputs going into the plant: hydroponic plant food and water.

* **Attending to Equity**
Have students do the writing and the placing of sticky notes on the candidates list. It will help establish the candidates list as something you're working on together as a class.

4. Analyze the hydroponic system.

10 MIN

Materials: science notebook, candidates list, tape, sticky notes or index cards

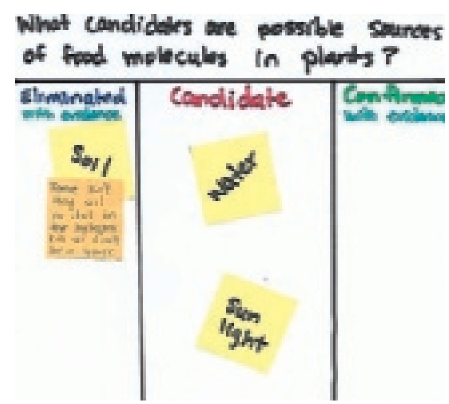
Conduct a whole-group discussion. Show **slide F**. Ask students to briefly talk as a whole group about the questions on the slide.

Suggested prompt	Sample student response
If soil and water are the sources of food molecules, how would they be getting into the plant?	*through the roots*

Summarize, *So if we think the food molecules are coming from the soil or water, we should see those things below the surface. For example, if the food molecules are coming from the soil, we would expect to see soil below the surface. If they are coming from the water, we would expect to see water, because if the candidate isn't there, then it can't be an input into the plant! So we should probably look below the surface to see what we find.*

Make observations of the hydroponic plant system. Present **slide G**. Have students make a Notice and Wonder Chart in their science notebooks. Gather students with their notebooks around the hydroponic boxes so everyone can see. Lift up the lid. There should be only roots hanging down in the water, no dirt, rocks, soil, and so on. Ask students to stop and jot down what they are noticing and wondering in their notebooks.

Suggested prompts	Sample student responses
What do you notice?	*There is no soil! It looks like there is only water in there with some bubbles.*
So could soil be one of our inputs into these plants? Why or why not?	*No! Because soil isn't even in there.*
Do we all agree that soil cannot be an input? Is there anyone who disagrees? Why or why not?	*Accept all responses. Encourage the class to reason out and convince each other why soil cannot be an input into the hydroponic system.*



Have students go back to their seats and have someone come to the candidates list and move "soil" to the eliminated side. Ask someone to write down the evidence that eliminates soil on a new sticky note or index card. Write something like, "Soil wasn't even in the box, so it can't be giving food molecules to these plants." Tape the evidence to the "soil" card. You might need to reinforce the sticky notes with tape.

Conduct a brief discussion about what else students are wondering about now that we know the plants in our class have been growing without soil.

Suggested prompt	Sample student response	Follow-up question
Now that we've eliminated soil as a candidate, what other things are you wondering about? What questions do you now have after checking out the hydroponic system?	*Is that just plain water? What's that rock thing with a tube in there doing? Is there something else in there that's giving the plant food? What's in the water?*	*Let's dig into some of those. I have a protocol of what I did to set up the hydroponic plant system. It might help answer some of your questions.*

5. Analyze the hydroponic plant setup.

7 MIN

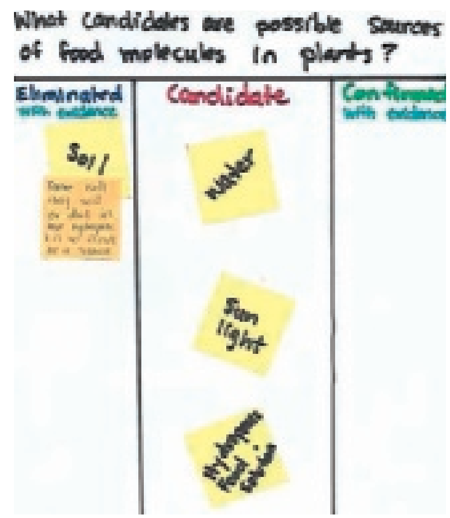
Materials: *Details of the Hydroponic Plant System*, candidates list, sticky notes or index cards, tape

Have students work in small groups to analyze the hydroponics protocol on *Details of the Hydroponic Plant System*.

Show slide H. Then project **slide I** and ask groups to work together to answer the questions. Finally, discuss the answers as a whole group.

Suggested prompts	Sample student responses
What does the bubble rock do?	*It circulates the water by blowing air from the air pump. Maybe it adds oxygen too?*
What happens when the buoy gets to the red mark?	*You need to add more liquid to the box.*
Why do you think the liquid needs to be replenished?	*Maybe it's evaporating or the plants are drinking it.*
If the lid is kept on, do you think evaporation would make the water level go down still?	*Probably not, because even if the water did evaporate a little, it would condense on the lid and fall back down.*
So if the plants are drinking it, how do you think it's getting into the plant?	*through the roots*
What is added to the water?	*It says plant food is added to the water! That's probably where the food molecules are coming from.*
Maybe we should add plant food to our candidates list?	*Yeah, we found a new candidate!*

Ask a student to write "Hydroponic plant food" on a sticky note or index card and tape it in the "Possible Candidates" column.



6. Investigate hydroponic plant food.

10 MIN

Materials: *Food Molecule Cards*, candidates list, bag of hydroponic plant food

Suggested prompts	Sample student responses
Now we have to examine our new candidate! What do we think the hydroponic plant food has that we're looking for?	*It has the food molecules for the plant!*
*What are food molecules again? What are they made out of? Let's check our molecular models. (Show **slide J** and/or hand out laminated copies of Food Molecule Cards.)*	*Food molecules are carbohydrates, proteins, and fats, and we figured out they are mostly made out of carbon, hydrogen, and oxygen atoms.*

Turn and talk. Present slide K. Students turn and talk about the questions on the slide (see suggested prompts).

Suggested prompts	Sample student responses
What evidence would help us determine whether hydroponic plant food is the source of food molecules?	*We should see carbohydrates, fats and/or proteins listed on the bag. We could test for food molecules like we did in our other unit.*
What could we do to figure out whether hydroponic plant food is the source of food molecules?	*Is there a way to check what they put in the plant food bag? Does it have a food label? We could look at the ingredients.*

Summarize, *OK, so if hydroponic plant food is the source of food molecules, it should have carbohydrates, fats, and proteins inside it. Let's check out the ingredient list to see what we find.*

Analyze the hydroponic food label. Present **slide L**. Have students work with a partner to analyze the hydroponic plant food label. You can also pass around the bag of hydroponic plant food if students are curious to see the full back of the bag.*

Use these suggested prompts for the whole-class building understandings discussion.

Suggested prompts	Sample student responses
What did you figure out? Did you see any food molecules listed as ingredients?	*No, there were no food molecules.*
Do you think the plant food manufacturer has to list them as ingredients? Do you think it could be possible that there are other things in the bag that aren't listed?	*I don't know—maybe not? Or maybe the manufacturer forgot to list them.*

Ask students to brainstorm another way we could test whether hydroponic plant food is a source of plant food molecules. Ask students, *How did we test for food molecules in the past? Discuss those ideas in the next class.*

*** Supporting Students in Developing and Using Patterns**
As students analyze the ingredients in the hydroponic plant food and compare this to the food molecules, encourage them to look for any patterns they notice between the two. Have students identify if any whole food molecules are found in the plant food. At this point in the lesson we are focused on whole food molecules, not parts of food molecules. Student may suggest this, but push back at this point in the lesson by asking what we could do to collect evidence for whether whole food molecules are found in hydroponic plant food.

Home Learning Opportunity

Have students brainstorm other ways we could see whether hydroponic plant food is the source of food molecules like carbohydrates, proteins, and fats. To give them ideas to start, ask whether they've tested for food molecules in the past. They should have used various food indicators to test for food molecules in the metabolic reactions unit.

End of day 1

7. Navigation

10 MIN

Materials: None

Help students recall where they left off in the last class. Return to ideas for how to check the hydroponic plant food for food molecules. Show **slide M**.

Say, *Even though we figured out from the ingredient list that no food molecules were listed, we thought it's possible that the manufacturer forgot to list them or is not required to list ingredients like carbohydrates, fats, and proteins. So we need some more evidence.*

Suggested prompts	Sample student responses
What's another way we could check whether the hydroponic plant food is the source of food molecules? What were some of the ideas you came up with?	*Accept all answers.*
Is there is a way you tested for food molecules in the past?	*Yeah, we used food indicators in the Inside our Bodies Unit.*
Do you remember which food indicators we used?	*I think we used iodine, Benedict's, and maybe others?*

Help students come to a consensus that we could use the same food indicators on the hydroponic plant food to test for carbohydrates and proteins as we used in the Unit 7.3: *How do things inside our bodies work together to make us feel the way we do? (Inside our Bodies Unit).*

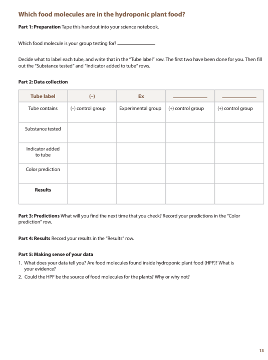
Alternate Activity

If students have not worked with food indicators in the past, they will need guidance on how to use the indicators. Each of the food indicators changes a certain color when a specific food molecule is present. Students will need to know what this color change is for each indicator and the type of food molecule before they can carry out their investigation. It might be helpful to do the control together for each indicator and then let groups carry out the rest of the investigation.

8. Investigate hydroponic plant food with food indicators. 25 MIN

Materials: Food indicator lab

Prepare for the lab experiment using food indicators to test hydroponic plant food solution. Hand out *Which food molecules are in the hydroponic plant food?* to students. Instruct students to tape their handouts in their science notebooks. Each student will be responsible for testing for a certain food molecule. However, this lab is meant to be done in jigsaw groups, so not all students will test for each food item.**


Which food molecules are in the hydroponic plant food?

Part 1: Preparation Tape this handout into your science notebook.

Which food molecule is your group testing for? ______________

Decide what to label each tube, and write that in the "Tube label" row. The first two have been done for you. Then fill out the "Substance tested" and "Indicator added to tube" rows.

Part 2: Data collection

Tube label	(–)	Ex	______	______
Tube contains	(–) control group	Experimental group	(+) control group	(+) control group
Substance tested				
Indicator added to tube				
Color prediction				
Results				

Part 3: Predictions What will you find the next time that you check? Record your predictions in the "Color prediction" row.

Part 4: Results Record your results in the "Results" row.

Part 5: Making sense of your data

1. What does your data tell you? Are food molecules found inside hydroponic plant food (HPF)? What is your evidence?
2. Could the HPF be the source of food molecules for the plants? Why or why not?

13

* Supporting Students in Engaging in Planning and Carrying Out Investigations

Students work with small groups to plan and carry out an investigation to look for evidence of food molecules in hydroponic plant food and in plain water. In the Inside our Bodies Unit, students used two different chemical food indicators (iodine and Benedict's solution) to test for the presence of food molecules. In this lesson students will again have these indicators in addition to two others. In small groups, students will decide what variable (hydroponic plant food, water, food indicator, or food sample) is the independent variable, the dependent variable, and the control. Each small group will only test for one type of food molecule and then the data will be shared out as a class. They will co-plan this investigation on a handout that has a template for them to use. Following this plan, they will carry out the investigation and collect data to share with the class.

Additional Guidance

If you choose to use the questions in Part 5 of *Which food molecules are in the hydroponic plant food?* as an assessment, you may wish to wait on having students put this in their notebook so they can turn it in for feedback.

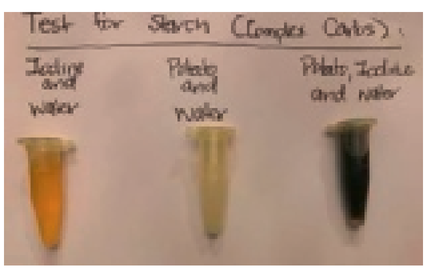
Assign each group of students a type of food to test for:

- **Group A**: Complex carbohydrates: Test using iodine.
- **Group B**: Simple carbohydrates: Test using Benedict's solution.
- **Group C**: Fats: Test using paper bags.
- **Group D**: Proteins: Test using biuret.

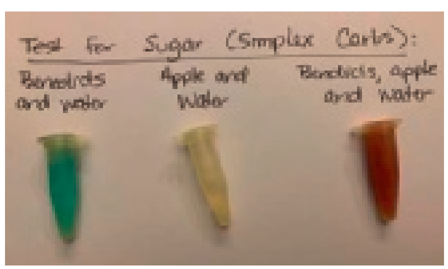
Project **slide N.** Help students work through the questions on the slide to determine what the negative control, the experimental group, and positive control will be and how those controls help us be more sure of our results.

Carry out experiments in small groups. Present **slide O**. Instruct students to gather supplies based on which food indicator they are using and refer to the *Lab experiment using food indicators to test hydroponic plant food* for protocols to follow for their assigned group. Present **slide P** with some general tips to follow for students as they carry out their investigation. Here are some sample test results:

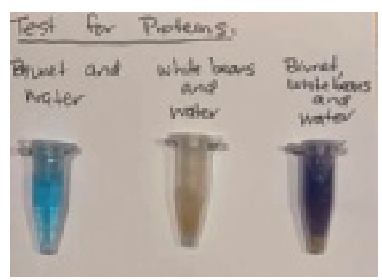
Starch Test



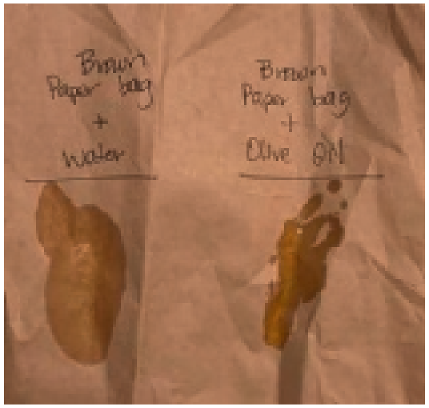
Sugar Test



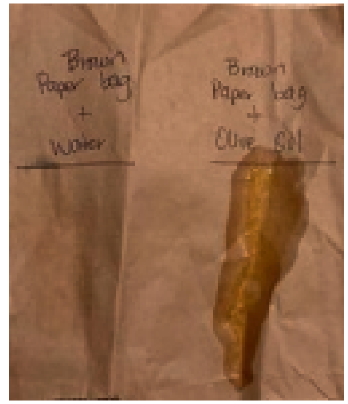
Protein Test



Initial Fat Test



Final Fat Test

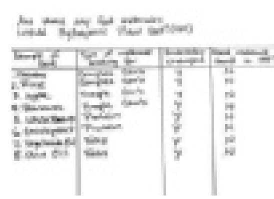


Instruct students to work on the questions in Part 5 of *Which food molecules are in the hydroponic plant food?* when they finish.

Assessment Opportunity

The two questions in Part 5 of *Which food molecules are in the hydroponic plant food?* can provide evidence of students' ability to argue with evidence. They should be able to argue that there are no food molecules found in the hydroponic plant food solution using evidence from the investigation. If students argue they found evidence of food molecules in the hydroponic plant food solution sample they tested, it might be helpful to talk through with them how they conducted their investigation and ask them for the data they collected (no color change or a color change when the food indicator was added to the solution).

Compile class data. Present slide Q. When students are finished running their experiments, compile the class data. Draw a data table on the board, and whenever a group is finished, each student should come to the board and record his or her findings by putting "Y" (if there was a change) and an "N" (if there was no change) in an open box for the type of food molecule tested for. This way, each student can see how his or her individual sample contributed to the community's interpretation. The hydroponic plant food solution should not have any food molecules inside and therefore none of the indicators should change color. See the example class data table.



Additional Guidance

At the end of the student facing slides, there are 4 optional slides with images of what each indicator should look like in the presence of food molecules. There is one slide for each indicator. These could be used with small groups of students if they are struggling with deciding whether the indicator has changed color or not. The Biuret's solution is the most challenging to see a color change.

*** Supporting Students in Developing and Using Systems and System Models**

Students plan and carry out an investigation to collect data about potential inputs into a plant that could be sources of food molecules. In this lesson specifically, students will analyze what could be potential inputs below the surface of a hydroponic plant system. Most times, students will claim soil or dirt is needed for a plant to grow, but when they analyze the hydroponic plant system and see there is only water, and eventually learn there is plant food added to the water, they can rule out soil/dirt as an input for the food molecules found in plants. Over the course of the lesson, students will test the hydroponic plant food for whole food molecules and find through their data that there are not any whole food molecules present, yet they are part of the hydroponic plant system. By the end of the lesson, students want to continue to look for other inputs into plants that could be sources of food molecules. This serves to broaden inputs for the plant system. Over the course of the next few lessons, students will begin to see other inputs and outputs of this system.

9. Building Understandings Discussion About Whether Food Molecules Are Found in Hydroponic Plant Food Solution

10 MIN

Materials: Progress Tracker, science notebook, candidates list, sticky notes or index cards, tape

Conduct a whole-class Building Understandings Discussion to eliminate hydroponic plant food as a source of food molecules in plants. Present **slide R**.

Key Ideas

Purpose of discussion: To come to an agreement that the hydroponic plant food solution and plain water are not a source of whole food molecules for plants.

Listen for:

- The hydroponic plant food solution did not contain carbohydrates, fats, or proteins, therefore it can't be the source of food molecules for plants.
- We should remove this from our candidates list.
- We can also remove water from our candidates list too because none of the indicators change color in the plain water.

Suggested prompts	Sample student responses
What do our data tell us? Are food molecules found inside hydroponic plant food (HPF)? (Have a representative from each type of food molecule group report out, and put "No" under the heading "Inside HPF" as groups share.)	*No, there aren't any food molecules in HPF.*
What is your evidence?	*None of the food indicators changed for our experimental group of HPF.*
How do you know your indicators were working?	*Because they did change for our (+) control group of food items we knew had food molecules in them like oil, radishes, potatoes, and white beans.*
What should we do with HPF on our candidates list?	*HPF is no longer a possible candidate! We should write down our evidence and move it to the eliminated side.*

Have a student write down the evidence eliminating HPF on a sticky note or index card and secure it to the "Hydroponic plant food" candidate card. Then move it to the eliminated side.

Work with students' ideas to motivate moving plain water off the candidate list as a source of food molecules because it was also tested and we have evidence that no change occurred and thus no food molecules were inside.

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

At the end of the lesson, students should be able to argue with evidence that hydroponic plant food does not contain whole food molecules through the data they collect from the investigation. In addition, students should be able to argue that plain water also does not contain whole food molecules based on the investigation.

Suggested prompts	Sample student responses
Let's look in our "Substance tested" row in our data tables. Is there anything there that is also on our candidates list?	*Yeah! We have water as a substance tested too! We thought it wasn't going to have any food molecules in it, and our results showed it didn't.*
What should we do with water on our candidates list?	*We can move water off our candidates list and move it to the "Eliminated" side too!*

Have a student write the evidence eliminating plain water on a sticky note or index card and secure it to the "water" candidate card. Then move it to the "Eliminated" side.

Come to an agreement. Say, *OK, our data so far hasn't helped us figure out where the food molecules are coming from. What can we conclude about the inputs that are below the surface? Are any of the candidates we investigated below the surface sources of food molecules?*

Project **slide S**. In their notebooks, students should draw a three-box Progress Tracker to help the class come to an agreement about the evidence and what the class has figured out in words and pictures. First have students write down the question they have been trying to answer, *Were any of the below the surface inputs sources of food molecules?* Ask students what evidence they have been working with to answer this question (e.g., the set up of the hydroponic plant system, the hydroponic plant food, water, etc.).*

Additional Guidance

Students work on this 3-box 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.

Give students an opportunity to generate a list of ideas they have figured out now.

Assessment Opportunity

As different students share what they figured out about the inputs that are below the surface and whether these can be sources of food molecules, listen for students to share ideas such as:

- There is not any soil in the hydroponic system.
- When the hydroponic plant food was tested with food indicators, there were not any of the food molecules.
- Plain water does not contain food molecules.
- None of the inputs we looked at that are below the surface contain food molecules.

As the class agrees to ideas on the table, students should draw and write those ideas into the Progress Tracker. Below is one suggested representation.

Question	Source of Evidence
Were any of the below the surface inputs sources of food molecules?	• Hydroponic Plant System • Hydroponic Plant food solution • Plain water

What we figured out in words/pictures

- Hydroponic plant food is not a source of food molecules because when we looked at the ingredient label, there were not any food molecules listed.
- Hydroponic plant food is not a source of food molecules because when we tested the plant food for carbohydrates using a food indicator, there were not any carbohydrates in the plant food. We know this because there was not a color change for the food indicator.
- Plain water is not a source of food molecules because when we tested the water for carbohydrates using a food indicator, there were not any carbohydrates in the plant food. We know this because there was not a color change for the food indicator.
- The hydroponic plant system did not have any soil in it and the plants were growing, so soil is not a source of food molecules.

Assessment Opportunity

This is a great opportunity for students to self assess on their engagement in classroom discussions using *Self-Assessment for Classroom Discussions*. This discussion rubric can be used anytime after a discussion to help students reflect on their participation in the class that day.

Say, *Wait… now that we have investigated the candidates that are potential sources of food molecules, we have moved them all to the eliminated column. So if none of our candidates below the surface are inputs into the plant for food molecules, then what else might be going on for the plant to have food molecules? This is confusing. Where else could the stuff that makes up the food molecules be coming from?*

10. Exit Ticket: Food Molecules from Below Surface Inputs

5 MIN

Materials: notecard

Exit Ticket. Project slide T. Say, *Take a few minutes to reflect on your own about where else the plant could be getting food molecules from. And, what new questions do you have now? Fill out the exit slip with your answers to these two questions and turn it in as you leave. We will share out ideas at the beginning of our next class.*

Assign students to fill out a notecard with their answers to the questions on the slide, as an exit ticket.

Additional Guidance

Sunlight might still be a potential input on your class poster and students may argue that all the candidates haven't been eliminated. If they do suggest sunlight could be a source of food molecules, remind them that we were looking at inputs below the surface where there isn't any sunlight.

Assessment Opportunity

Before Lesson 3, review students' exit tickets. The exit ticket will provide valuable information about what other inputs students think could be a source of food molecules for the plant. The exit ticket can also provide insight about the types of questions students have about where plants get food molecules.

SCIENCE LITERACY: READING COLLECTION 1

Plants, Food, and Plants' Food

1 **Plant Gallery**
2 **Plants That Feed the World**
3 **All That in One Avocado?**
4 **Sugar**

Literacy Objectives

- ✓ Summarize key points related to plants as foods.
- ✓ Identify a claim and list the evidence that supports it.
- ✓ Contrast pros and cons of eating avocados.
- ✓ Translate text to visual/graphic representation of ideas.

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 meme in response to the reading.

Instructional Resources

Student Reader

Collection 1

Science Literacy Student Reader, Collection 1
"Plants, Food, and Plants' Food"

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: Where does this stuff come from?
- Lesson 2: Do plants get their food molecules by taking them in?

Standards and Dimensions

NGSS

Disciplinary Core Idea LSC.1: Organization for Matter and Energy Flow in Organisms
Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (MS-LS1-6)

LS4.A: Evidence of Common Ancestry and Diversity Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent. (MS-LS4-2)

Science and Engineering Practices: Analyzing and Interpreting Data; Obtaining, Evaluating, and Communicating Information

Crosscutting Concept: Patterns

CCSS

English Language Arts

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.

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

RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

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

sucrose

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.

carbohydrates	**cholesterol**	**evolution**
fat	**fructose**	**gluten**
grain	**green algae**	**mineral**
proteins	**species**	**starch**
vascular tissue	**vitamin**	

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

1. Plan ahead.

Exercise Page

EP 1

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.

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 Matter Cycling and Photosynthesis 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.
    - *First, you will view a gallery of photos showing the diversity of the plant kingdom. See if you can figure out which of these types of plants are represented on the diagram showing the evolution of plants.*

- *Next, you'll read an infographic describing ten crops that are grown as food for humans around the world.*
- *Then, you'll read and interpret a Nutrition Facts label for a cup of freshly sliced avocado. Is your mouth watering?*
- *Finally, you'll read an article about the sugar glucose—how plants make it, what they do with it, and what people do with it.*

- 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 meme that is your response to one or more of the big ideas in Collection 1. So, as you read, think about what you find interesting, odd, amazing, or inspiring.*
- 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
In what way is the plant kingdom like a tree with one trunk and many branches?	*The trunk represents a common ancestor from which all the kinds of plants on the branches have evolved.*
What surprised you about the graph showing plants that feed the world?	*that more sugarcane is harvested than any other crop* *that so much cassava is harvested and I've never even tasted it* *that more tomatoes are harvested than barley (I thought, because barley is a grain, there would be more harvested.)*

Suggested prompts	Sample student responses
Which are healthier to eat, saturated or unsaturated fats?	*unsaturated fats*
What does it mean if you see -ose in the name of a substance?	*It means it is a kind of sugar.*

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 do all plants have some sugar in them?	*because plants produce glucose as a product of photosynthesis*
Why do all Nutrition Facts food labels list fats, carbohydrates, and proteins?	*because all foods from plants contain these three main food molecules*
The fourth reading shows a model of a sucrose molecule. Where does sucrose come from?	*Sucrose forms when molecules of glucose and fructose bond and occurs mainly in sugarcane and sugar beets.*

Exercise Page

EP 1

- 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 meme that demonstrates your understanding of one or more big ideas from this collection in an entertaining way.*
    - *That memes—er, means—you'll show off what you have learned—but also your sense of humor.*
    - *Think about your audience as being other students in your school.*
    - *Look through the reading selections, and think about what ideas tie them all together—those are big ideas. Summarize one or more of those big ideas in your meme.*
    - *Play with your words in an amusing way, such as by making a pun or referring to a famous character in the movies or from a TV show.*
    - *While most internet memes have photos for images, this assignment only requires a drawing. Drawing skill is not required—stick figures and simple outlines can work, too.*
    - *An important criterion for your meme is that it shows off your new understanding of plants and food with just a picture and a few words.*
- Remind students that many internet memes use foul language or are offensive in other ways. Their product must avoid this problem.
- 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 first reading selection is a gallery of the plant kingdom with interesting facts and includes a diagram showing the evolutionary connections between some of the plants shown in the gallery.

Pages 4–13 **Suggested prompts**	**Sample student responses**
What is the general purpose of the first selection, "Plant Gallery"?	*It surveys some of the variety of plant species in the world and shows how some of these plants are related on a diagram.*
How does the first selection help you build knowledge on top of what you learned in the Preface?	*In the Preface, we read that ancient Polynesians probably carried coconuts from island to island to plant as food crops. This reading explains that coconuts can also be carried on ocean currents to other islands, where they could sprout and grow into palm trees.*
According to the diagram, which kinds of plants produce seeds? Which have vascular tissue?	*Just gymnosperms and angiosperms produce seeds.* *Gymnosperms, angiosperms, ferns, and club mosses have vascular tissue.*
What is the general purpose of the second selection, "Plants That Feed the World"?	*It displays ten of the largest food plant crops in the world on a bar graph and describes some facts about each.*
How does the second selection help you build knowledge about wheat on top of what you learned in the first selection?	*The first article explains that the seeds are the parts of wheat plants that are used to make flour and other foods. The second article uses the word grains for the seeds and explains that gluten is a protein some people have trouble digesting.*
Using your powers of inference, which of these ten crops are mainly harvested for the seeds that people eat?	*maize (corn), wheat, rice, and barley*
What is the general purpose of the third article, "All That In One Avocado?"	*to explain what the categories listed on a Nutrition Facts label mean*
What are the pros and cons of eating avocado on a regular basis?	*Pros: You get plenty of unsaturated fat, which is good for you. They have no cholesterol. They contain 24% of your daily need for vitamin C and 20% of vitamin B12. They also have a lot of fiber, which is good for you.*

Student Reader

Collection 1

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.

Online Resources

SUPPORT—Regarding the common ancestor, explain to students that there are about 10,000 species of green algae alive today, most of which live floating or attached to rocks in freshwater.

Pages 4–13 Suggested prompts	Sample student responses
	Cons: They also have some of the bad fat—saturated fat—and overall, a cup of avocado has almost 1/3 of your daily need for fat. Also, they don't have much of the minerals calcium and potassium.
Look at the Connection box. The number 2,000 is a nice round number that is within the calorie range needed for most adults and children. If a family were attempting a two-week backpacking trip, how might this affect their calorie needs? How should they pack for their trip?	*It might increase them well beyond 2,000 calories. They should pack more food than they normally eat.*
What is the general purpose of the fourth article, "Sugar"?	*It describes different forms of sugar, their sources, and which one is used in the kitchen to sweeten other foods.*
Looking at the data table, what do you notice about plant foods that taste sweet?	*They have the highest amounts of total sugars.*
Based on that correlation, what other plant foods do you predict are high in total sugars?	*grapes* *peaches* *watermelons* *beets* *butternut squashes and pumpkins* *sweet potatoes*
What evidence in this reading supports the claim that a tomato "is mostly sugar and a bit of fiber"?	*Looking at the table, since the total carbohydrate number is 8 and the total sugars number is 7, it means that there is very little starch in tomatoes, just sugar and fiber.*

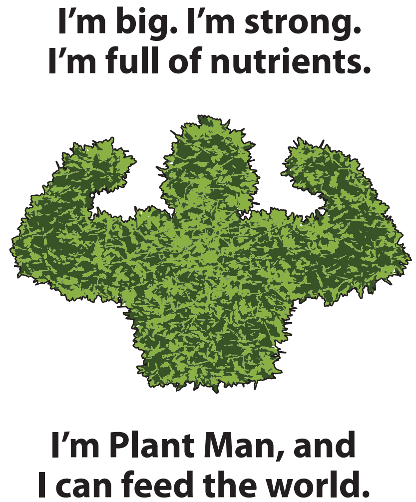
CHALLENGE—Start a brainstorming list on a whiteboard or somewhere else all students can view it. Ask, "What are some delicious ways to eat avocado?" Invite students to add ideas for recipes that can be as simple as avocado toast (ripe mashed avocado on toast) or as complicated as cold avocado and cucumber soup. Mexico, by far, harvests the largest crop worldwide, so if you have any students of Mexican descent, invite them to offer their expert advice on using avocado.

5. Check for understanding.

Evaluate and Provide Feedback

For Exercise 1, students should create a meme that is inspired by what they learned about plants and plants as food in Collection 1. Their memes should show understanding that there is great diversity in the plant kingdom and/or that plants contain a variety of food and nutrients essential for human growth and functioning. Look for students' understanding that successful memes should grab the attention with cultural references and a sense of humor. See an example shown.

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



EXTEND—If students want to create more polished memes or customize established memes, allow them to use drawing applications or online meme generators. Meme tools have templates students can edit and step-by-step directions for creating, downloading, and sharing their memes. Some allow GIFs or video clips instead of using a static image. Check the age requirements, content for vulgarity, and privacy policy of any tool before students use it to make sure it conforms with your school district's internet-use policies.

LESSON 3

What other inputs could be sources of food molecules for the plant?

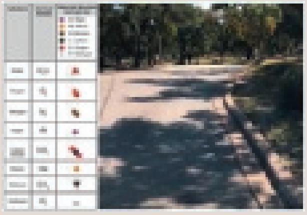
Previous Lesson

We used a hydroponic plant system and developed a list of candidates to track investigations of possible sources of food molecules inside plants. Using food indicators, we realized potential candidates could be eliminated after testing the hydroponic plant food water.

This Lesson

Problematizing

1 DAY



We revisit the composition of air and light to look for possible sources of food molecules. After looking at air and light (in addition to water and hydroponic plant food) we figure out none of our initial candidates contain whole food molecules. We realize that we might have to adjust our question and look to find whether plants could be putting together parts of food molecules, instead of directly taking in whole food molecules.

Next Lesson

We will see whether candidates from above the surface that contain parts of food molecules go into plants. We will use data we produce and secondhand data to figure out that plants are taking in carbon dioxide and releasing water and oxygen.

Building Toward NGSS

MS-LS1-6, MS-LS2-3, MS-PS1-3

What Students Will Do

Construct an explanation by applying scientific reasoning to show why data found in images and charts show patterns that parts of inputs could be the source of food molecules in a plant.

What Students Will Figure Out

- Air and light do not contain whole food molecules that can be taken in by plants.
- Air, hydroponic plant food, and water contain the same atoms that food molecules contain. These are parts of food molecules that could be taken in by plants.

Lesson 3 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Look back at the consensus model from Lesson 1. There are no more candidates from below the surface, so we move to look at inputs above the surface for new candidates for the source of food molecules in plants.	A	consensus model
2	6 min	**DISCUSS WHAT WE ALREADY KNOW ABOUT LIGHT** Revisit what we have figured out about light in previous units.	B	
3	7 min	**DISCUSS WHAT WE ALREADY KNOW ABOUT THE COMPOSITION OF AIR** Revisit what we have figured out about the composition of air in previous units.	C-D	*Composition of Air*
4	9 min	**PROBLEMATIZE CANDIDATE SOURCES FOR PLANT FOOD MOLECULES** Problematize our current question, which centers around identifying sources for whole food molecules. Form a new question that seeks candidates for *parts* of food molecules found in plants.	E	consensus model, candidates list
5	9 min	**LOOK FOR PATTERNS BETWEEN CANDIDATES AND FOOD MOLECULES FOR PARTS OF FOOD MOLECULES** Analyze food molecules and candidate inputs to look for patterns between their chemical compositions.	F	dry-erase markers, *Food Molecule Cards*, *Composition of Air*, chart paper, markers
6	3 min	**REVISE OUR CANDIDATES LIST TO "PARTS" OF FOOD MOLECULES** Revisit the candidates poster, retitle it to look at parts of food molecules and move water, air, and hydroponic plant food back into the candidates column and update the consensus model.	G	candidates list, markers
7	3 min	**REVISE CONSENSUS MODEL TO INCLUDE CONFIRMED INPUTS** Return to the initial class consensus to add the confirmed inputs of hydroponic plant food and water.	H	
8	3 min	**NAVIGATION: WHERE DO WE GO NEXT?**	I	consensus model
				End of day 1

Lesson 3 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide** **Student Work Pages**	• science notebook	• *Composition of Air* • dry-erase markers • *Food Molecule Cards*	• consensus model • candidates list • chart paper • markers

Materials preparation (30 minutes)

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

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

Use the laminated student reference *Food Molecule Cards* or place it in sheet protectors. It is helpful to have this reference sheet laminated because students can use dry-erase markers to mark up the food molecules cards this lesson. This reference sheet will also be frequently pulled out in later lessons.

Online Resources

Lesson 3 • Where We Are Going and NOT Going

Where We Are Going

In previous lessons, students developed the idea that hydroponic plant food and water are going into a growing plant and that plants contain food molecules such as carbohydrates, proteins, or fats. However, they found that hydroponic plant food and water did not contain food molecules. In this lesson, students add to their understanding by checking to see if light and air contain food molecules (two other inputs they suggested as sources of food molecules for the plants).

During the lesson, students will bring in ideas from previous units about the composition of light and air and that matter cannot spontaneously appear or disappear. This will lead them to understand that since food molecules are not entering the plant, then plants must be making them from other inputs that have the same atoms in them. This leads students to wanting to reevaluate our candidates, looking at the parts of candidates to see if these could be sources of parts of food molecules.

Where We Are NOT Going

This lesson does not address the cycling of other nutrients that are in some food molecules, like nitrogen and sulfur, beyond that they are present in hydroponic plant food and in proteins and amino acids. This lesson does not confirm air molecules enter plants but suggests this might be happening based on patterns in air molecules and food molecules. This will be investigated in Lesson 4. This lesson does not confirm that light is an input for plants to make food molecules or the purpose of light. This will be explored in Lessons 5 and 6. Students will examine the role animals and decomposers play for matter cycling later in the unit.

1. Navigation

5 MIN

Materials: science notebook, consensus model

Gather around the consensus model. Show **slide A**. Have students gather in a standing Scientists Circle around the consensus model from Lesson 1. Ask students to open their science notebooks to their Progress Trackers to help us look back at our thinking from the end of the previous lesson. Give students 1 minute to turn and talk with a partner before sharing out with the whole class.*

Suggested prompts	Sample student responses
What did we figure out last lesson?	*Hydroponic plant food solution and water do not contain food molecules.*
So far, we've been looking at candidates like soil, water, and hydroponic plant food as inputs to the plant. Is there anything else below the surface that we didn't test?	*No, we don't really see anything else. (Students might say the bubbles from the air pump; if so, use that to also bring up that there is air above the surface too!)*
So what are we still trying to figure out?	*We still don't know where the food molecules in plants are coming from!*
What are some other potential inputs that could be sources of food molecules?	*Well, we moved water and hydroponic plant food solution to the eliminated column of our candidates list, but we still have sunlight on our poster.*
Is there anything else coming into contact with our plants above the surface besides light?	*Air is also around the plants.* *We can see sunlight or the grow lights in the hydroponic plant system.*
So can someone help remind me how looking at air and sunlight will help us make progress on our question about where the plant is getting food molecules?	*If we see food molecules in the air or the light then we will know where the plant is getting its food molecules.* *If we do not find any food molecules in light or air then we will need to look for more candidates or a different way for the plant to get food.*
Okay, so it sounds like we should still find out more about air and sunlight so we can move them to the confirmed or eliminated columns.	*Yeah!*

Add sticky notes for sunlight and air to the candidates list if they are not listed already.

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

Why don't we just tell students what to do next? Having students think through and engage in the decision making helps them work through the logic of why we are doing the next activity in class. These are the type of critical thinking skills we want to help students develop.

Summarize, *We have evidence that hydroponic plant food and water aren't sources of food molecules and there wasn't anything else below the surface that could be a source of food molecules. Now we have decided we want to look at inputs that are interacting with the plant above the surface. We have an input of sunlight and an input of air. Let's think about sunlight first.*

Have students return to their seats.

Science Notebook

In the next few activities students will be recalling what they know from previous units and then connecting those ideas to what we know about food molecules. You may wish to have students record what they know about light, air, and food molecules in their notebooks before they formally look for patterns between the two toward the end of the lesson.

2. Discuss what we already know about light. 6 MIN

Materials: None

Engage in a whole-class discussion to revisit what we know about light from previous units. Show **slide B**.

Say, *What do we know about sunlight already? What have you figured out in earlier units? What is sunlight made of? What does sunlight do?*

Key Ideas

Purpose of this discussion: The purpose of this discussion is for students to recall what they have learned about light in previous units to see if light is a possible source of food molecules for the plant.

Listen for these ideas:

- When sunlight interacts with some materials it can be absorbed and cause the material to heat up. When this happens, the mass of the material does not change, but the temperature of the material changes.
- When sunlight is absorbed by the ground, it causes the ground to heat up. Then the air that collides with the ground gets heated up from the ground.
- Sunlight is not made of particles or matter; it is a source of energy that can heat things up.

Additional Guidance

From earlier units, students have investigated light and how it interacts with different materials. Specifically:

- In 6.1: *Why do we sometimes see different things when looking at the same object?* (One-way Mirror Unit), students figured out that light interacts in different ways with matter, one of these ways being absorption.
- In 6.2: *How can containers keep stuff from warming up or cooling down?* (Cup Design Unit), students figure out that when light is shined on materials (matter) and is absorbed these materials heat up. When objects heat up there is no change to the mass of the object. Therefore light is a source of energy but is not a source of matter.

- In 6.3: *Why does a lot of hail, rain, or snow fall at some times and not others?* (Storms Unit), students build on what they have figured out about light to include that when light from the sun is absorbed by the ground, the ground gets heated up, which in turn heats up the air that interacts with the ground. This deepens our understanding that light is a source of energy and is not made up of matter.

Suggested prompts	Sample student responses
Okay, so if light isn't made of particles and isn't a source of matter, then can it be a source of food molecules?	*No because food molecules are made of particles and have weight or mass. We saw that in Lesson 2.*
So if light isn't made of matter, then should we keep it on our candidates list?	*Yes … because I know plants need light to grow, so it must do something for plants to be able to make food molecules.* *Maybe … because we learned light is a source of energy to heat things up, so maybe plants need heat to grow.* *No … I think we should remove it because it isn't made of matter.*
Okay, so it sounds like we are not in agreement about whether we should remove sunlight from our candidates. I am wondering if we might want to keep it on our poster with a ? and the word "energy."	*Yeah … we should keep it, but definitely put a ? and the word "energy" by it to keep track that we are not all sure it is necessary. Let's keep it in the candidates column for now.*
OR	*OR*
It sounds like we are all in agreement that light is a source of energy based on what we figured out in other units, so I am wondering if we might want to keep it on our poster with a ? and the word "energy." Or should we remove it from our list?	*No ... we think we should remove it from the candidates because it can't be a source of matter. But it does seem like we still need to figure out more about why (or if) plants need light.*

Additional Guidance

Whether students decide to keep sunlight on the candidates list or remove it at this point isn't important. It is more important for them to be problematizing that sunlight seems an important component to plant growth, but it isn't made of matter. Later in the unit, we will discover the role of light for plant growth. Later in this lesson, the class will revisit the consensus model and add "light" with a ? and "energy" if it isn't there already to keep track of this idea that plants need light, but light can't be a source of molecules since it isn't made of matter. At this point, you can press for removing light from the candidates poster if it isn't removed here.

3. Discuss what we already know about the composition of air. 7 MIN

Materials: *Composition of Air*

Recall what we know about the composition of air from previous units. Show **slide C.** Say, *We still have air on our candidates list. Let's recall what we know about air from investigations in earlier units.*

Suggested prompts	Sample student responses
Do you recall what air is made out of? Is it one substance?	*Air is made of different types of gases like oxygen, water, carbon dioxide, nitrogen, and some others.* *I don't remember.*
Is air matter?	*Yeah, we learned it has weight and is made up of atoms, so that means it is matter.*
So it sounds like we should look more closely at what air is made of and compare this to the food molecules found in plants?	*Yeah, can we look again at what air is made of?*

Additional Guidance

From earlier units, students have investigated air—both the composition of air and how air helps us move and have energy. Specifically:

- In the Storms Unit, students figure out from a reading that air is composed of different types of gases such as nitrogen, oxygen, argon, carbon dioxide, and water.
- In 7.1: *How can we make something new that was not there before?* (Bath Bombs Unit), students figure out these different gases that make up the air have different properties. These properties can be used to determine if a new substance was made from an old substance.
- In 7.3: *How do things inside our bodies work together to make us feel the way we do?* (Inside our Bodies Unit), students revisit the composition of air when figuring out what happens to fat that we "burn" from our body. They figure out we breathe in oxygen that our body uses by going through chemical reactions for energy and when this reaction is done, we breathe out carbon dioxide.

Analyze the composition of air to look for food molecules. Show **slide D.**

Remember together, *We looked at a similar chart earlier in* the *Storms Unit. Let's analyze this again thinking about whether air could be a possible source of food molecules.*

Give students a minute to look at *Composition of Air* to see if there are any food molecules in air.

Share out what they figured out about air in a whole-class discussion.

Suggested prompts	Sample student responses
What do we notice when looking at the composition of air?	*Air is made of nitrogen, oxygen, argon, carbon dioxide, water, and a few other substances.*
Can someone remind us what molecules we found make up plant food in Lesson 1 and 2?	*carbohydrates, fats, and proteins*
When we look at the composition of air, are there any food molecules?	*There are no carbohydrates, proteins, or fat in air.*
Huh! So if none of the food molecules in air are the same as those in plant food, where could the food molecules be coming from?	*I don't know, we're stuck!*

4. Problematize candidate sources for plant food molecules. 9 MIN

Materials: science notebook, consensus model, candidates list

Discuss ideas for where plants could get food molecules. Project **slide E.** Have students turn and talk about their ideas before sharing out with the whole group to problematize that the class should change the question to what candidates could be the source of *parts* of food molecules that are found in plants.

Say, *Let's think back to analyzing the little seeds and how they grew into these fully grown plants that are much larger! We know you can't just make something out of nothing. The matter to build up the fully grown plant had to come from somewhere! Maybe they are not coming into the plant "looking" like whole food molecules. Maybe they are disguised somehow.*

Suggested prompts	Sample student responses
If none of the inputs we investigated contain whole food molecules, then what could be the source of food molecules for the plant?	*We saw that the inputs we looked at contained some of the same atoms that food molecules contain.*
Do you have any ideas about how plants could get food molecules without directly taking them in like we do?	*Maybe a chemical reaction happens when the plant takes in these different inputs to make the food molecules. We figured out our body goes through chemical reactions when we breathe in oxygen and breathe out carbon dioxide, so maybe the same thing happens in the plant.*
What evidence would help us determine whether hydroponic plant food, air, or water could be involved in a chemical reaction to make food molecules?	*We should see the parts of carbon, hydrogen, and oxygen and maybe a little nitrogen and sulfur inside it!*
So, if we looked at the parts of food molecules and the parts of our candidates to see if there are any similarities, how would that help us answer our question?	

Additional Guidance

You may need to build in more time here if students have not looked at food molecules in the Inside our Bodies Unit to allow students to make sense of the *Food Molecule Cards* before they use this to compare to the molecules in water and hydroponic plant food. In addition, if students have not investigated chemical reactions in either the Bath Bombs Unit or Inside our Bodies Unit, then they may need more support to discuss how parts of whole food molecules could be made from parts of the different candidates we investigated.

5. Look for patterns between candidates and food molecules for parts of food molecules. 9 MIN

Materials: science notebook, dry-erase markers, *Food Molecule Cards*, *Composition of Air*, chart paper, markers

Look for patterns between *Food Molecule Cards* and *Composition of Air*. Show **slide F.** Say, *Work with your partner to find patterns that might help us figure out whether plants could be putting together parts of food molecules*. Hand out dry-erase markers to draw on the laminated *Food Molecule Cards*. Students can record patterns in their notebook.

Alternate Activity

If you are not able to laminate *Food Molecule Cards*, you can print out a grayscale version and have students mark up that one. Alternatively, you can have students write things they notice in their science notebooks, and during the whole-class discussion, project the image on a whiteboard and have students come up to the board and circle things on the projected image of food molecules.

Additional Guidance

To make an explicit connection to ideas from the Inside Our Bodies Unit, ask students what we know about food molecules. As students are revisiting *Food Molecule Cards* ask them what they notice when they look at these and compare this to what is found in the air, water, and hydroponic plant food. Add these ideas to the list:

- The atoms found in food molecules are also found in water and the air.
- Some of the atoms that are part of substances found in hydroponic plant food are also found in food molecules.

Share out patterns as a class in a Building Understandings Discussion. After about five minutes of partner work, pull students together to report out some of the patterns they noticed. Encourage students to come up to the projected image of *Food Molecule Cards* to show what they noticed. If possible, project the image of the student reference *Food Molecule Cards* on a whiteboard and have students come up to draw and circle what they are noticing. Record patterns on chart paper.

Key Ideas

Purpose of this discussion: Students will analyze the images of food molecules, of the plant food label with chemical formulas included, of air molecules, and of water molecules. Using what they notice about similarities between atoms types of the potential inputs and of the food molecules, help students verbalize and consider that it is possible that parts of food molecules come from these different inputs.

Listen for these ideas:

- All the food molecules are made up of carbon, hydrogen, and oxygen atoms, while some also have nitrogen and sulfur atoms.
- The molecules that are part of the hydroponic plant food system have nitrogen, oxygen, and sulfur, so maybe parts of these molecules are used in the plant to make food molecules.
- The molecules in the gases in the air contain atoms that are also found in the food molecules, like carbon, oxygen, hydrogen, nitrogen. Maybe some of these atoms are used by the plant to make the food molecules.
- We figured out (in previous units) when chemical reactions occur, molecules break apart from each other and get rearranged to make different substances. Maybe that is what is happening here.

Suggested prompts	Sample student responses	Follow-up questions
What patterns did you notice when comparing the food molecule cards with other substances surrounding the plant?	*Some of the things in the surroundings have the same parts (types of atoms) that are in the food molecules.* *There are three parts that are common among all the food molecules. They are all made of C, H, and O atoms.* *Water (has hydrogen and oxygen atoms).* *Carbon dioxide (has carbon and oxygen atoms).* *Both of those, as well as O_2, have oxygen atoms.*	*What's your evidence for that?* *Why do you think that?* *Can you come up to the board and show us where you saw that?*
So maybe our original question when we were looking at candidates wasn't the right question! Instead, we should change our possible sources question!	*Yeah! We should look at inputs that could be the source of parts of food molecules.*	

6. Revise our candidates list to "parts" of food molecules. 3 MIN

Materials: candidates list, markers

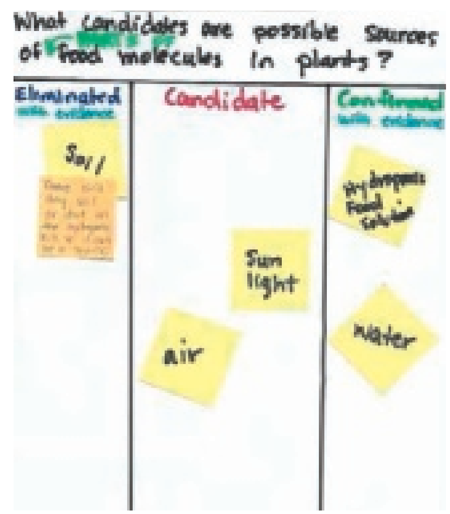
Revise the main question on the candidates list. Show **slide G.** Use a colored marker and add "FOR PARTS" to the already existing question. The new question should now read "What are the possible sources FOR *PARTS* of food molecules in plants?" Now all the possible candidates written on sticky notes (except soil) should be moved back into the Candidates column because they need to be investigated under this new question.

Additional Guidance

Soil should remain in the Eliminated column since it was not an input for the hydroponic system at all. Therefore, it cannot be a source of parts of food molecules either.

Summarize, *OK, so if hydroponic plant food or water is the source of food molecules, it should have carbon, hydrogen, and oxygen inside it. Let's check out the ingredients list to see what we find.*

Suggested prompts	Sample student responses
Do we have evidence the plants in our hydroponic system use the hydroponic plant food and the water in the bin?	*Yes … we had to add more to the bin, so the plant must be using these to grow.*
How does that show that the plants are taking in the hydroponic plant food and water molecules?	*The roots of the plants are in the hydroponic plant food solution inside the hydroponic plant system and they are getting bigger as the amount of solution gets smaller. So they are taking in the solution.*
When we looked at the food labels, did all the plants in our hydroponic system have food molecules?	*yes*
So if they all had food molecules and the amount of hydroponic solution and water decreased, then can we conclude these two sources are inputs of parts of food molecules?	*Definitely … because we saw the same atoms in the food molecules and the hydroponic solution and water.*
What did you find when you compared the atoms found in food molecules to hydroponic solution and water?	*Hydroponic plant food has nitrogen and sulfur, which are atoms found in proteins and amino acids.* *Water is made of hydrogen and oxygen atoms and these atoms are also found in all the food molecules.*
So if these two inputs from below the surface have parts that match parts in the food molecules, are they sources of food molecules?	*yes*
What should we do with hydroponic plant food and water on our candidates list then?	*We should move them to Confirmed!*



Move the hydroponic plant food and water over to Confirmed.

7. Revise Consensus Model to include confirmed inputs.

3 MIN

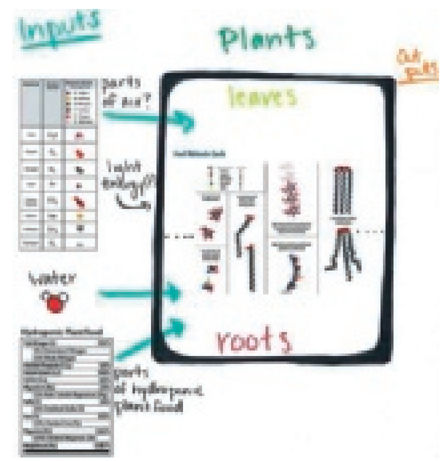
Materials: science notebook

Revist the initial consensus model. Show **slide H.** Have students walk over to or look at the initial consensus model. Discuss confirmed inputs that we still have question marks about. During the discussion add or point out where we still have questions about light and air. Remove or put an X over soil as we have confirmed it is not needed for plant food.

Say, *So now that we have revised our question to include the parts of food molecules and confirmed two inputs, let's zoom in and go back to our consensus model to look more closely at what might be happening for plants to have whole food molecules.*

Suggested prompts	Sample student responses
What inputs can we confirm on our consensus model?	*We can confirm hydroponic plant food and water.*
How could we represent this on our model?	*We could draw arrows going into the plant for the hydroponic plant food and water.*
	We should draw out what the molecules look like or are made of to show that it is parts of each of them that go into the plant to help make plant food.
What inputs have we figured out some things about but still might need more evidence?	*We think light is important but we know it is not a source of matter for food molecules.*
	We know there are parts of food molecules in the air outside the plant. We want to know if those parts of air could be going into the plant?
	We are also curious about what is going on with the water in the air.

Here is a possible representation of the revised consensus model.



8. Navigation: Where do we go next?

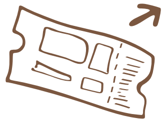
3 MIN

Materials: science notebook, consensus model

Elicit ideas about what to investigate next. Show **slide I.** 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 know where a plant is getting the inputs needed to make food molecules. 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.

Say, *We have confirmed two inputs for below the surface that plants grow—parts of hydroponic plant food and water. Before you leave for the day, let's make sure to explain what we figured out and what we still have questions about.*

Exit Ticket



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

1. Explain your reasoning using evidence: Why have we revised our question to be what candidates are possible sources **for parts** of food molecules found in plants?
2. *What else do we need to figure out about potential sources of food molecules?*

Explain your reasoning using evidence. Why have we revised our question to be what candidates are possible sources **for parts** of food molecules found in plants?

Assessment Opportunity

Read the exit tickets before you begin Lesson 4.

Use this exit ticket to determine if students are understanding the patterns between food molecules and the matter that makes up candidate sources of food molecules like air, light, hydroponic plant food, and water.

Look for students to show:

- Air, water, hydroponic plant food, and light do not contain any whole food molecules.
- All the parts of food molecules can be accounted for if you combine parts of the air, water, and hydroponic plant food.

If your students struggle with identifying why the question needs to be revised to include parts instead of just (whole) food molecules have your students revisit the air composition chart and *Food Molecule Cards*. Cue students to look for similarities in the atoms present in air and food molecules. You can also cue them to look back at their Progress Trackers from Lesson 2 to confirm that soil is not needed for plants to grow and that hydroponic plant food and water do go into the plant as it gets bigger. Then they can revisit the nutrition labels for plant food and water to see what parts of food molecules are found in the ingredients.

LESSON 4

Are any parts that make up food molecules coming into the plant from above the surface?

Previous Lesson

We revisited the composition of air and light to look for possible sources of food molecules. After we looked at air and light (in addition to water and hydroponic plant food) we figured out none of our initial candidates contained food molecules. We realized that we might have to adjust our question and look to find whether plants could be putting together parts of food molecules, instead of directly taking in whole food molecules.

This Lesson

Investigation

2 DAYS

We conduct an investigation and produce data showing carbon dioxide decreasing and water increasing in the air surrounding plant leaves exposed to light. We analyze and interpret secondhand data, confirm carbon dioxide and water patterns, and discover that oxygen levels are increasing around the plant. This sparks questions about how these gases are getting into and out of the leaves.

Next Lesson

We will observe the surface of leaves and see small openings that could be how gases get into and out of leaves. We will also look inside of leaves and see green chloroplasts inside plant cells and discover that they move in response to light.

Building Toward NGSS

MS-LS1-6, MS-LS2-3, MS-PS1-3

What Students Will Do

Engage in argument from evidence by comparing and critiquing claims that plants take in (input) water through their roots and give off (output) water through their leaves.

Analyze and interpret data and graphs to identify patterns to show that plants are taking in (inputs) carbon dioxide and releasing water and oxygen (outputs).

What Students Will Figure Out

- Carbon dioxide enters plants through the leaves.
- Since carbon dioxide is the only input containing carbon, it is the source of carbon in food molecules.
- Plants also release water and oxygen from their leaves.

Lesson 4 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Motivate a need for investigating what happens to air molecules around plant leaves.	A	consensus model
2	20 min	**PLANNING AND INVESTIGATING ABOVE THE SURFACE SOURCES** Brainstorm how to figure out if parts of food molecules are entering the plant through the air. Set up a closed system and monitor carbon dioxide and water levels within a closed system for 10–15 minutes. Record what the patterns show.	B-H	*Investigating Above the Surface Inputs*
3	10 min	**MAKE SENSE OF RESULTS IN A WHOLE-CLASS BUILDING UNDERSTANDINGS DISCUSSION** Discuss the "Making sense" questions from the previous activity. Motivate a desire to see whether other gases are changing around the plant.	I	chart paper, colored markers
4	10 min	**COMPARE AND CRITIQUE ARGUMENTS ABOUT THE ROLE OF WATER** Students complete an assessment where they provide feedback to three different claims about what happens to water inside plants. After using evidence to support or refute the three claims, they will choose which claim they think is best supported by evidence and why.	J-L	tape, *Comparing and Critiquing Arguments about Water in Plants*
				End of day 1
5	5 min	**NAVIGATION** Revisit the idea of wanting to know if other gases in the air are going into or out of the plant.	M	
6	20 min	**ANALYZE AND INTERPRET SECONDHAND DATA** Evaluate secondhand data produced by other students who measured carbon dioxide, water, oxygen, and light. Analyze and interpret these data using the I^2 strategy and discuss patterns.	N-Q	*Another Plant Experiment*, *Data from Leaves in the Light*, tape
7	15 min	**CONSENSUS DISCUSSION ABOUT SECONDHAND DATA** Use evidence from both sessions to argue about which gases in the air we think are inputs and which we think are outputs. Consider that we've previously seen oxygen turn into carbon dioxide in our own bodies and motivate students to wonder if plants do something like breathing.	R-S	Progress Tracker, consensus model, chart paper, sticky notes or index cards, colored markers

Part	Duration	Summary	Slide	Materials
8	5 min	**NEXT STEPS** Record ideas for how to investigate how gases are getting into and out of plants.	T	

End of day 2

Lesson 4 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide** **Student Work Pages**	• *Investigating Above the Surface Inputs* • science notebook • tape • *Comparing and Critiquing Arguments about Water in Plants* • *Another Plant Experiment* • *Data from Leaves in the Light* • Progress Tracker		• consensus model • chart paper • colored markers • sticky notes or index cards

Materials preparation (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.

Watch Lesson 4 Video demo of setup video. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Test this experimental setup yourself before class.

Day 1: Carbon dioxide/water lab

- **Group size:** whole class
- **Setup:** Watch video for a demo of the setup. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) Gather materials for lab.
  1. Decide what plant leaves to use.
     - You will need 40+ square inches of leaf area (~10-12 leaves) to get a noticeable drop in carbon dioxide level in 10 minutes.
     - Fresh spinach leaves work best so purchase them no more than 1-2 days before the investigation.
     - Alternatively, use your hydroponically grown spinach or radish leaves (if available) or store bought hydroponic plants (like green leaf lettuce). You may need to use 1 or 2 plants to get the necessary leaf area.

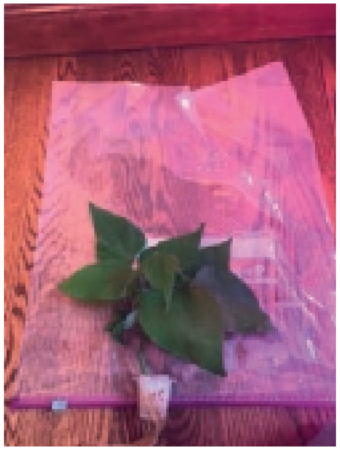
2. Conduct a trial run to see whether you can get a reliable decrease in carbon dioxide levels. If not, consult *Tips for teachers on the CO_2/RH detector experiment* for troubleshooting.
    - Check to make sure that the carbon dioxide detector is working properly.
    - Lay out and test the lab materials as suggested in video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**).
    - The image below and right shows the piece of aluminum foil with the spinach leaves used in the video on a 1-gallon ziplock bag. If your spinach leaves take up more area, it may be difficult to reseal the bag and have enough room for the detector.
    - To see significant changes in carbon dioxide and water levels, place the leaves about 6-8 inches directly below the hydroponic grow light.
    - You want to see a decrease in carbon dioxide of ~50 ppm after the leaves in the bag are under the light for 5 minutes.
    - Alternate activity: If you are using hydroponically grown plants, only place the leaves in the bag and keep the roots outside. Depending on the size of the plant, you may need to use a 2-gallon ziplock bag as shown on the right. You can place the roots in a cup of hydroponic plant food solution during the experiment (optional).

- **Notes for during the lab:** Use the set up from your trial that gave measurable changes in carbon dioxide (~50 ppm decrease) and water levels after 5-10 minutes. Use a new ziplock and new spinach leaves for each class or data collection if you do the experiment more than once per class.
- **Disposal:** Ziplock bags and used spinach can go in the wastebasket.
- **Safety:** To minimize the amount of stray UV light, you may want to place the entire set up in a large box. Protective eyewear can also be used, especially when reading the detector.
- **Storage:** To keep spinach leaves fresh, store in refrigerator until needed. Keep unused spinach leaves in the refrigerator since you will also need them for Lesson 5.

Lesson 4 • Where We Are Going and NOT Going

Where We Are Going

In previous lessons, students developed the idea that food molecules are not going into the plants' roots (from the hydroponic food solution) or into the leaves (from air). This lesson introduces a key idea from NGSS Disciplinary Core Idea PS3.D, that carbon dioxide is an input to plants and that plants also produce oxygen and water molecules. Students have theories that plants are using their inputs to make food molecules. However, students do not yet understand exactly what plants are doing with these molecules. In Lesson 6, they will figure out that plants are building sugars (food molecules) by using energy from light and carbon dioxide and water. In Lesson 7, they will figure out that this chemical reaction, photosynthesis, requires an energy input to occur (e.g., light from the sun). In Lessons 10 and 11, students will figure out that plants, like humans, release energy through a chemical reaction with sugars (food molecules)



and oxygen, and produce carbon dioxide and water. This will help students explain why they saw humidity levels increasing in this lesson.

Students may come with ideas that plants take in water not only through their roots, but also through their leaves. Through first- and secondhand data analysis, they will see that, in fact, leaves are releasing water, which should help convince students that leaves do not take in water.

Where We Are NOT Going

Students will probably come to the unit with the idea that plants need light to grow. In this lesson, they may want to look at what happens to carbon dioxide and water levels in the dark. Students will get to these investigations in Lesson 10 after they try to explain how maple trees can produce sap in the winter when there are no leaves. Encourage students to record these ideas for investigations, but wait to investigate them until they know more about the role of light.

LEARNING PLAN FOR LESSON 4

1. Navigation

5 MIN

Materials: consensus model

Revisit the idea of investigating components of air. Project **slide A** and refer to the consensus model from Lesson 3. Give students a few minutes to turn and talk to a partner about the questions on the slide. Then ask students to share out.*

Suggested prompts	Sample student responses
What were some of the things we noticed when we compared the composition of substances around plants to food molecules?	*When we compared the composition of substances surrounding plants with food molecules, we noticed that C, H, O are in water and components of air and hydroponic plant food.*
Did we investigate all the below the surface inputs?	*Yes, we know water and hydroponic plant food go into the plant roots because they need to be refilled.*
So then what's left for us to investigate now?	*We decided to look closer at above the surface sources (air).*

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

A community norm we have been following is using evidence to convince each other. We've previously used this norm while discussing our candidates list and below the surface inputs. This norm also holds during other classroom discussions because that's how the scientific community works all the time!

2. Planning and Investigating Above the Surface Sources

20 MIN

Materials: *Investigating Above the Surface Inputs*

Discuss ideas for investigations. Show **slide B** and discuss as a class how we could test for changing gases in the air. Push the class to want to measure what is in the air over time to see whether it changes. Amplify student ideas around measuring changes in the level of gases containing C, H, and O around plant leaves.

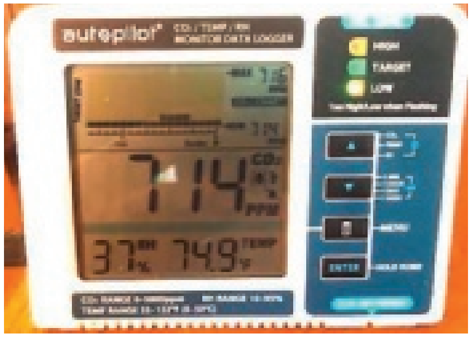
Suggested prompts	Sample student response
I've got this detector that can measure stuff in the air. (Show detector.) It can measure carbon dioxide and water. *How could using this detector help us to know if parts of food molecules are going into the plant?*	*We could use it to see if the amounts of carbon dioxide and water in the air around the plant change.*

Alternate Activity

If students struggle to reason through how measuring if certain inputs are increasing or decreasing in the environment answers our question, you can do the following demonstration:

- Present a plastic bin that represents the plant and a bin right next to it that represents the environment.
- In the environment bin, put in some manipulatives (e.g., paper clips) and tell students that these represent inputs to plants, like water, air, and nutrients, that come from the environment.
- Move a few manipulatives from the environment bin to the plant bin and ask students, *If these are inputs from the environment that are actually going into the plant, how would we know?* This will push students to think about how we could monitor the amount of the substances in the environment and see whether they are decreasing.

Additional Guidance



If students want to measure other gases at this point, that's fine. We can only measure water and carbon dioxide right now, and students will have a chance to think about oxygen later in the lesson. We will not actually address nitrogen because it's not one of the main atoms (C, H, and O) in all food molecules, so you don't need to push on that.

Show students the carbon dioxide detector. Introduce students to the device that you have that measures the amount of carbon dioxide (CO_2) in the air and the relative humidity in the air.

Show **slide C** to reference the different parts of the detector. Get the class to agree that measuring carbon dioxide and water seems like a good place to start because those two molecules have Cs, Hs, and Os, though we agree there could be others too.

Motivate the need for a closed system. Show **slide D** and have students turn and talk about if just placing the detector close to the plant leaves tell us if gases are going into the plant. Ask student pairs to share what they discussed with the whole group.

Suggested prompt	Sample student responses
Will just placing the detector close to the plant leaves tell us if gases are going into the plant?	*No, it would detect gases in the air all around it.* *We would have to collect the gases around the leaves some how.*

Additional Guidance

If you have done the Unit 7.3: *How do things inside our bodies work together to make us feel the way we do?* (Inside our Bodies Unit), some students should remember using a closed system with a carbon dioxide detector in Lesson 11. If you have not done that unit previously, you may want students to talk about how to investigate this, in pairs first, and you may need to spend more time discussing using a closed system.

Present the closed system, ziplock-bag setup. Show students the closed container, a ziplock bag, and tell students that we can record carbon dioxide and water vapor (relative humidity) readings in the air inside the sealed ziplock bag, which is a closed system.

Place the carbon dioxide detector in the ziplock bag and seal it. Be careful not to breathe on the detector. Tell students that the detector needs some time to stabilize, so you'll put the carbon dioxide detector into the bag now.

Additional Guidance

You want the carbon dioxide detector to sit inside the ziplock bag for about five minutes so the reading can stabilize. It will fluctuate initially because of students breathing nearby. Placing the detector in the bag now gives some time for the reading to stabilize.

Discuss what part of the plant should go into closed system/ziplock bag.

Ask students, *We need to decide what part of the plant should go into our closed system. We're trying to figure out whether any parts that make up food molecules are going into the plant from the air. So, which parts of the plant are touching the air?*

As students respond with ideas about the leaves and stem, validate their ideas and suggest that we should measure what's happening in the air around those parts of the plant. So, suggest that we put leaves in the bag. Don't put them into the bag yet because the carbon dioxide detector should still be in the bag stabilizing.

Additional Guidance

The most reliable results with the carbon dioxide detector will be obtained by using store bought loose spinach leaves. It is easier to place the individual leaves flat to maximize the leaf area exposed to light. To get students to agree that it's OK to use loose spinach leaves, you can say, *I didn't want to damage our hydroponic spinach plants during this investigation so I got some spinach leaves at the grocery store. I thought that most of the spinach plant that's above the surface is the leaves, so I thought we could try them and see what happens.*

Explain that we want the system to look as close to the hydroponic system as it can, so we'll put our grow light on it.

Alternate Activity

If your hydroponic plants are large enough to put in a closed system and see a change in carbon dioxide and water vapor levels, you can use those. Be sure to test this ahead of time.

Materials needed

- One or two of your hydroponically grown spinach or radish plants.
- A cup with hydroponic plant food solution that you can place the roots in (optional).
- All the additional materials outlined in the lab setup.

Alternate setup

- Only place the top part of the plant (the leaves) into the ziplock bag. Leave the sponge, basket, and roots outside the bag.
- Gently try to arrange the leaves to maximize the area exposed to light. Damage to the leaves will increase the level of cellular respiration and could potentially skew the results.
- Optional: Place the plant roots in the cup of hydroponic plant food and water solution. This is not necessary, but you can do this if students want to.

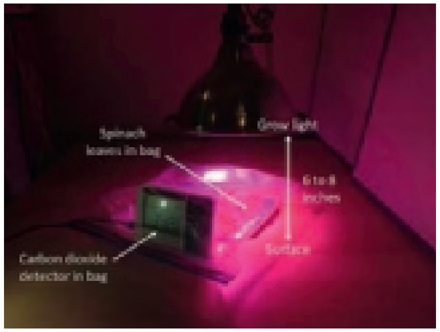
Prepare for data collection. Hand out *Investigating Above the Surface Inputs* and have students tape it into their science notebooks and fill in the gases they will be monitoring under the "Substance" column (**slide E**). Create a data table on the board or on chart paper that includes time (add lines for the first readings at 0 and 5 minutes and then leave the rest blank for now) and two additional columns, one for carbon dioxide and one for water vapor.

Time (minutes)	Carbon dioxide (CO_2) gas, ppm	Water vapor (H_2O), % relative humidity
0		
5		

Invite a student volunteer to take initial carbon dioxide and water readings. The system has now been closed for about 5 minutes, so the carbon dioxide and relative humidity levels should have stabilized. Have a student volunteer read out the carbon dioxide and water readings from the detector. Do not take the detector out of the bag for this reading because this is our baseline for within the closed system. Have students record those carbon dioxide and water readings at time 0 on the class chart and in part B of their *Investigating Above the Surface Inputs* handout.

Set up the closed system with the plant in it:

- Open the sealed ziplock bag with the carbon dioxide detector inside.
- Quickly place a piece of aluminum foil with 10-12 loose spinach leaves (right side up) inside the ziplock bag. Be sure that the leaves are not covering each other too much.
- Seal the plastic bag.
- Position the grow light so it is about 6 inches above the top of the ziplock bag.



Note, this is not an airtight system, but it will suffice for capturing changes in carbon dioxide and water vapor within the system.

Set a timer for 5 minutes to tell you when to return to this setup for the next data measurement.

Additional Guidance

If there is not sufficient light, the sensor will produce data showing carbon dioxide levels increasing. This is because the carbon dioxide produced by cellular respiration will be greater than the carbon dioxide taken into the plant from photosynthesis. Make sure to use your hydroponic grow light and have it 6 inches or less from the top of the ziplock bag to produce data with a decreasing effect. Also, humidity levels should start relatively low (around 0–70 percent) and will steadily increase within the first 10 minutes. This will be counterintuitive to students, because so far water has been an input, not an output.

Have students make a prediction. While you wait for 5 minutes, have students record a prediction about what will happen to the amount of each substance and why (in part A of Data Collection Table and **slide F**). Then have a few students share what their predictions were with the class. Example student predictions might look like these:

- *Maybe humidity will go down because the plant will take that water out of the air . . . maybe through its leaves.*
- *Maybe carbon dioxide will change (not sure if it will go up or down), because some of us heard that plants do something with carbon dioxide.*

Record measurements after 5 minutes. Return to your setup and record measurements after the first 5 minutes. The readings have changed quickly, and students may be surprised. Check in with the class to see whether they think we should keep watching for another few minutes. Invite another student to use a timer to record readings every minute and provide them with protective eyewear. Have the students record readings every minute for another 5–10 minutes. Then, take apart the setup, project **slide G**, and have students fill out parts C and D of their tables.

Additional Guidance

Do not leave your setup overnight or else you will produce data that show the effects of cellular respiration. Students will have the opportunity to produce those data in Lesson 10. But at this point, it will confuse students to see those patterns.

Make sense of our results. Project **slide H** and give students a few minutes to respond to the "Making sense of our results" questions on their *Investigating Above the Surface Inputs* handout in pairs.

3. Make sense of results in a whole-class Building Understandings Discussion.

10 MIN

Materials: science notebook, chart paper, colored markers

Conduct a whole-class Building Understandings Discussion. Project **slide I** and remind students of the question we were trying to answer: "Are any parts that make up food molecules coming into the plant from above the surface?" Have students share their ideas from the "Making sense of our results" section on their *Investigating Above the Surface Inputs* handout.*

*** Strategies for This Building Understandings Discussion**
A Building Understandings discussion is a useful kind of discussion following an

Key Ideas

Purpose of this discussion: Draw conclusions based on the evidence we collected that above the surface plants are taking in carbon dioxide and releasing water, and raise questions about what other gases might be entering or exiting plants through the leaves.

Listen for these ideas:

- Carbon dioxide levels in the air around plant leaves decrease over time.
- Water levels in the air around plant leaves increase over time.
- Since carbon dioxide levels decrease in this closed system, it is probably going into the plant leaves.
- Since water levels increase in this closed system, water is being released from the plant leaves.
- Plant leaves do not take in water.
- There are other gases in air that have parts of food molecules. Maybe some of those are going into the plant leaves.

Suggested prompts	Sample student responses
*Are there any **parts that make up** food molecules going into the plant from above the surface?*	*Plants are taking in carbon dioxide, because carbon dioxide levels in the air inside the bag went down. Carbon dioxide has C and O atoms that are also in food molecules.*
What other claims can you make based on evidence from this experiment?	*Plants are giving off water because the water vapor levels in the air inside the bag went up. That means plants don't take in water through their leaves, only their roots.*
What are you unsure of or what new questions does this raise for you?	*It was surprising that water levels went up. Why are plants taking in water through roots, but then also releasing it through leaves? What are they doing with the water? Are these the only gases changing around leaves?*

investigation because the purpose is to focus students on drawing conclusions based on evidence. Your role during the discussion is to invite students to share conclusions and claims and to push them to support their conclusions and claims with evidence. Students can disagree with each other and the class does not need to reach consensus on all ideas shared, but rather areas of disagreement can motivate future investigations. Helpful prompts during these kind of discussions include:

- What can we conclude?
- How did you arrive at that conclusion?
- What's your evidence?
- Does anyone have evidence to support Student A's claim?
- What data do we have that challenges Student B's claim?

4. Compare and critique arguments about the role of water. 10 MIN

Materials: science notebook, tape, *Comparing and Critiquing Arguments about Water in Plants*

Question the role of water in the plant system. If it has not already come up, push students to notice that water is now listed as both an input and output to the plant system.

Suggested prompt	Sample student response
Does anyone notice anything weird about our revised consensus model?	*Well, we just figured out that water comes out of the leaves but earlier we figured out that water goes in through the roots.*

*** Supporting Students in Engaging in Argument from Evidence**
This assessment offers an opportunity for students to compare and critique multiple arguments on the same topic and analyze whether they emphasize

Compare and critique multiple claims. Show **slide J**. Read the text on the slide and have students talk with a partner about the slide content. While they are doing this, hand out copies of *Comparing and Critiquing Arguments about Water in Plants* to students. After 2 minutes, bring students back together as a class.

Say, *These claims are from another class that has done the same investigations and generated the same evidence that we have up to this point. They also noticed that water seems to be an input and an output, and wondered what is happening to water inside the plant. Read the claims and briefly discuss with a partner.*

Provide feedback on supporting each student claim. Ask students to tape *Comparing and Critiquing Arguments about Water in Plants* into their science notebooks. Show **slide K** and give students time to write out feedback for each student in their science notebooks.

Say, *Take some time right now to provide each student with some feedback about what evidence and reasoning could be used to support their claims. Refer back to your Progress Tracker, our consensus model, and your science notebook to identify evidence and reasoning that would support each claim.**

Alternate Activity

You can also have students work with a partner to provide feedback. Struggling students can also choose 1 or 2 claims to work with.

Choose the strongest claim. Show **slide L**. Ask students to think about which claim about what happens to water inside plants they think the evidence best supports. Ask them to write their responses in their science notebooks. If you are short on time, assign this as home learning.

Assessment Opportunity

At this point in the unit, students do not have any evidence about what happens to water inside the plant. In this assessment, we are really looking to see if students can cite evidence and reasoning for water as both an input and output; this is common to all three claims. The reasoning they use as they try to explain what happens to water inside the plant provides valuable insight into their thinking that can be leveraged in Lessons 6 and 11 where students will be able to associate different inputs and outputs with photosynthesis and cellular respiration.

Check the assessment guidance section and *Key: Lesson 4 - Student Assessment* for what to look for in student responses.

Additional Guidance

At this point in the unit, look to see that students include some of the science ideas that they have from previous units, like conservation of matter, chemical reactions as a way of rearranging atoms, and states of matter.

End of day 1

similar or different evidence. By providing feedback on three different claims, students have the opportunity to cite the relevant evidence and reasoning supporting water as a plant input and output.

5. Navigation

5 MIN

Materials: science notebook

Help students recall where they left off last class. Show **slide M**. Return to the evidence the class collected that showed carbon dioxide as an input and water as an output. Zero in on student wonderings about what is happening with other gases. Students can refer to the "Making sense of our results" section of *Investigating Above the Surface Inputs*.

Suggested prompts	Sample student responses
Can someone summarize what we figured out from the investigation we did last class?	*Carbon dioxide from the air goes into the plant leaves.* *The plant leaves give off water to the air.*
What kinds of questions did this raise?	*How can water be both an input and an output?* *Are any other gases in the air around the plant leaves changing? We only measured* CO_2 *and water.* *In the M'Kenna case,* CO_2*, water, and also oxygen were involved, so maybe we should look at oxygen too?*
(If it doesn't arise from students, pose this question to the class:) Do you think that carbon dioxide and water are the only gases that are changing around the leaves?	*Oxygen or nitrogen could also be changing. We've heard that plants are involved in giving us oxygen to breathe. Maybe that's changing?*

Tell students, *We want to look at other gases, but I don't have any other sensors for us to measure those gases. I do have data and graphs from another group of students that did a very similar experiment, and they measured carbon dioxide, water, and oxygen, so we can figure out if other gases are changing.*

6. Analyze and interpret secondhand data

20 MIN

Materials: science notebook, *Another Plant Experiment*, *Data from Leaves in the Light*, tape

Situate the secondhand data set. Find *Another Plant Experiment* in the Student Procedure Guide and give students time to read through the experimental setup. Project **slide N** and discuss first in small groups and then as a whole class how this other group's data were produced in similar and different ways to the data the class collected in the previous session.*

Suggested prompt	Sample student responses
How were these data produced in similar and different ways to our data?	*Ways that are similar:* *They used sensors and a closed system.* *Ways that are different:* *They measured every second.* *Their sensors were hooked up to a computer.*

*** Supporting Students in Engaging in Analyzing and Interpreting Data**
This reference offers an opportunity to promote explicit student reflection about measurement. By reading about another group's experimental setup, students have the opportunity to discuss how this secondhand data set was produced and how the

Suggested prompt	Sample student responses
	They also used oxygen and light sensors. *They used dandelion leaves, and we used spinach leaves.* *Their closed system was a plastic tub.*

measurements were taken, as well as compare how these tools and methods for data collection compare to their own.

Tell students that because these students collected data every second, this led to a very large database. Tell students that you have an example of this table for reference as well as a simplified table and graphs made from data taken every second.

Have students make a prediction. Have students create a T-chart in their science notebooks (**slide O**) to record their predictions about how carbon dioxide, water vapor, and oxygen levels will change. Have students share some of their ideas. Most students will predict that carbon dioxide will go down quickly and water will go up, based on the experimental results from the previous class. Some students may think that oxygen will also change in the same amount of time.

Additional Guidance

Be sure that you don't distribute *Data from Leaves in the Light* until students have had the opportunity to make their predictions.

Introduce and prepare for the Identify and Interpret (I^2) sensemaking strategy. Present **slide P** to students and remind them how to use the I^2 strategy to analyze and interpret data. Tell them that this time, instead of recording their notes, they can discuss their "What I see" (WIS) and "What it means" (WIM) comments. Arrange students in groups of three. Hand out to each student a copy of the *Data from Leaves in the Light* handout and have students tape this into their science notebooks.

Have students make observations of the graph using "What I see" comments. As they review the data, prompt students to first discuss WIS comments in their small groups. After 4–5 minutes, bring students together to discuss their observations of the graphs (e.g., *What did you notice? Did anybody else notice something similar?*). Project **slide Q**. Focus the discussion initially on patterns of increasing and decreasing substances, but then broaden it to other observations students made, such as noise in the oxygen data. Record some of the WIS comments on a white board or in an online document in a table similar to the one below.

Interpret observations using "What it means" statements. Have students discuss "What it means" (WIM) for each of their WIS statements. These ideas 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 and then have several groups share some of their interpretations aloud. Probe deeper into a few of the interpretations, specifically about carbon dioxide and oxygen. Record some of the WIM comments on a white board or in an online document.

Example WIS and WIM comments that the class might come up with.*

*** Supporting Students in Engaging in Analyzing and Interpreting Data**
Encourage students to discuss larger patterns as well as what variation within these messy data means. They will see a lot of variation in the oxygen level data and may notice that light level also changes. Encourage students to think about how these data are produced and what might cause that variation. Also encourage students to consider how data may be correlated, though that doesn't necessarily imply causation (e.g., carbon dioxide levels are going down while oxygen levels are going up).

WIS	WIM
Carbon dioxide steadily decreases.	*Plants are taking in carbon dioxide.*
Water vapor steadily increases until it flattens out at 100 percent.	*Plants are releasing water vapor. Once enough is released, the level stays at 100 percent.*
Oxygen levels increase.	*Plants are releasing oxygen.*
Oxygen level data are noisy.	*Maybe the oxygen sensor is sensitive?*
Light stays constant.	*Light is not causing these changes because it remains constant.*
Light level fluctuates between 1,033 and 1,037 lux.	*Maybe the light sensor is sensitive?*

7. Consensus Discussion about Secondhand Data

15 MIN

Materials: science notebook, Progress Tracker, consensus model, chart paper, sticky notes or index cards, colored markers

Generate claims based on evidence. Project **slide R** and have students record a claim and one piece of evidence that they can bring to the Scientists Circle about inputs and outputs we can add to our model.*

Get into a Scientists Circle and lead a consensus discussion about what we should add to our models with certainty. Invite students to share their claims about what should be added to the model and cite the evidence that supports their claims. Ask students to argue from evidence for how what we figured out helps explain whether parts of food molecules are entering plants. As a class, come to a consensus for how to update the model to represent these ideas.

Key Ideas

Purpose of this discussion:

See what we can agree on regarding above the surface plant inputs and outputs.

Listen for these ideas:

- Carbon dioxide levels in the air around plant leaves decrease over time.
- Water levels in the air around plant leaves increase over time.
- Even though the data are noisy, oxygen levels in the air around plant leaves increase over time.
- The light level data has very small variations but basically remains constant over time.
- Since carbon dioxide levels decrease in this closed system, it is probably going into the plant leaves.
- Since water and oxygen levels increase in this closed system, these substances are being released from the plant leaves.

*** Strategies for This Consensus Discussion**
The purpose of having students record their claims is to give them time to think about their claims before they share their ideas with the class. You can have students bring their own claims to the Scientists Circle, or pass their claims to another student so they could share either their own ideas or another student's ideas with the class. This allows multiple voices and ideas to be shared during the discussion.

Suggested prompts	Sample student responses	Follow-up questions
What inputs from our candidates list that contain parts of food molecules are entering plants?	*Carbon dioxide because its levels went down in our experiment and the other kids' data.*	*Would anyone have put this point a different way?* *How should we represent this on our model?*
What else did we figure out from our data and the other kids' data?	*Water and oxygen are coming out of the leaves.*	*What is our evidence for this?* *How should we represent it on our model?*
What new questions do we have that might help us move forward?	*How do the gases get in there?* *How is carbon dioxide going in and oxygen going out?* *What's happening inside the system?*	*What other processes of living organisms involve the same gases?*

Tell students that, *This process of plants taking in water through the roots and some of that water evaporating from parts of it that are in the air such as its leaves and stems, is called transpiration.*

Additional Guidance

This idea of transpiration is not a critical idea for this unit and therefore you can decide whether to add it to the word wall.

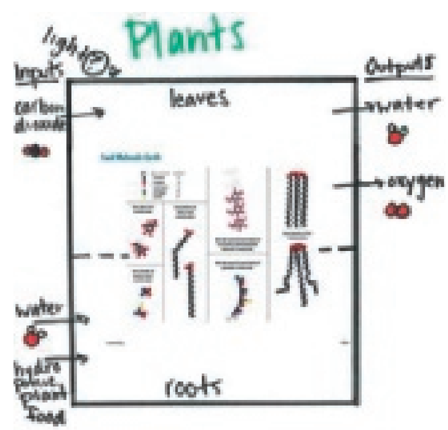
Update the consensus model. As the class comes to an agreement about what to add to the consensus model and how to represent it, make those additions. At this point, the following should be added to the model: carbon dioxide as an input and water and oxygen as outputs.*

*** Strategies for This Consensus Discussion**
It is important to use words that the class agrees on to capture the essential ideas outlined here, rather than using the exact wording in this teacher guide. It is recommended that you include a pictorial representation.

Remain in a Scientists Circle to update individual Progress Trackers. Slide S is provided for reference, but there is no need to project it.

Since you are in a Scientists Circle for this update of the tracker, you will want to draw out the format, headings, and lesson question for the 3-box Progress Tracker (shown below) on chart paper for students to reference. Have students draw the 3-box Progress Tracker directly in their science notebooks in the section set aside for Progress Trackers. Ask them to list the sources of evidence from this lesson and use their own words and pictures to describe what we figured out. This can be done individually or with a partner. Below is one possible representation of student Progress Tracker.

Question	Source of Evidence
Are any parts that make up food molecules going into the plant above the surface?	• CO_2 and water data from the investigation we did as a class • Another class's data on CO_2, water, oxygen, and light levels



What we figured out in words/pictures
• Carbon dioxide goes into plant leaves. Plants could be using it to make food molecules because it has C and O. • Water comes out of plant leaves. Plants don't take in water through their leaves. • Oxygen also comes out of plant leaves. Plants must be making oxygen somehow.

8. Next Steps

5 MIN

Materials: science notebook

Remain in a Scientists Circle and motivate students to wonder about what is happening within the system. If it hasn't arisen already, push students to wonder about what is happening inside the plant to make carbon dioxide levels decrease and oxygen and water levels increase and discuss next steps for investigation.

Suggested prompts	Sample student responses
Matter can't just disappear and appear. *How could there be less carbon dioxide and more oxygen?*	*Maybe something is happening inside the plant? We know plants make their own food, and these contain parts (atoms) that make up food molecules. Maybe it's some kind of chemical reaction with the food?*
What other systems have we seen that also change the amount of carbon dioxide and oxygen in the air around them? What in those systems caused that to happen?	*There was a connection between oxygen, carbon dioxide, and food in M'Kenna. It was related to what we were breathing in and out and how our bodies were using food as fuel . . . We breathe in oxygen and breathe out carbon dioxide when we are burning fuel to provide energy. This is a chemical reaction. But this trend seems like the opposite pattern in the gases.*
What does this mean? What could be going on with plants?	*Are plants breathing somehow like we are?*

Additional Guidance

If you did not do the Inside our Bodies Unit, you may need to use another way to elicit students' prior knowledge about what we breathe in and out. Students likely know we breathe in oxygen. You can help build students' understanding that we breathe out carbon dioxide by having students blow onto your carbon dioxide detector. If you did do the Inside our Bodies Unit, push students to share ideas about the chemical reactions happening here.

Generate next steps. Project **slide T** and focus the class on the questions, "Why are these gases moving in and out of plant leaves? How does that happen?" Before returning to their seats, ask students to record their ideas for how to investigate this question in their science notebooks.

ADDITIONAL LESSON 4 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

In *Comparing and Critiquing Arguments about Water in Plants* students are asked to provide suggestions for students in another class to help them build strong claims supported with evidence. This work contributes to **CCSS.ELA-LITERACY.WHST.6-8.1.B** as students are practicing the skills needed to craft a strong argument by supporting claims.

How are these gases getting into and out of leaves?

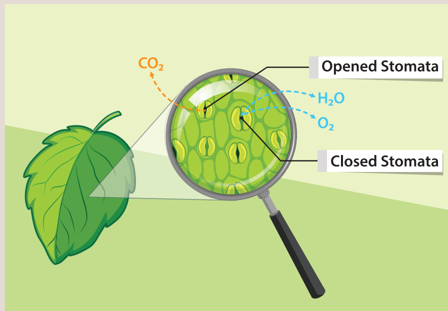
Previous Lesson

We used data we produced and secondhand data to figure out that above the surface, plant leaves are taking in carbon dioxide and releasing water and oxygen. We wondered how gases are getting into and out of the plant through its leaves.

This Lesson

Problematizing

1 DAY



We observe the surface of real leaves along with microscopic leaf images and a video. We see small openings on the leaf surface and discuss how these could allow plants to "breathe," by letting gases in and out. Inside the leaves, we see moving green circles inside repeating structures. We gather information from a reading that the repeating structures are plant cells, and the green circles, or chloroplasts, are moving in response to light. We discuss how light and chloroplasts fit in our plant model and review the other inputs and outputs. We discuss how a simulation could help us figure out what exactly is happening inside plant leaves.

Next Lesson

We will use a computer simulation to explore how water, carbon dioxide, light, and chloroplasts interact in a plant cell. We will investigate how changing the amount of one of these inputs affects the outputs of the plant cell and use the evidence collected to argue how water, carbon dioxide, light, and chloroplasts interact to produce oxygen and sugar molecules.

Building Toward NGSS

MS-LS1-6, MS-LS2-3, MS-PS1-3

What Students Will Do

Obtain information from scientific texts to describe how chloroplasts (microscopic leaf structures) respond to light (an external stimulus).

What Students Will Figure Out

- Leaves have small openings on the leaf surface that allow gases like carbon dioxide, oxygen, and water to enter and exit the leaf.
- Leaves are made of cells.
- Plant cells have chloroplasts in them that move in response to light.

Lesson 5 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	2 min	**NAVIGATION** Discuss ideas about how to investigate how gases get into and out of leaves.	A	Progress Tracker
2	7 min	**OBSERVE THE OUTSIDE AND INSIDE OF LEAVES** Observe spinach leaves with a magnifying lens and microscope images of different sections of leaves. Record observations about possible functions for each source.	B-D	*Leaf Observations*, *Microscopic Leaf Images*, tape, Spinach Leaf Observation Lab
3	8 min	**WATCH A VIDEO OF CHLOROPLASTS MOVING** Watch a video of a plant cell and record observations and ideas about possible functions. Discuss how the data sources help us understand how gases get into and out of leaves.	E-G	*Leaf Observations*, computer and projector to show Video of Elodea under a Microscope - Unit 7.4 Matter Cycling & Photosynthesis Lesson 5 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)
4	10 min	**READ Plant Cells** Read *Reading: Plant Cells* in pairs and answer questions comparing plant and animal cells. Investigate chloroplasts and light.	H	*Reading: Plant Cells*
5	15 min	**BUILDING UNDERSTANDINGS DISCUSSION ABOUT PLANT AND ANIMAL CELL STRUCTURES** Gather to discuss what the class figured out about plant cells and revise our model.	I-J	*Reading: Plant Cells*, Progress Tracker
6	3 min	**NAVIGATION** Brainstorm what to put in a simulation to figure out what's happening inside plant cells.	K	notecard, chart paper
				End of day 1

Lesson 5 • Materials List

	per student	per group	per class
Spinach Leaf Observation Lab materials	• magnifying lens (1 per student) • spinach leaves (at least 1 per student)		
Lesson materials **Student Procedure Guide** **Student Work Pages**	• Progress Tracker • science notebook • *Leaf Observations* • *Reading: Plant Cells* • notecard	• *Microscopic Leaf Images* • tape	• computer and projector to show Video of Elodea under a Microscope - Unit 7.4 Matter Cycling & Photosynthesis Lesson 5 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) • chart paper

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.

Have tape available for students to attach *Leaf Observations* to their science notebooks.

Make student copies of *Reading: Plant Cells* so that students can write on it and take notes while reading.

Check the video of chloroplasts moving inside the leaf to make sure it will play. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Day 1: Spinach Leaf Observation Lab

- **Group size:** Create groups of 2-3 students.
- **Setup:** Gather enough hand magnifiers so that each student has one and enough spinach leaves so that each student has at least one. Use spinach leaves that were left over from the same opened bag or box from Lesson 4.
- **Storage:** Keep spinach leaves in the refrigerator to prevent wilting throughout the day.

Lesson 5 • Where We Are Going and NOT Going

Where We Are Going

In previous lessons, students developed the idea that plants are taking in carbon dioxide and producing oxygen and water, but they are not yet sure how that is happening. In this lesson, they add to their understanding by exploring microscopic leaf structures that are key in a plant's ability to "breathe." During this lesson, students will read a text to see that chloroplasts react to light, an external stimulus in the system. By the end of this lesson, they will not yet understand why chloroplasts are important, only that they are a structure unique to plant cells. In Lesson 6, they will figure out that chloroplasts are where a chemical reaction between carbon dioxide and water occurs, producing oxygen and sugar when light energy is available. In Lesson 11, students figure out that both plant and animal cells have mitochondria, which is where cellular respiration takes place.

Along with earlier lessons, this lesson reinforces a key idea from NGSS Disciplinary Core Idea PS3.D that sunlight could be an important input for how plants produce complex food molecules (sugars). By the end of this lesson, students do not yet understand why sunlight is important. They will explore how light energy is used in plants in Lessons 6 and 7.

In previous units, students should have seen cells under the microscope and should be familiar with the idea that animals and humans are made of cells. Students can bring to this lesson the ideas that gases can enter into and move out of cells through permeable membranes (i.e., holes that let molecules through) and that chemical reactions take place in human cells.

Where We Are NOT Going

This lesson and the unit do not address *how* the structures of plants transport water and gases within plant systems, including how gases get from the surface of the leaf into cells, or how water moves from a plant's roots up to the leaves.

Students also do not need to know the name of the "little mouths" (stoma/stomata) or that stomata are on the underside of the leaf.

Mitochondria are mentioned and visualized in the images in the reading in this lesson, but students do not need to go any deeper with their understanding of them yet. Mitochondria and their function will be further explored in Lesson 11 when learning about how plant cells function and survive in the absence of light.

LEARNING PLAN FOR LESSON 5

1. Navigation

2 MIN

Materials: Progress Tracker

Review what we figured out and the ideas for next steps. Have students use their Progress Trackers to recall where the class left off. Present **slide A**.

Suggested prompts	Sample student responses
Using your Progress Tracker, what did we figure out last class?	*We figured out what happens when plant leaves interact with air. We saw that carbon dioxide was going into leaves and that oxygen and water were coming out. We also reasoned that water and plant food were going in through the roots.*
Let's take a moment to look back at our candidates for parts of food molecules. Do we have evidence now to support moving air over to our confirmed list of candidates?	*Yes! We saw that the amount of carbon dioxide in the air decreases over time which means that it must be going into the plant. And we saw that the amount of oxygen and water in the bag increased.*
Great! Can someone write that down on a sticky note and add it under the "air" sticky note, and move it on our candidates list?	*(Pick a student to do this.)*
So knowing that these gases seem to be going into and out of the leaves, what did that make us wonder?	*Like how are they actually going in and out of the leaves?*

Turn and talk with a partner about how gases might be moving in and out of a leaf. Have students discuss the question on **slide A** with a partner: "How do you think gases are moving into and out of leaves?"

Suggested prompts	Sample student responses
How do you think gases are moving into and out of leaves?	*Maybe there are little mouths? Maybe there are holes in the leaves?*
What proposals did we have for ways to investigate how gases were going into and out of leaves?	*Maybe there are little flaps or air pumps? We wanted to see what a leaf looks like up close.*

Additional Guidance

To help students recall what we have figured out thus far in the unit, they can use their Progress Tracker at the front of their science notebooks. Progress Trackers can be used to make a plan about where to go next or used as a reminder about what we wanted to figure out next. Since we dedicate time to filling in the Progress Tracker, it is a good idea to indicate its usefulness throughout the unit.

Say, *I wonder if we look really close at the surface of the leaves, maybe we would see some of the ideas you came up with. I have some magnifying lenses so we can look closely at some leaves. Let's see what we find!*

2. Observe the outside and inside of leaves. 7 MIN

Materials: Spinach Leaf Observation Lab, science notebook, *Leaf Observations*, *Microscopic Leaf Images*, tape

Prepare students to make observations of leaves. Show **slide B.** Hand out *Leaf Observations*, and have students tape it into their science notebooks to record their leaf observations. Have students write "Leaves under a magnifying lens" as a description of source A.

Say, *We saw spinach leaves produce carbon dioxide and water last time, so we know something is happening. Why don't we look at some spinach leaves up close?*

Make observations of leaf structure. Hand out magnifying lenses and spinach leaves. Have students work in small groups of two to three to make observations of leaf structures and record those observations.


Leaf Observations

Does the structure of the leaf provide any evidence for how carbon dioxide gets into a leaf, how oxygen gets out, or what is happening inside the leaf?

Data source	Observations of the leaf structure	Ideas about function
Source A:		
Source B:		
Source C:		
Source D:		
Source E:		

25

Additional Guidance

Students will only be able to see hairs and veins with their magnifying lenses, which will *not* help them answer the question about how gases are getting into and out of leaves. Observations of these veins do provide evidence for students to reason how matter moves around once it's inside a plant, like how water gets from the roots to the leaves. While understanding plant structures is not a primary focus of the unit, conversations about plant structures may arise.

Discuss spinach leaf observations. Lead a *brief* discussion of the structures students observed, the functions that students propose for the structures, and the limitations of magnifying lenses to answer the question about how gases get into and out of leaves.

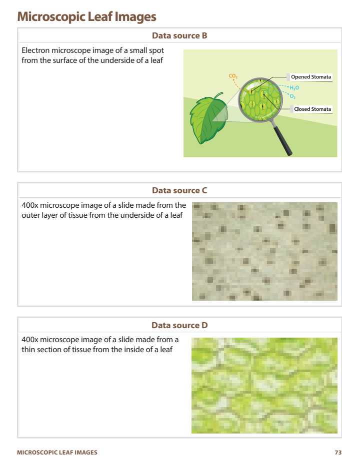
Suggested prompts	Sample student responses
What did you observe about the surface of the leaves?	*They have veins.* *They have some hairs.*
What do those structures remind you of?	*The veins are like veins in our bodies. Maybe they move stuff around like our blood moves gases around?* *Plants have hairs on the surface, and we also have hair on our skin.*
Does this help us answer our question about how gases are getting into and out of leaves? What else could help us?	*It's hard to see, so not really. We need to zoom in closer. We need close-up pictures or something like that.*

Tell the class, *Okay, I have four more data sources that are images and a video of some other leaves. Some of the sources are taken of the surface of the leaf and others are taken of the inside of the leaf.*

* Supporting Students in Developing and Using Structure and Function

This is the first time in this unit that students work with the concept of structure and function, but students previously worked with this idea in the Inside our Bodies Unit. Remind students of when they considered how the shape of M'Kenna's small intestine caused a change in function. Looking at leaf structures presents an opportunity for students to infer their function based on observations of their microscopic structures.

Introduce images of the surface and inside of a leaf. Present **slide C** and tell students that these are images showing the surface of a leaf. Present **slide D** and tell students this image shows the inside of a leaf. Have small groups of students find *Microscopic Leaf Images* in the Student Procedure Guide, which has the same three leaf images as the slides. Give students time to work in small groups to observe these images and make sense of their observations as they examine data sources B–D. Have students write a description of each source in addition to recording observations about structure and ideas about function, on *Leaf Observations*. Some ideas to listen for include the following.*



Observations of structure	Ideas about function
There is an oval with an opening in the middle that is shaped like a mouth.	*Breathes gases in and lets gases in and out?*
There are hexagonal shapes across the entire image.	*Maybe these are cells, like the animal cells we've seen before, and maybe they do functions similar to animal cells?*
The hexagonal shapes are filled with little green circles.	*Maybe this is what makes plants green?*

3. Watch a video of chloroplasts moving.

8 MIN

Materials: science notebook, *Leaf Observations*, computer and projector to show Video of Elodea under a Microscope - Unit 7.4 Matter Cycling & Photosynthesis Lesson 5. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Show the video of the inside of a leaf. Tell students you have one more data source, a video of the inside of a living leaf up close. Present **slide E** and show students this video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**). It's not necessary to play the entire video before having students record data. Give students a few minutes to work in small groups to make sense of their observations as they complete the final row of their table (source E).

Hold a whole-class discussion about how our data sources help us think about how gases get in and out of leaves. Show **slide F.** Draw out the idea that the holes on the leaf surface let gases in and out of the leaves.* Push students to wonder about cells and the green circles, but don't provide any other information about chloroplasts yet.

Key Ideas

Purpose of this discussion: The purpose is to get us thinking about plant cells as living things that have structures with functions. We also want to motivate a comparison between what we learned about animal cells in the Inside Our Bodies Unit and what we're seeing in plant cells. This discussion can be brief.

Listen for these ideas:

- The holes could let gases go in and out.
- These look like cells too.

*** Attending to Equity**
Knowing the name "stoma" (singular) or "stomata" (plural) is not necessary and is outside the Disciplinary Core Ideas for middle school. Having students generate names for these structures that make sense to them, such as "tiny mouths" or "holes," can support language development. If it helps the class to be able to talk about this structure more easily, you can introduce the word scientists use for these structures, stoma or stomata, *after* students have generated names that make sense to them. If your students want, the class could add "stomata" or "stoma" to the class word wall after the discussion.

- The green circles are moving but we don't know why.
- Maybe the cell is doing something similar to what animal cells do.

Suggested prompts	Sample student responses	Follow-up questions
What structures did you notice on the surface of the leaves? (Sources B and C)	*It looks like there is an oval with an opening in the middle. It's shaped like a mouth.* *There are many of these ovals when you zoom in to 400×.*	*What do people think about what _____ said?*
What do these structures remind you of?	*The holes look like little mouths.*	*Can you say more about that?*
Do you have ideas about their function?	*Maybe the holes open and close like a mouth so gases could go in and out?*	*Why might that be important?*
Were there any other structures you noticed inside the leaves? (Sources D and E)	*Inside the plant looks sort of similar to cells we've seen in animals.* *There are hexagonal shapes across the entire image filled with little green circles.* *The green circles are moving around in the video.*	*Does anyone else have any additional observations of structures?*
What ideas do you have about the function of these structures?	*Maybe the cells do similar things that animal cells do?*	*Can anyone tell me more about this idea? What might animal cells do that is similar to plant cells?*
What evidence do your observations provide for how gases could get in and out of the leaves?	*Gases can go in and out through the holes.*	*Can you remind me how we know gases could be going in and out the holes? What evidence do we have for this?*

Say, *What else do you think is going on here? Let's take a minute to jot down any new questions we have in our science notebooks. Be prepared to share any new questions you may have.*

Stop and Jot new questions. Project **slide G** and have students record in their science notebooks questions they have now. Then have the class share some of those questions.

Suggested prompt	Sample student responses
What new questions do you have?	*Are plants made of cells also?* *What are those green circles and why are they moving?*

4. Read Plant Cells.

10 MIN

Materials: *Reading: Plant Cells*, science notebook

Introduce the reading. Tell students that you have a short reading with reflection prompts that will help answer some of their questions about the structures inside the leaf, particularly, their questions about the green circles.

Read *Plant Cells* and answer questions in pairs. Project **slide H** and have students use *Reading: Plant Cells* to make notes on. Students should work with a partner to read the reference and discuss the questions as they go. Have students record notes about their responses in their science notebooks. Tell students that if they are not sure about the answers to a question, they can record their initial ideas and/or questions that arise.

Additional Guidance

Students will have seen the animal cell image previously in the Inside our Bodies Unit and may recognize it as human intestinal cells. You can use this to leverage the fact that similar to animal cells, plant cells are also living things that have inputs and outputs to their systems. *Plant Cells* briefly mentions mitochondria and their function. Students may bring this up, but it is not necessary to dig deeper into mitochondria at this point in time. We will figure out more about mitochondria and their role in plant and animal cells in Lesson 11.

The plant and animal cells in the photos are taken with different types of microscopes. This is not important for student understanding, but it may need to be addressed. The human intestinal cells have been stained for imaging causing them to appear pink and purple. The plant cells have not been stained, but the chloroplasts still show up as green under a light microscope.

Alternate Activity

Instead of writing in their science notebooks, you can have partners jot down ideas on a small whiteboard. This is a good way to keep the activity focused but not let students get bogged down on answering every question fully in writing. Having notes in their science notebooks or on a whiteboard will give students something to refer to as they share out during the whole-class discussion that follows.

5. Building Understandings Discussion about Plant and Animal Cell Structure

15 MIN

Materials: *Reading: Plant Cells*, science notebook, Progress Tracker

Gather in a Scientists Circle for a Building Understandings Discussion.* Show **slide I.** Have students bring their science notebooks with their notes (or whiteboards, if you used them) and *Reading: Plant Cells* to the circle. Facilitate a discussion in which students discuss what they learned in the reading, including the similarities and differences between plant and animal cells, about how plants are living things, and talk about the role of light.

*** Strategies for This Building Understandings Discussion**
A Building Understandings Discussion is a useful kind of discussion following an

Key Ideas

Purpose of discussion: Identify similarities and differences between plant and animal cells based on evidence from *Reading: Plant Cells*. This leads us to wonder why plant cells have chloroplasts and what chloroplasts do.

Listen for these ideas:

- Plant cells have a hexagonal shape.
- Animal cells are more round.
- Plant and animal cells are similar because they both have boundaries or outlines.
- The plant cells have green circles in them. These circles are chloroplasts.
- Animal cells don't have chloroplasts.
- Parts of plant cells move, so maybe they're alive.
- Plants must be using sunlight somehow.

Suggested prompts	Sample student responses
What do we know about animal cells?	*All animals are made of tiny cells.* *Stuff can get in and out of the cell boundary.* *Chemical reactions happen there in humans.*
How are plant and animal cells similar and different?	*They are both repeating structures.* *They both have boundaries.* *They are different colors (from the images).* *Plant cells are hexagonal or rectangular in their shape, and animal cells are more round or oval.* *Plant cells have a lot of green circles called chloroplasts.**
What does it mean if plants have moving things in their cells?	*If plants are moving, or have moving parts in their cells, then I think that means they are alive.*
We know plants need sunlight. How do plants use sunlight?	*We're not sure. Maybe it has something to do with those chloroplasts because plants are the only ones that have them?*
What new questions do you have?	*How do plants use sunlight?* *Are chloroplasts using sunlight, and, if so, how are they using it?* *Do plant and animal cells have the same structures? Do they do the same things?*

investigation because the purpose is to focus students on drawing conclusions based on evidence. Your role during the discussion is to invite students to share conclusions and claims and to push them to support their conclusions and claims with evidence. Students can disagree with each other and the class does not need to reach consensus on all ideas shared, but rather areas of disagreement can motivate future investigations. Helpful prompts during these kind of discussions include:

- What can we conclude?
- How did you arrive at that conclusion?
- What's your evidence?
- Does any group have evidence to support Group A's claim?
- What data do we have that challenges Group B's claim?

*** Attending to Equity**

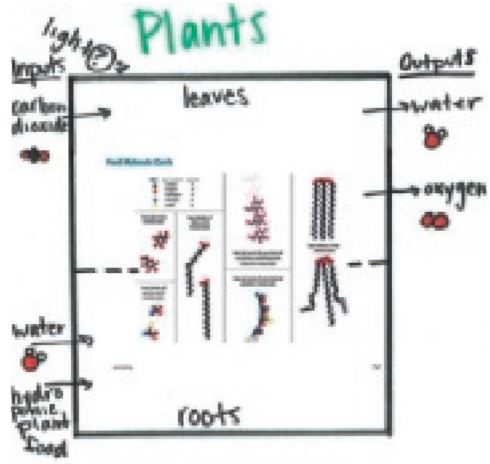
When new scientific words, like "chloroplast," are introduced, it can be helpful for emergent multilingual students to see a reference to those words added to a word wall. Add these words to the word wall as they emerge in the discussion, rather than before. This would be a good time to add *chloroplasts* to the word wall. In Lesson 6 we will figure out that chloroplasts are using light for photosynthesis, so refrain from adding that chloroplasts are

Revisit our class model and decide whether we want to add or update it with anything we've learned.

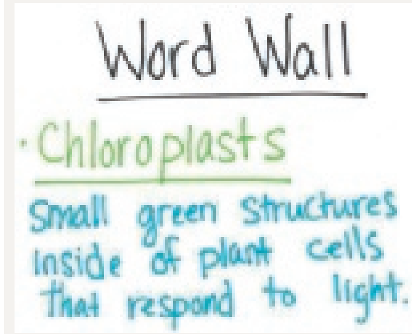
Say, *Let's see if we have some agreement about how gases get into and out of leaves and what's going on inside of plant leaves.* Show **slide J.**

Ask students to propose ideas to add or revise the model. Ask students to cite evidence to support their ideas. Prompt other students to listen to the idea when it's shared and to ask clarifying questions or suggest alternatives.

Ask students to also share ideas they figured out about what's happening inside of the leaf.



doing photosynthesis at this point in the unit. One representation is shown below:



Suggested prompts	Sample student responses
Are there any new pieces that we want to add to our consensus model?	*We should add chloroplasts.* *We should add little mouths (stomata).*
How could we represent this on our model?	*We could draw green circles in the plant for the chloroplasts.* *We should draw little holes or mouths on the edge of the box and have our inputs and outputs going in and out of them.*
What inputs and outputs have we figured out some things about but still might need more evidence?	*We still think light is important and somehow it is used by chloroplasts.* *We know that something is happening (a chemical reaction?) inside the plant cell to change the inputs into outputs.* *We want to know more about what the chloroplast are doing.*

Key Ideas

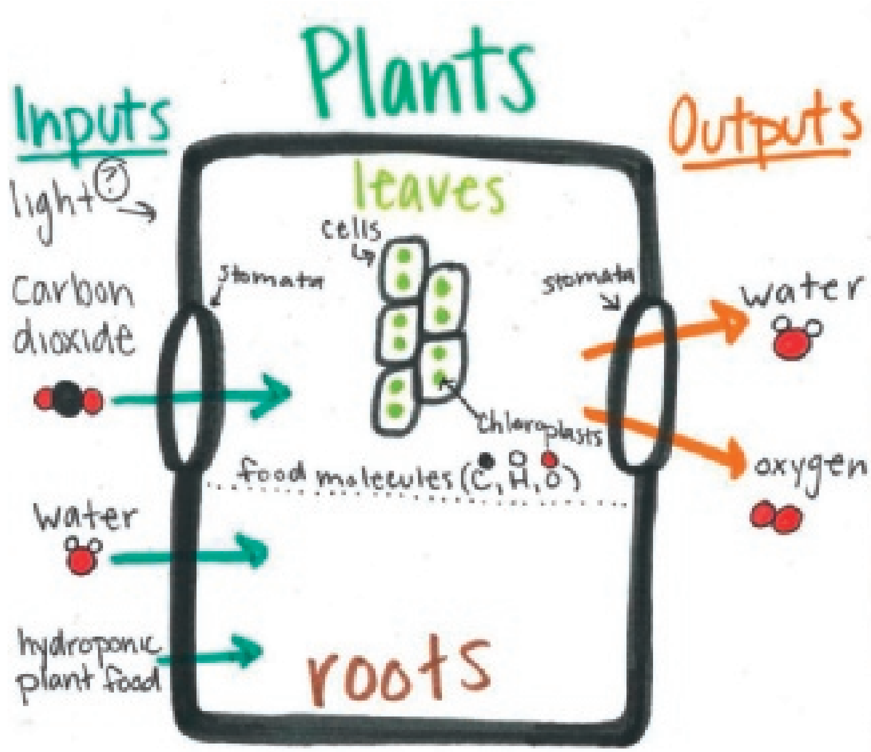
Purpose of discussion: The purpose of this discussion is to have students begin to see the uniqueness and importance of plant cell structures, specifically chloroplasts. If possible, we want to add chloroplasts to our class model and potentially link it to sunlight. Adding stoma/stomata is fine, but less important than chloroplasts.

Listen for these ideas:

- Chloroplasts must be doing something with the sunlight.
- If the chloroplasts are moving to optimize sunlight then the light must be really important. The plant must be using light somehow.

- Could there be a chemical reaction happening inside the plant cell to change the inputs to the outputs?
- It's really tricky to keep track of all these inputs and outputs and everything is so small.

Review the inputs and outputs of the system.



Remain in a Scientists Circle and remind students that we're trying to figure out where food molecules in plants come from and we think plants must be making them somehow.

Ask students, *How is it possible that carbon dioxide could be going into the plant and oxygen and water is coming out? What exactly is happening* ***inside*** *the plant cell?* Draw out student ideas that it's possible that a chemical reaction could be happening.

Suggested prompt	Sample student responses	Follow-up question
What exactly is happening ***inside*** *the plant cell?*	*We don't know!* *We can't see what is happening!* *We know the parts of food go in and whole food molecules are inside plants so something must be happening in between!*	*So, let me see if I've got what your saying. Are you saying that the inputs to the plant are different than the outputs so there's some kind of reaction occurring?*

Suggested prompts	Sample student responses	Follow-up questions
How can we figure out if something is happening to those inputs inside the plant?	*We could find more videos or images.* *We could do an experiment.* *We need to zoom in!*	*Can you say more about what you would want to see in the videos or do in the experiment?*
What structures inside the plant would you zoom in on?	*We saw the chloroplasts moving and we know they respond to light. We want to know what's going on inside of them.*	*So I hear you saying that if we zoom in on the inside of the chloroplasts we might see something happening to the inputs, is that right?*
What do you think we would see if we zoomed in on the chloroplast?	*Maybe the inside structures we saw in the plant cells are using the parts to make the food molecules.* *Maybe the little mouths or the chloroplasts are doing something.*	*Can anyone build off that idea and explain what we think we might see happening inside the structures in plant cells?*

Additional Guidance

In the Inside our Bodies Unit when students saw that people breathe in oxygen and breathe out carbon dioxide, they figured out that this took place through a chemical reaction. Depending on what prior instruction students have had, you can and should draw the ideas out that we just saw that plants take in carbon dioxide and release oxygen and that the carbon could have gone somewhere through a chemical reaction.

Assessment Opportunity

This is a great opportunity for students to self assess on their engagement in classroom discussions using *Self-Assessment for Classroom Discussions*. This discussion rubric can be used anytime after a discussion to help students reflect on their participation in the class that day.

6. Navigation

3 MIN

Materials: notecard, chart paper

Discuss what to include in a simulation of a plant cell. Project **slide K**. Explain that one tool scientists use to understand what's happening in the world is a simulation.

Say, *Scientists often build computer simulations to help investigate and visualize outcomes in systems that have parts (cell structures or molecules) in them that are too small to see. Computer simulations are programmed to have the objects and interactions that the user wants or needs. Think about what you would want to see included in such a computer simulation that would help you better understand what's going on inside of a plant cell. On a notecard, record what inputs you would want to have in a computer simulation.*

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 what we want to accomplish with the simulation. Have pairs of students brainstorm what they would want to include in a simulation to understand how all these things are interacting inside a plant cell.

Assessment Opportunity

Read the exit tickets before you begin Lesson 6.

Use this exit ticket to determine if students are understanding which inputs, outputs, and pieces of the model are important to the plant system.

Look for students to show:

- *Inputs: carbon dioxide, water, light?*
- *Outputs: oxygen, water*
- *Structures: the plant, the plant cell, chloroplasts*

If your students struggle with identifying important components, have them revisit the Progress Tracker and the class consensus model.

Additional Guidance

It is important that students don't perceive simulations as exact illustrations of what is going on, but rather as tools constructed by people to visualize particular aspects of a phenomenon. The process of having students brainstorm what they would want to put in a simulation can help them come to see simulations as tools to think with. Talking about the authors of the unit helps students consider that someone created the simulation they are going to work with and that students may have made different decisions about what to include if they had been the simulation's authors.

Collect *Microscopic Leaf Images* and *Plant Cells* and/or the Student Procedure Guide to reuse with other classes.

ADDITIONAL LESSON 5 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

In *Reading: Plant Cells* students practice **CCSS.ELA-LITERACY.RST.6-8.1**. Students first read and understand the text, then use evidence from the text to answer questions about patterns of movement within plant cells. Students combine the information from this reading with prior knowledge to make predictions about the role of light in plant cells.

LESSON 6

How are all these things interacting together in this part of the plant?

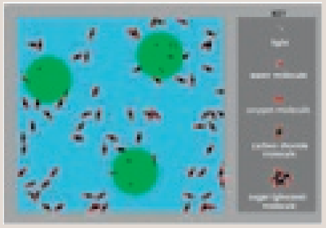
Previous Lesson

We observed the surface and inside of leaves and saw small openings on the surface that could be how gases get into and out of leaves. We discovered green chloroplasts inside plant cells that move in response to light. We kept light on our model and discussed how a simulation could help us understand what is happening inside leaves.

This Lesson

Investigation

2 DAYS



We use a computer simulation to explore how water, carbon dioxide, light, and chloroplasts interact in a plant cell. We then use the simulation to carry out an investigation into how changing the amount of one of these inputs affects the outputs of the plant cell. Then we use the evidence we collect to argue that decreasing the amount of water, carbon dioxide, light, and chloroplasts decreases the amount of oxygen and sugar produced by the plant cell. We also argue that removing any one of these inputs prevents the plant from producing oxygen or sugar.

Next Lesson

We will examine food labels to figure out how much energy the different inputs and outputs of the plant system provide for the body. Since water and carbon (inputs for the plant) do not have energy in the form of calories but glucose (an output) from the plant does, we will argue from evidence that sunlight must be the source of the energy for plants to rearrange the Cs, Hs, and Os.

Building Toward NGSS

MS-LS1-6, MS-LS2-3, MS-PS1-3

What Students Will Do

Plan and carry out an investigation to support a claim about how the inputs to a plant are related to what the plant cell can produce from chemical reactions in the chloroplasts (outputs).

Engage in argument from evidence about what plants need to make food molecules using evidence from the computer simulation and scientific reasoning to support an explanation for why decreasing the amount of water, carbon dioxide, light, or chloroplasts (cause) in a plant cell decreases the amount of sugar and oxygen it produces (effect).

What Students Will Figure Out

- Water and carbon dioxide molecules, along with light, interact in chloroplasts in plant cells, where they are used to make oxygen and sugar molecules. Each of these inputs is needed to produce these outputs.

- In this process, molecules of water and carbon dioxide are broken apart and the atoms that make them up (carbon, hydrogen, and oxygen) are rearranged to form new substances.
- As more inputs are provided to the plant cell, the more oxygen and sugar are produced.

Lesson 6 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Review what we wanted to see put in a simulation to figure out what's happening inside plants.	A	
2	7 min	**ORIENT STUDENTS TO THE SIMULATION** Orient students to the interface for the simulation and have them evaluate which elements it appears to include that they specified would be useful to include in a simulation.	B-G	computer with access to a browser, Link for simulation: Chloroplasts and Food (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)
3	7 min	**CONDUCT INVESTIGATION A** Have students explore the simulation using the procedures for investigation A in student reference *Simulation Procedures*.	H	*Simulation Procedures*, a computer with a browser and internet access to run the simulation
4	10 min	**MAKE SENSE OF INVESTIGATION A**	I-J	*Simulation Procedures*, chart paper, colored markers, computer with a browser and internet access to run the simulation
5	15 min	**PLAN INVESTIGATION B** Have groups plan investigation B to explore how changing the inputs affects the outputs.	K	Planning and Carrying out Investigations, *Simulation Procedures*
				End of day 1
6	15 min	**CONDUCT INVESTIGATION B** Students conduct their team investigations of the simulation and share their results.	L	Planning and Carrying out Investigations, *Simulation Procedures*, a computer with a browser and internet access to run the simulation
7	10 min	**SHARE OUR CLAIMS WITH OUR GROUPS** Share claims with their group members, and connect the claims to argue for what is needed for plants to produce oxygen and sugar.	M–N	Planning and Carrying out Investigations, clock (to record time)

8	15 min	**CONSENSUS DISCUSSION ABOUT INTERACTIONS** Gather students in a Scientists Circle to share their claims and update their Progress Trackers.	O	Progress Tracker, Planning and Carrying out Investigations, colored markers, chart paper, tape
9	5 min	**NAVIGATION** Brainstorm why plants need sunlight if all the atoms that are in the outputs of photosynthesis come from water and carbon dioxide. Assign home learning to evaluate an alternative representation of photosynthesis.		Optional Making Sense of the Computer Simulation
				End of day 2
		SCIENCE LITERACY ROUTINE Upon completion of Lesson 6, students are ready to read Student Reader Collection 2 and then respond to the writing exercise.		Student Reader Collection 2: *Plants and Chemistry*

Lesson 6 • Materials List

	per student	per group	per class
Lesson materials Student Procedure Guide Student Work Pages	• science notebook • *Simulation Procedures* • a computer with a browser and internet access to run the simulation • Planning and Carrying out Investigations • Progress Tracker • colored markers • Optional Making Sense of the Computer Simulation	• Link for simulation: Chloroplasts and Food (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)	• chart paper • colored markers • computer with a browser and internet access to run the simulation • clock (to record time) • tape

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.

Check the simulation to make sure it works and run through the procedures for student investigations A and B for yourself. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) Student groups will need access to a computer or tablet for the simulation.

Online Resources

Lesson 6 • Where We Are Going and NOT Going

Where We Are Going

This lesson helps students uncover how plants produce complex food molecules (sugars). By the end of this lesson, students will understand that water and carbon dioxide molecules, plus light, interact in/at the chloroplasts in plant cells, where they are used to make oxygen and sugar molecules. And the simulation will help them determine that plant cells need all these inputs to produce these outputs.

They will get evidence that, in this process, energy transformations occur as light is absorbed and molecules of water and carbon dioxide are broken apart and the atoms that make them up (carbon, hydrogen, and oxygen) are rearranged to form new substances (oxygen and sugar).

This lesson develops a key idea from NGSS Disciplinary Core Idea PS3.D that sunlight is an important input for how plants produce complex food molecules (sugars). Students may not yet understand what light provides the chloroplasts in this process, though they will likely argue it isn't a molecule, like water, carbon dioxide, sugar, or oxygen. They will explore what light provides (energy) in greater depth in Lesson 7.

The simulation represents the outputs of photosynthesis (glucose) as the final step in a multistep series of chemical reactions occurring in the chloroplasts.

In previous units, students should have seen cells under the microscope and should be familiar with the idea that animals and humans are made of cells. Students will have ideas that gases can enter into and out of cells through permeable membranes and that chemical reactions take place in human cells.

Some students may have heard of photosynthesis before, but may not have thought of it as a type of chemical reaction occurring in a specialized structure of plant cells.

Students may think that energy is being created in the chloroplasts when they see one charging up, rather than thinking of it as energy being converted from light energy to some sort of potential energy. In Lesson 7, students will determine that carbon dioxide and water do not provide us with energy and that the energy that glucose can provide when it reacts with oxygen in cellular respiration can be traced back to the light that was absorbed in this reaction.

Where We Are NOT Going

This lesson and the unit do not address *how* the structures of plants transport water and gases within plant systems, including how gases get from the surface of the leaf into cells or how water moves from the plant's roots up to the leaves.

The multistep process shown in the simulation represents a series of more complex substeps in photosynthesis, including the light reactions and the Calvin cycle. Students do not need to know any of the processes or substeps shown going on in the chloroplasts, as these are beyond the scope of the disciplinary core ideas for this grade band. The simulation shows something that looks like electrical energy and white dots within the chloroplasts getting built up before each new carbon dioxide molecule is disassembled. This represents some of the electrical potential that is built up as hydrogen ions are removed from water in the light reactions and ATP is produced. These light reactions produce oxygen gas before glucose is fully formed. Gradual rearrangement of carbon dioxide molecules is shown occurring before a fully formed glucose molecule is produced. This represents some of the gradual rearrangement of carbon atoms from carbon dioxide that occurs in the Calvin cycle, though the intermediate arrangements of those carbon atoms are different.

The simulation does not show what is happening in mitochondria in plant cells. Students will figure out the role of mitochondria in plant and animal cells in later lessons.

LEARNING PLAN FOR LESSON 6

1. Navigation 5 MIN

Materials: science notebook

Review what some of our ideas for next steps that we generated in the previous lesson.

Remind students, *We've been trying to figure out where food molecules come from that are in plants. We think plants must be making them from parts of substances that they take in. We decided that one tool we can use to figure out how all the parts of the system are interacting is a simulation. And we identified some of the things that might be interacting in the system.*

Present **slide A**.

Share out ideas for what to include in a simulation. Have the class share some of the ideas that they would want to see included in a simulation to understand what might be going on in the plant.

Additional Guidance

It's important for students to articulate what to include in the simulation so they can genuinely interact with it and use it to plan an investigation of their own later in this lesson, rather than just experiencing it more like a computer game.

Suggested prompts	Sample student responses
What were some of the inputs and outputs of the plant system we wanted to represent in that simulation?	*carbon dioxide* *water* *oxygen* *Light, maybe?*
What were some of the structures of the plant we wanted to represent?	*Maybe the plant itself?* *Maybe a plant cell or chloroplasts?*

Tell students, *I have a simulation that may have some of the components you mentioned now and in your exit tickets. It may fall short of everything we are looking for. Either way, now that we have specified what it is we think such a simulation should include, we will be in a better position to evaluate and critique whether that simulation is useful for our investigations.*

2. Orient students to simulation. 7 MIN

Materials: computer with access to a browser, link for simulation: Chloroplasts and Food (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Orient students to some of the interface controls in the simulation. Show **slide B**. Direct students' attention to the two images on the screen, showing them that the simulation view shown on the right represents some of the inner parts of the virtual plant cell shown on the left.

Have students record this question in their science notebooks: "How are all these things interacting together in this part of the plant?"

Show slide C. Read the text on that slide to students. Say, *The simulation gives you a control panel to adjust the inputs and structures in the virtual plant cell. Each slider controls a different variable. For example, the first slider controls the number of chloroplasts that are in the virtual cell.*

Describe what each of the remaining sliders controls:

- The second slider controls the amount of carbon dioxide in the system initially (like we did by putting a bag around the leaves of the plant).
- The third slider controls the water flow through the leaf.
- The fourth slider controls the amount or intensity of light that reaches the plant cell.

Evaluate the inputs. Show **slide D.** Ask students, *Which, if any, of these inputs were ones we also wanted to see included in the simulation?*

Suggested prompt	Sample student response
Were any of these inputs ones we also wanted to see included in the simulation?	*water, carbon dioxide, and light*

Orient students to additional interface controls and information available in the simulation. Show **slide E**. Read the text on that slide to students. Say, *The sliders that control the number of inputs for the simulation are only applied after you click on setup/reset. If you don't click this before clicking on go/pause, nothing will happen.*

Show **slide F**.

Say, *When you load the simulation, you will also see monitors and a graph to help you keep track of inputs and outputs to the virtual cell, and there will be a key that describes the things that are interacting in the model, off to the right.*

Emphasize that in the first investigation, they will **not** be changing any of the values of the sliders, and that they should keep them unaltered so that everyone can compare the outcomes from the same set of default settings.

Say, *For the first time we are all running the simulations, you should notice that the timeframe for how long the simulation will run, representing how long the chloroplast is receiving the inputs, is set at 2000. Also, the number of chloroplasts is set as is the amount of carbon dioxide, waterflow, and light. Do not change any of these sliders for the first run(s) of the simulation. We want to be able to compare our results at first. Later in the lesson, you will have the opportunity to plan an investigation around changing the inputs to find out how that affects the results.*

Ask, *Why might it help us to all try the simulation with the same variables to begin? How might this help us to make sense of the simulation as we are evaluating it?*

Suggested prompt	Sample student response
Why might it help us to all try the simulation with the same variables to begin? How might this help us to make sense of the simulation as we are evaluating it?	*If we all use the same variables at first, we should get similar results. This will help us decide if this simulation will help us figure out what is going on inside the plant cell for food molecules to be made.*

Examine the elements in the key of the simulation. Show **slide G**. Give students time to examine the elements of the simulation shown in the key so that they will be better able to watch for the interactions of these elements when they run the simulation. Ask, *Which, if any, of these inputs were ones we wanted to see included in the simulation?*

Additional Guidance

Before running the simulation, the purpose of this brief whole-class discussion is to ensure students are making sense of the simulation and they know what all the variables are that should be inputs. If students are mentioning variables such as oxygen or sugar, then press back to ask about what evidence we have so far of inputs we know are going into the plant. Do we have evidence a plant takes in sugar? Do we have evidence a plant takes in oxygen?

3. Conduct Investigation A.

7 MIN

Materials: science notebook, *Simulation Procedures*, a computer with a browser and internet access to run the simulation

Pass out a copy of student reference *Simulation Procedures* to each student. Show **slide H**. This slide shows the procedural steps that are also on the student reference handout. The link for the simulation is included on the slide if needed, but it will most likely be easier for students to read the link off the reference handout.*

Tell students to follow the procedure for investigation A, *without* adjusting any of the sliders in the simulation (use the default ones that the simulation has when it is loaded). Then have them begin the investigation and record their observations from this in their notebooks.

*** Supporting Students in Engaging in Planning and Carrying Out Investigations**
While using this simulation to investigate what is happening inside a plant cell for food molecules to be produced, students will be working with different amounts and types of inputs. These will be referred to as different types of variables. Similar to what they did in Lesson 2, during investigation B of this lesson, students will have the opportunity to decide which variable they are changing and which variables they are keeping the same. You may need to take a

few minutes to remind students what the terms independent and dependent variable mean before they conduct investigation B with their small group.

4. Make sense of Investigation A.

10 MIN

Materials: *Simulation Procedures*, chart paper, colored markers, computer with a browser and internet access to run the simulation

Show **slide I**. Ask students to summarize what there was in the plant cell at the start. There should be a large amount of agreement, based on the sliders that were introduced before they ran the simulation; then move on to what was there at the end. There should be agreement around there being new molecules that weren't there before (oxygen and sugar). Students may also say that there was less water or less carbon dioxide than before.

Ask students how they know that there was less or more of something in the simulation, and whether they found any ways to quickly get a count of the total number of things in the simulation. Students should say that you can look at the monitors (or graph) in the simulation.

Show where these monitors and the graph are located in the simulation to remind all students that they can get a count of some types of molecules by reading the monitors or by letting their mouse cursor hover over a particular point on the graph.*

Facilitate an Initial Ideas Discussion about the interactions in the simulation. The details of the interactions aren't critical to record, as they are beyond the scope of the disciplinary core ideas at this grade band, but some examples of the sorts of things that students might suggest are provided below. Make sure to honor all the interesting things students might have seen happening there, as they are likely to raise new questions from these noticings that prime them for future investigations to pursue in high school. End with an Initial Ideas Discussion to summarize the activity.

Key Ideas

Purpose of this discussion: Facilitate a discussion with students to summarize what was figured out from the simulation. They should then argue that the result of this chemical reaction is glucose molecules are made.

Listen for these ideas:

- The atoms that make up the things the plant takes in (inputs) such as carbon dioxide and water go through a chemical reaction in the chloroplasts when light is shined on the plant.
- Oxygen and glucose molecules are produced (outputs) as a result of that chemical reaction.

*** Attending to Equity**
As a strategy for differentiation, encourage students to use the graph produced by the simulation to verbally explain the relationships they see occurring between the amounts and types of inputs they start with and the outputs they end up with. Mathematically, though, the relationship between any input and any output are piecewise functions as each input serves at one point as a limiting factor in the system, and therefore explaining a quantitative relationship between inputs and outputs is beyond grade band. But analyzing and verbalizing how the graph is changing and how one line decreases while the other increases based on inputs and outputs is another way students can share their findings.

Add these ideas to a poster, similar to the table on **slide I**, to refer to again at the end of this lesson. A sample poster is below:

What was in the plant cell at the start? **(Inputs)**	**Interactions** <--- Between these ---> and the chloroplasts	What was in the plant cell at the end? **(Outputs)**
• Water molecules • Carbon dioxide molecules • Light (or light rays)	• Light appears to be absorbed by the chloroplasts. • Water molecules disappear and oxygen molecules appear when some white dots (maybe hydrogen atoms) are trapped in what looks like electricity. • Atoms from water and carbon dioxide are captured, reassembled, and chained together until a whole sugar molecule is made.	• Oxygen molecules • Sugar (glucose) molecules

Emphasize that this series of chemical reactions is known as photosynthesis.

Tell students, *The inputs and outputs of this process are due to a series of chemical reactions known as* ***photosynthesis****. We saw in this process how atoms from some of the molecules—water and carbon dioxide that are inputs—are used to produce new molecules that weren't there before as outputs—namely, sugar (glucose) and oxygen molecules. We also saw how atoms are rearranged in this process, which occurs in chloroplasts when light is also an input.*

Additional Guidance

In the 7.3 unit: *How do things inside our body work together to make us feel the way we do? (Inside our Bodies)*, students figured out that our body takes in food and oxygen to use for energy, growth, and development. The food we eat goes through multiple chemical reactions inside our body until it is broken down into small enough pieces that our body can use for growth and development. An output of this process is our waste. Students also learned that we breathe in oxygen that goes through a chemical reaction in our cells with food pieces to give us energy. An output of this chemical reaction is carbon dioxide.

Make predictions about the relationship between the inputs and outputs. Show **slide J**.

Ask students to turn and talk to make some predictions about the following two questions:

- Would increasing the amount of any of these inputs or structures affect the outputs?
- Would reducing or removing them affect the outputs? Why?

5. Plan Investigation B. 15 MIN

Materials: Planning and Carrying out Investigations, *Simulation Procedures*

Plan investigation B on their own. Direct students to *Simulation Procedures* and ask them to read the directions for planning investigation B on their own for a minute.

As they are doing this, hand out a copy of Planning and Carrying out Investigations. Show **slide K**.

Tell students you want to collect this handout at the end of the period so they should *not* put the handout in their science notebooks yet.

Point out that there are two sections for them to complete on Planning and Carrying out Investigations to prepare for investigation B:

- The first is a table that they will complete to help outline the plan for the variable they are going to investigate, which they will make with their group.
- The second is a space to construct a data table for recording the values of the independent variable and resulting values of the dependent variable(s) for each simulation run they plan to conduct.

Tell students that they need to decide how to structure the data table so that they can record the relevant data needed to answer their question.

Students will likely want to choose to record two dependent variables (oxygen produced and sugar produced) in investigation B as measures of how the output is affected when a single independent variable is changed. Because you want to collect as much data as possible when you do an experiment, it is OK to collect data on all the different things that can change as a result of tinkering with the independent variable.

On the other hand, if you have multiple independent variables, you cannot draw a correlation as to which one caused a change in the dependent variable. This is why it is important to help students recognize the need to vary only a single independent variable in investigation B, while keeping the rest of the inputs in the simulation constant (and the length that they run the simulation each time).*

Give students time to work with their groups to complete these sections.

*** Supporting Students in Engaging in Planning and Carrying Out Investigations**
Now students will be adjusting different variables within the simulation. If needed, take a few minutes to confirm with students what the independent and dependent variable means for their small group investigations. Remind them again, this is similar to what they did in Lesson 2 with the food indicators.

Additional Guidance

A few suggestions are below if you should have technical issues with acquiring enough devices for small groups to run the simulation, or having difficulty with multiple devices accessing the simulation website:

- Follow the plan as written up to through day 1.
- On day 2, when you have returned the students' investigation plans, use your teacher device to run one of the investigation plans per group.
- Each group will collect the same data, but everyone will still be able to finish the rest of the investigation and continue on to make claims based on this evidence.

Additional Guidance

When students are working in their small groups with the simulation, each student chooses a different variable to observe and collect data about. On the handout, students are directed to make a table to collect this data. If your students struggle with how to set up the data table, remind them that back in Lesson 2, when we used the food indicators to collect data about whether the hydroponic plant food solution contained food molecules, they used a table to keep track of the data they collected.

Remind students, *You've outlined a plan for your investigation. Next time, you will conduct your investigation, collect your data, and make some claims about how the inputs you are changing affect the outputs of the system. I am excited to see your investigation plans.*

Have students turn in their investigation plans, Planning and Carrying out Investigations, so you can assess their progress in the science and engineering practice of planning and conducting investigations.

Assessment Opportunity

Students need multiple opportunities and feedback to refine their abilities to identify independent and dependent variables and controls, how measurements will be recorded, and how much data are needed to support a claim. Here is an opportunity to provide feedback before they conduct their investigations in the next period to help them refine their plans.

End of day 1

6. Conduct Investigation B.

15 MIN

Materials: Planning and Carrying out Investigations, *Simulation Procedures*, a computer with a browser and internet access to run the simulation

Remind students, *I was excited to review your investigation plans from last time. If I provided some feedback on your plan, please review it before conducting your investigation. If I did not, then prepare to conduct your investigation by reading through your plan again. The procedure to follow to implement your plan is in Simulation Procedures "Planning investigation B." Review that as well before we get started.*

Pass back Planning and Carrying out Investigations annotated with the feedback you provided students.

Give students time to conduct investigation B. After students have time to orient to the handout and the student reference, show **slide L**.

7. Share our claims with our groups. 10 MIN

Materials: Planning and Carrying out Investigations, clock (to record time)

Use talking sticks protocol to share claims with group members. Present **slide M** to prepare students to share with their group members. Present **slide N** and review the directions on it. Ask students if they have any questions for following the talking stick protocol for the first two rounds. Set the timer for each one-minute round once all group members are facing each other in a small circle, and then have students complete the protocol.

Assessment Opportunity

The talking stick protocol is used to ensure equitable floor time for all students in the discussion in the first couple of rounds. No one should interrupt, not even ask questions for the first round. This gives students an opportunity to practice articulating their claims in front of a smaller audience before going public in front of the whole class. The second round of discussion encourages students to build off each other's ideas, which requires them to actively listen to what their peers said.

Key Ideas

While students are sharing out their claims in their small groups about how changing the inputs for a plant cell affects the outputs for the plant cell, some things to listen/look for while you visit different groups include:

- Students can agree or disagree with another student's claim using evidence from their investigation.
- Students can build off each other's ideas to articulate how the results from their investigations relate.

8. Consensus Discussion about Interaction 15 MIN

Materials: science notebook, Progress Tracker, Planning and Carrying out Investigations, colored markers, chart paper, tape

Bring students together in a Scientists Circle for a Consensus Discussion. Present **slide O**. Have students attach Planning and Carrying out Investigations to their science notebooks and have them reconvene in a Scientists Circle.

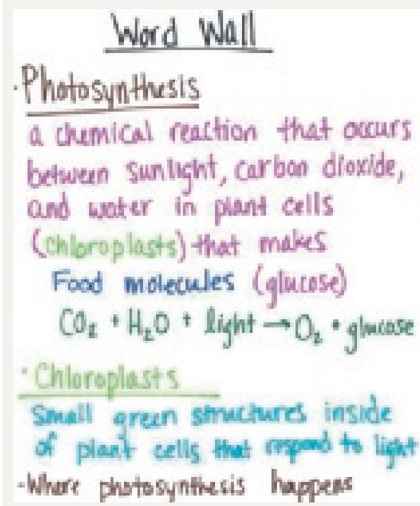
Say, *Let's develop a model to pull together what we figured out about this question. Do we have some agreement about how all these things are interacting together in these cells of the plant?*

Develop a model as a class on the whiteboard, or on a poster, using what students have just come to consensus about regarding what happens inside the chloroplast of the plant to make food.

Suggested prompt	Sample student responses
What are some of your observations from the simulation about how the inputs interact within the plant?	*I noticed that when carbon dioxide and water molecules entered a chloroplast and a lightning zap happened, part of a glucose molecule was made.* *I noticed that if I started with zero carbon dioxide molecules, then no glucose was made.*

*** Attending to Equity**

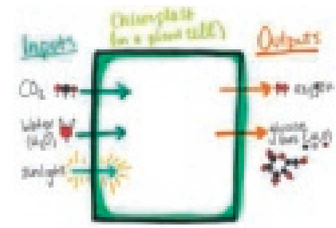
At this point, students should have figured out the inputs and outputs to photosynthesis and understand that a chemical reaction is happening inside the chloroplasts. Add *photosynthesis* to the word wall and amend *chloroplasts* if the class wants to add that that's where photosynthesis happens. Ideally use the wording your students come up with based on what they have figured out from this investigation but, an example of how to define these can be found below:



Suggested prompt	Sample student response
How are these inputs interacting within the plant cell to produce food molecules?	*It took more than one carbon dioxide and water molecule and light zap for a whole glucose molecule to be made.*

Say, *Okay, so let's develop together to capture what we figured out is happening between the inputs inside the plant for a food molecules to be produced.**

The purpose of recording this model here is to take stock of what we have figured out so far about where food molecules in plants are coming from and to navigate to the next lesson by wondering what role light plays when a plant makes food. One example:



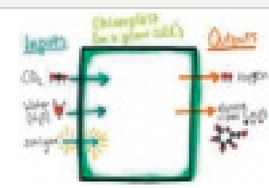
Before asking students to return to their seats, tell them to turn to the Progress Tracker section of their notebook and set up a 3-box tracker. As a class, fill in the question and the source of evidence. Then ask students to return to their seats and fill in the "What we figured out" section using words and/or pictures based on the discussion you just finished. Give students a few minutes to do this on their own so they can synthesize and make sense of their evidence from the simulation and from the discussion.

Assessment Opportunity

The purpose of the Progress Tracker tool is for students to use it to synthesize what they have figured out up to this point in the unit. They should use the Progress Tracker as a place to keep track of evidence they have collected, science principles they have figured out, and models developed based on evidence collected. If used as an assessment, the Progress Tracker should only ever be used as a formative assessment, never a summative assessment.

If you have time, you could ask a few volunteers to share what they recorded in their "What we figured out" section.

A suggested representation is below.

Question	Source of Evidence
How are all these things interacting together in this part of the plant?	• Our results from investigations with a computer simulation of chloroplasts in the plant cell of a leaf.
What we figured out in words/pictures	
• Water and carbon dioxide molecules that enter the plant cell through small openings, along with light, interact in chloroplasts in plant cells, where they are used to make oxygen and sugar molecules. • Each of these inputs is needed to produce these outputs. The more of these inputs that are provided, the more oxygen and sugar they produce. • In this process, molecules of water and carbon dioxide are broken apart and the atoms that make them up (carbon, hydrogen, and oxygen) are rearranged to form new substances, sugar and oxygen. 	

9. Navigation

5 MIN

Materials: Optional Making Sense of the Computer Simulation

Revisit the role of sunlight in photosynthesis. Remain in a Scientists Circle and point out that the outputs of photosynthesis (sugar and oxygen molecules) are made of the same parts (atoms) that were in the molecules of water and carbon dioxide. This raises the questions, "Why is sunlight needed, and what does it provide the chloroplast?"

Ask students to turn and talk with an elbow partner about this question for a couple of minutes. Have a few students share out their initial ideas if time permits.

Tell students that we should further investigate this question about why plants need sunlight for this reaction to occur next time.

Tell students, *We have been using different ways to represent what we have figured out about where plants get food molecules. Today we learned about a process called photosynthesis that a plant goes through to make food molecules. Tonight for home learning you will compare two ways this process can be represented while thinking about the evidence we have collected about where food molecules in plants come from.**

Home Learning Opportunity

(Optional) Pass out a copy of Making Sense of the Computer Simulation to each student. Remind students that the simulation we looked at was constructed to highlight particular aspects of a phenomenon, but that diagrams of this same process of photosynthesis may also be helpful in highlighting different aspects of that phenomenon. Tell students to compare the inputs and outputs of the photosynthesis diagram in the handout to the inputs and outputs they found in the simulation. Then they should evaluate the strengths of each representation to help them understand and explain an answer to our lesson question.

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

It is important that students don't perceive simulations as illustrations of factual truth, but rather a model constructed by people to highlight particular aspects of a phenomenon. The home learning can help students weigh the advantages of the representations they saw in the simulation against those of a diagram of photosynthesis. By comparing the advantages of different representations, students engage in evaluating the limitations of a model for a proposed object or tool, which is a target element of Developing and Using Models in middle school in appendix F of NGSS.

ADDITIONAL LESSON 6 TEACHER GUIDANCE

Supporting Students in Making Connections in Math

In this lesson, students use a computer simulation to investigate how the amounts of different inputs into a plant system affect the amount of sugar, or food, a plant makes. The simulation includes a graph representation of what happens over time to the amount of inputs (carbon dioxide) and outputs (food). Though the mathematical relationship between the amount of carbon dioxide and water that a plant takes in and the amount of food a plant produces is not a linear relationship, students can describe the relationship in terms of comparisons (as the amount of ___ increases/decreases, the amount of ___ increases/decreases) using the numeric and graphical representations in the simulation.

CCSS.MATH.CONTENT.6.SP.B.5 Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.

SCIENCE LITERACY: READING COLLECTION 2

Plants and Chemistry

1 **All-Star Building Blocks of Food**
2 **Photosynthesis**
3 **More than Glucose**
4 **Fertilizers**
5 **Plants in Water, Water in Plants**

Literacy Objectives

- ✓ Summarize key points related to plants and chemical processes.
- ✓ Organize related details about compounds in plants.

Literacy Exercises

- Read varied text selections related to the topics explored in Lessons 3–6.
- 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 set of "MVP Compounds" trading cards in response to the reading.

Instructional Resources

Student Reader
Collection 2

Science Literacy Student Reader, Collection 2
"Plants and Chemistry"

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: What other inputs could be sources of food molecules for the plant?
- Lesson 4: Are any parts that make up food molecules coming into the plant from above the surface?
- Lesson 5: How are these gases getting into and out of leaves?

Standards and Dimensions

NGSS

Disciplinary Core Idea PS3.D: Energy in Chemical Processes and Everyday Life The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. (secondary to MS-LS1-6)

Science and Engineering Practice: Obtaining, Evaluating, and Communicating Information

Crosscutting Concepts: Energy and Matter; Systems and System Models

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.6-8.10: By the end of grade 8, read and comprehend science/technical texts in the grades 6-8 text complexity band independently and proficiently

Math

CONTENT.7.RPA.2: Recognize and represent proportional relationships between quantities.

- Lesson 6: How are all these things interacting together in this part of the plant?

CONTENT.7.RPA.3: Use proportional relationships to solve multistep ratio and percent problems. Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error.

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.

photosynthesis

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.

cardiovascular
conservation of matter
cuticle
glucose
nutrient
organic molecule
spawn
starch
umami

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 Matter Cycling and Photosynthesis 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.
  - *First, you'll look at some mock trading cards showing "all-star" elements and read about their roles in plant processes.*
  - *Next, you'll take a closer look at one of those plant processes—photosynthesis—and compare the reactants with the products to see if matter is conserved.*
  - *Glucose may be an important product of photosynthesis, but you'll also read about some other interesting and useful compounds plants produce.*
  - *Next, you'll read about the different ratios of nitrogen and other elements in fertilizers and follow up with a simulated wildlife scientist's notes on how matter is transferred from one Earth system to others.*
  - *Finally, you'll read a comparison of how land plants and aquatic plants take in carbon dioxide and water.*
- 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 set of "MVP Compounds" trading cards with examples taken from the readings in Collection 1.*
- 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 three elements got the "all-star" trading card treatment in the first reading?	*carbon, hydrogen, and oxygen*
How can you use the chemical equation for photosynthesis to demonstrate the idea of conservation of matter?	*You can count the number of atoms of any element in the reactants, and there will be the same number in the products.*
How can eating foods high in sugar contribute to cardiovascular disease?	*When one kind of sugar (fructose) is processed by the liver, a product is a fat that builds up in blood vessels.*
How do land plants ultimately benefit from the nutrients in the bodies of salmon when these fish swim upstream to spawn?	*When bears eat them, some of the nutrients are transferred to the bear and then to the soil as bear scat. Then, plant roots can take up the nutrients from the soil.*

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 we conclude in our class discussions is the function of "light" over the arrow in the photosynthesis chemical equation?	*It's important to making the chemical reaction take place, but it's not a source of matter to make food molecules.*
The images we saw in Lesson 5, taken through a microscope, of terrestrial plant leaves showed an oval opening in the leaf. Does eelgrass need these opening to take in nutrients? Explain.	*probably not* *Eelgrass does not have a waxy covering, so the gases can easily pass from the water into the cells of the plant.*
Based on the computer simulation you used in Lesson 6, where in plants do you think the chlorophyll is located? Why?	*probably in the chloroplasts, because those are the structures where water and carbon dioxide interact with light to produce food molecules*

- 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 set of most valuable player (MVP) trading cards to highlight compounds that are essential to plant chemistry or essential to users of plants.*
    - *That means you'll want to review all five readings and find examples of compounds or molecules.*
    - *Then you'll need to decide which ones to highlight on your trading cards.*
    - *The important criteria for your work are that you have identified five compounds or molecules and accurately described their functions.*
- 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. Students begin the reading activity by learning about four elements essential for producing glucose inside plants cells and for producing much of the mass of living plants in the form of proteins. In the details on each "all-star" card, students will find clues to how these elements are parts of large, complex systems.

Student Reader

Collection 2

Pages 14–23 **Suggested prompts**	**Sample student responses**
What is the general purpose of the first selection, "All-Star Building Blocks of Food"?	*It describes four elements important to plants, how their atoms are parts of molecules, and how they cycle in and out of plants.*
Using your powers of inference, how would you define the term organic molecules, *from the carbon card?*	*Maybe those are molecules made or existing in living things.*
There is also a reference to "hydrocarbons" on the carbon card. Why is the increase in carbon in the atmosphere a concern to scientists?	*It is causing the atmosphere to warm and Earth's climate to change.*
What is the general purpose of the second selection, "Photosynthesis"?	*It displays models for the molecules involved in photosynthesis. It also shows how you can tell that atoms are conserved by looking at the equation for photosynthesis.*
How does the second selection help you build knowledge on top of what you learned in the first selection?	*The first article tells some of the large-scale facts about carbon, oxygen, and hydrogen. The second article details how atoms of these elements are rearranged during photosynthesis to make glucose and oxygen molecules.*
Where do the carbon atoms in the glucose molecule come from?	*from carbon dioxide in the atmosphere*
How do humans and other land animals depend on ocean plankton?	*Most of the oxygen that land animals need to break down glucose comes from these ocean creatures.*
What is the general purpose of the third article, "More than Glucose"?	*It describes compounds that plants produce, other than glucose.*
Which of the compounds described is most important to people, and why?	*[Students should choose one and support their evaluation with reasoning.]* *lignin—Without it, we wouldn't be able to use trees for wood to build homes.* *chlorophyll—Without it, we wouldn't have any grains, fruits, or vegetables to eat.*

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

SUPPORT—Explain to students that the three-part number for a fertilizer represents a proportional relationship. Then have them solve a problem involving the weight of each fertilizer component in different sized bags. For example, if they buy a 20-pound bag of fertilizer, what is the weight of nitrogen, phosphorus, or potassium in the bag?

SUPPORT—To make sure students understand what it means to dissolve one substance in another, provide small groups with a cup of room-temperature water, a stirrer, and a teaspoon of salt. As students stir the salt into the water, they will observe that the salt seems to vanish. To verify that it is still there, they can pour some of the

Pages 14–23 Suggested prompts	Sample student responses
	glutamate—That umami flavor adds flavor to foods.
	alkaloids—They are needed for medicines that can save human lives.
	terpenoids—We would not have had fishing boats to feed people over hundreds of years.
	alkaloids—They are used to cure people of deadly diseases.
	fructose—I like to bake and couldn't make dessert without fructose, which is part of a table sugar molecule.
How did you use this selection when choosing "MVP Compounds" for the trading cards you developed?	*Because this reading lists seven compounds, I knew I would find good MVP choices here.*
What is the general purpose of the fourth article, "Fertilizers"?	*It has two parts. The first explains how to read the labels on fertilizers that some people put on their gardens or food crop fields. The second is written by a scientist who hypothesizes about how the matter in salmon becomes fertilizer for trees in forests.*
How does the first part of this reading help you build knowledge needed to understand the second part of the reading?	*The first part explains why plants need to take in nitrogen from their environment. This helped me understand why the scientist in the second part says it is important to know how much of the nitrogen in the local forests comes from salmon.*
If you buy a 100-pound bag of 28-7-14 fertilizer, what is in the bag by weight?	*There are 28 pounds of nitrogen, 7 pounds of phosphorus, and 14 pounds of potassium, and the remaining 51 pounds must be some other material not listed on the label.*
What is the general purpose of the fifth article, "Plants in Water, Water in Plants"?	*It explains how water plants get carbon dioxide and how land plants get water.*
The author refers to "dissolved" gases and nutrients moving in and out of aquatic plants. What are these materials dissolved in?	*They are dissolved in the water that the plant lives in, such as pond or salt-marsh water.*
Summarize what global warming has to do with plant cuticles.	*Because aquatic plants do not have cuticles, they can take in a lot of carbon dioxide and store the carbon so that it does not go into the atmosphere and cause more global warming.*
Look at the Connection box at the end of this reading. Why is the transfer of nutrients, such as nitrogen, described as a cycle?	*because once the nutrient moves from the soil, to inside a plant, and is released from the plant, it is taken up again by plants in a never-ending cycle*

solution into a shallow plate and leave it in a warm place. When the water evaporates, the salt left behind will be visible. Discuss how salt particles break apart in water until they are too small to be seen, the same thing that happens with gases and other nutrients in an eelgrass bed.

5. Check for understanding.

Evaluate and Provide Feedback

For Exercise 2, students should create a set of "MVP Compounds" trading cards to highlight some of the important compounds (molecules) that transfer into and out of plants, between living systems, the atmosphere, and the hydrosphere. Look for evidence that their choices came from at least two of the reading selections, that the facts written on the backs of the cards are accurate, are related to plants, and support the idea that matter changes. Compounds in the readings from which students may choose are

- Bicarbonate
- Cellulose
- Chlorophyll
- Carbon dioxide
- Fructose
- Glutamate
- Lignin
- Methane
- Oxygen gas
- Starch
- Strychnine
- Sucrose
- Triglyceride
- Water

A completed sample is shown below, but any choices are acceptable if students can explain why they chose them.

EXTEND—Have students cut out their trading card backs and fronts and shuffle them. Then challenge them to match the fronts to the backs, using the Student Reader as needed. To make the game even more challenging, have two or three students shuffle all their fronts and backs together and then try to match the fronts and backs. After confirming that the matches are correct, distribute tape or glue so that students can attach the fronts and backs. Next, invite students to invent a whole-class game using the trading cards. For example, you might say "I'm thinking of. . ." and, based on your hint, students must hold up the card for the compound that correctly completes your sentence.

MVP Compounds in Plants

Glucose	• A sugar • Made by plants during photosynthesis
Chlorophyll	• Needed to capture sunlight during photosynthesis
Carbon Dioxide	• In the atmosphere • A reactant for photosynthesis
Oxygen gas **O_2**	• In the atmosphere • A product of photosynthesis
Triglyceride	• A fat made by the liver from fructose • Can damage blood vessels
Water	• Land plants take it in through roots • A reactant in photosynthesis

Why do plants need light?

Previous Lesson

We used a computer simulation to explore how water, carbon dioxide, light, and chloroplasts interact in a plant cell. We investigated how changing the amount of one of these inputs affects the outputs of the plant cells. And we used the evidence we collected to argue how water, carbon dioxide, light, and chloroplasts interact to produce oxygen and sugar molecules.

This Lesson

Investigation, Problematizing

1 DAY

We think sunlight gives plants energy, but so far our models only account for matter. We know sunlight is needed for plants to make food, but we aren't sure what it's doing. So we decide to investigate the role of sunlight. We examine food labels to figure out how much energy water, carbon dioxide, and glucose can provide for the body. We find out that water and carbon dioxide do not provide energy for our body, but glucose does. We argue from evidence that since glucose (an output of plants) provides energy for our bodies in the form of calories, but inputs of plants, water and carbon dioxide, do not have energy in the form of calories, the energy must be coming from some other inputs. The sunlight must be the source of the energy for plants to rearrange the Cs, Hs, and Os through chemical reactions.

Next Lesson

We will develop a Gotta-Have-It Checklist and take an individual assessment. We will build a consensus model to explain how plants get food molecules and where food molecules come from. Our models will include everything we figured out in Lessons 1–7.

Building Toward NGSS

MS-LS1-6, MS-LS2-3, MS-PS1-3

What Students Will Do

Obtain, evaluate, and communicate information to show the relationships among matter and energy between the inputs and outputs for the process by which plants use energy from light to make sugars from carbon dioxide and water (photosynthesis).

Engage in argument from evidence and scientific reasoning to support the claim that plants use sunlight for energy to convert carbon dioxide and water into sugar that provides a form of energy the body can use.

What Students Will Figure Out

- Water and carbon dioxide don't provide energy (measured in calories) for the body, but glucose does.
- The plant must be getting energy from the light.
- Plants must use sunlight as an input for energy so that they can do chemical reactions to make sugar (glucose and other complex food molecules).

Lesson 7 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	8 min	**NAVIGATION** Motivate a need for evidence to support the hypothesis that maybe plants need sunlight as an input for energy.	A-B	red marker
2	12 min	**READ: HOW DO SCIENTISTS MEASURE ENERGY IN FOOD?** Individually read about food labels and the scientific information they display about the energy provided in food.	C	*Reading: How do scientists measure energy in food?*
3	10 min	**EXAMINE FOOD LABELS FOR EVIDENCE THAT THE INPUTS TO THE PLANT SYSTEM PROVIDE ENERGY** Students examine food labels of water, sparkling water, and glucose tablets for evidence that they can provide energy for us.	D	*How many calories are in each input and output for plants making food?*, *Nutrition Labels: What is in food?*, tape
4	12 min	**ARGUE FROM EVIDENCE IN A SCIENTIST CIRCLE ABOUT THE ROLE OF SUNLIGHT** Students orally argue from evidence that light *must* be giving plants energy.	E	*How many calories are in each input and output for plants making food?*, consensus model, colored markers
5	5 min	**UPDATE OUR PROGRESS TRACKERS** Students use a Progress Tracker in their science notebooks to record evidence of what they've figured out so far about why plants need light.	F	

End of day 1

Lesson 7 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide** **Student Work Pages**	• science notebook • red marker • *Reading: How do scientists measure energy in food?* • *How many calories are in each input and output for plants making food?* • *Nutrition Labels: What is in food?*		• tape • consensus model • colored markers

Materials preparation (30 minutes)

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

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

Make sure students can access *Nutrition Labels: What is in food?* from Lesson 1.

Online Resources

Lesson 7 • Where We Are Going and NOT Going

Where We Are Going

This lesson builds off of 5-LS1-1 ("Support an argument that plants get the materials they need for growth chiefly from air and water") and 5-PS3-1 ("Use models to describe that energy in animals' food [used for body repair, growth, and motion, and to maintain body warmth] was once energy from the sun"). This lesson also builds off of 2-LS2-1 ("Plan and conduct an investigation to determine if plants need sunlight and water to grow").

By investigating both matter and energy inputs and outputs, students figure out that plants need light for energy to make sugars (food) from carbon dioxide and water. Students make a critical realization that the process by which plants produce complex food molecules (sugar) requires energy input from the sun. Students argue from evidence that since one of the outputs in their models (glucose) has energy and two of the inputs (water and carbon dioxide) do not. Even though students don't have evidence from this lesson to make a claim about whether oxygen has energy, it is important to note that oxygen does not have energy. Students often believe that light is food for the plant itself, not energy used for chemical reactions to make food.

Where We Are NOT Going

In **Lesson 8,** students will put the pieces together to develop a model individually and as a class that tracks the flow of matter and energy through the process of photosynthesis. While students experienced chemical reactions in the human body in Unit 7.3: *How do things inside our bodies work together to make us feel the way we do?* (Inside our Bodies Unit), students will not investigate cellular respiration in plants and what plants do with food molecules until Lessons 10 and 11. In these lessons, students will also look at what happens to plants when photosynthesis is not occurring.

In Lesson 13, students will examine the role of decomposers in the cycling of matter and flow of energy and how decomposers can use a variety of inputs for matter and energy, beyond that of humans.

In middle school it is not in grade band to examine the biochemical pathways for creating glucose. Students will not be figuring out the nitrogen cycle and nutrients for growth for plants; it is in the high school grade band.

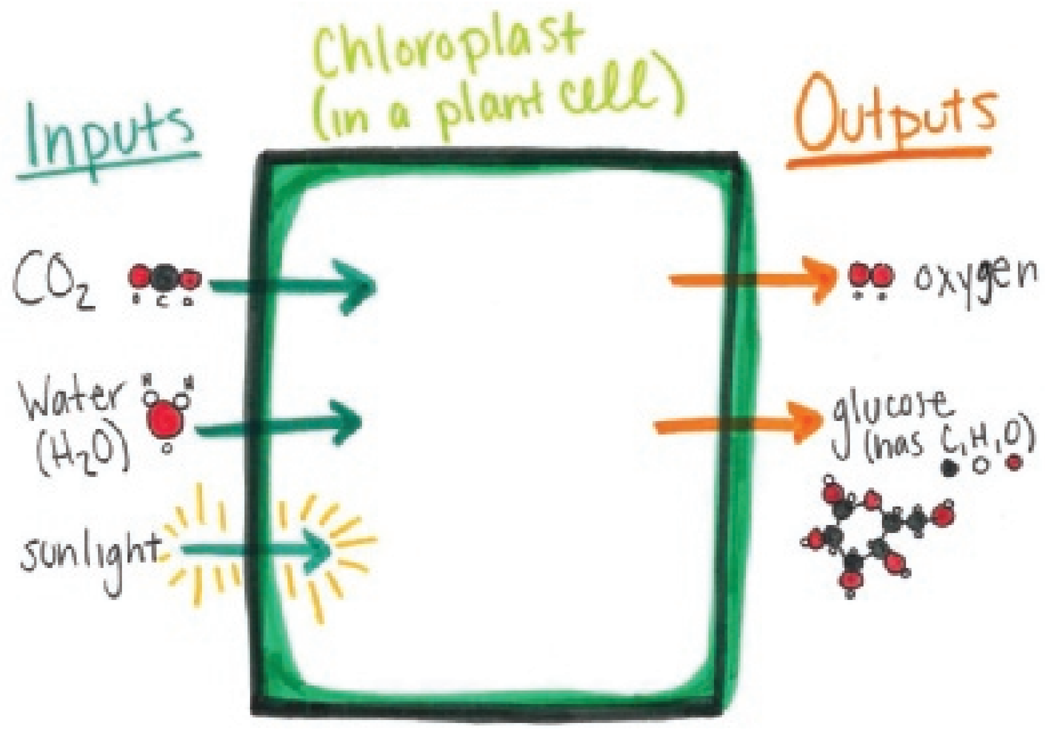
1. Navigation

8 MIN

Materials: science notebook, red marker

Revisit the findings from the previous investigation. Display **slide A**. Remind students that last time we realized that chloroplasts *only* make sugar and oxygen when carbon dioxide, water, *and* light are all present.

Say, *Let's go back to some of the claims we made about the simulation we used last class. We claimed that the chloroplasts in plant cells can make sugar and oxygen (products). Can someone remind me when we saw this happening? Okay, so we only saw glucose and oxygen being made when carbon dioxide, water, and light (reactants) are all present. Did anyone try running the simulation last time without any light? Was there any glucose made when there wasn't any light? So when carbon dioxide and water are present, but there isn't any light, does the plant make sugar? Let's revisit the inputs and outputs of our plant system model.*



Revist the representation from last class of the *inputs* (carbon dioxide, water, and sunlight) and *outputs* (oxygen and glucose). Have students come up and point to each component of the model as they are explaining their thinking.

*** Supporting Students in Developing and Using Energy and Matter**

Although students should already have a working understanding of *matter*, it may help to ask students to remind you that when we say "matter," we mean "stuff" that makes up things in our world, that has mass, and that takes up space. Consider the prompts, *Can someone remind me what we mean when we say "matter"?* or *What examples of interactions with matter do we have from previous units?*

Suggested prompts	Sample student responses
In the simulation, where was sugar being made?	*in the chloroplasts in plant cells*
What were the inputs (reactants) in our simulation?	*carbon dioxide, water, sunlight*
What were the products (outputs) in our simulation?	*oxygen and glucose*
Based on what we saw happening in the simulation, what happens inside the chloroplasts in plant cells?	*We think that a chemical reaction or a series of chemical reactions are taking place that are somehow rearranging the carbon dioxide and water into oxygen and glucose. (Add a label to the inside of the chloroplast to indicate this.)*

Additional Guidance

It may help students to keep track of the carbon (C), hydrogen (H), and oxygen (O) atoms (i.e., matter inputs and outputs) either by color coding or writing out the letters.Although color coding is a useful way to quickly reference the parts of the model, letter or number coding also helps ensure accessibility for any student who may be color-blind. Create a key to track what colors, symbols, numbers, or letters represent different parts of the model. If students are able to keep track of the Cs, Hs, and Os, they may start to develop some of the ideas related to the conservation of energy and mass.

Assessment Opportunity

This is a great opportunity to see if student thinking is progressing as we continue to add and clarify the role of components in the consensus model. If students are struggling to recall that molecules are made of atoms which is the “stuff” that makes up matter, refer them to *Composition of Air* from Lesson 3. Ask them what they notice about what air is made of and what do we mean when we say “matter”?

Take stock of what we know about light and what we want to figure out. Point out that our inputs and outputs in our model are mostly types of *matter that is used to make food molecules*. In Lesson 3, we recalled that sunlight is a little different, though, because we don’t typically think about light as being made up of the matter to make food molecules. It may help to have students recall that they figured out in elementary school that plants need the sun to survive, so it makes sense that we have included the sun in our models. It may also help to point out that most students included sunlight on their initial models (from Lesson 1). But if sunlight isn’t the source of *matter* needed to make food molecules, then what is it and why do plants need it?*

Suggested prompt	Sample student responses
Which of the inputs and outputs in our model represent matter?	*anything with Cs, Hs, or Os* *the carbon dioxide, water, oxygen, and glucose*

Suggested prompts	Sample student responses
What about the sunlight? Is that matter? We saw that sunlight is an important input for a plant to be able to make food molecules. What could sunlight represent in our model?	*No, we don't think sunlight is the matter we need to make food molecules.* *We figured out in previous units that light is something else (maybe energy).* *In the Storms Unit, we saw that sunlight is absorbed by the ground and heats it up. Maybe sunlight is absorbed by the plant so it can make food.*
Okay, so we know from earlier grades that plants need sunlight, and we included sunlight as a key element in our initial models. So if sunlight isn't made up of molecules like carbon dioxide and water, then what is it and why do plants need it?	*It sounds like sunlight is something that is a little different from everything else in our model.* *We don't think that it is matter that could make up food like everything else.* *We think that sunlight might provide energy but we're not entirely sure why.*

Additional Guidance

The "Storms Unit" that a student might refer to is the 6th grade Unit 6.3: *Why does a lot of hail, rain, or snow fall at some times and not others?* (Storms Unit). In *Storms* Lesson 4 students collect and examine data from different surfaces to figure out that energy from the Sun is absorbed by the ground, which then increases the kinetic energy (and therefore temperature) of the particles in the ground and different surfaces heat up differently depending on how much energy from the Sun is absorbed.

Turn and Talk about why plants might need light. Show **slide B**. Ask students to turn and talk with the person next to them.

- Why do you think chloroplasts need light to make sugar and oxygen?
- Why do you think carbon dioxide and water, *without light*, aren't enough to make sugar and oxygen?

Share initial ideas in a class discussion. Have students share out their responses to the discussion prompts. Amplify the intuitive student ideas that sunlight somehow gives plants *energy*.

Suggested prompt	Sample student responses
Why do you think chloroplasts need light to make sugar and oxygen?	*Maybe the light gives the chloroplasts the energy that they need to rearrange the Cs, Hs, and Os.* *Maybe the light gives the chloroplasts a "zap" that rearranges everything.*

Suggested prompt	Sample student responses
Why do you think carbon dioxide and water, without light, aren't enough to make sugar and oxygen?	*Maybe the carbon dioxide and water are pretty stable—they don't really break apart easily.* *Maybe the carbon dioxide and water need some sort of energy or "zap" to separate from each other.*

Summarize the class discussion. Point out that many of the students had intuitive ideas that sunlight somehow gives plants energy. Revisit the representation of the inputs and outputs and note that our model hasn't really included a way to distinguish between matter and energy. Encourage students to begin distinguishing between matter and energy in the model by labeling each input and output as "Matter," "Energy," or "Matter and energy." So far, we have evidence that water, carbon dioxide, glucose, and oxygen are matter.*

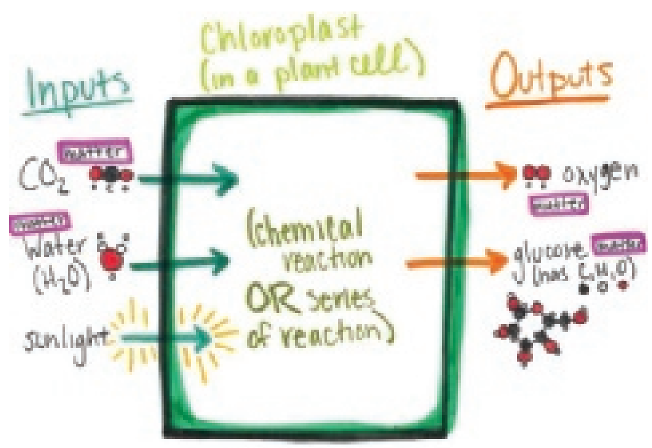
*** Supporting Students in Developing and Using Energy and Matter**
At this point, students are encouraged to think about matter and energy as different entities. By tracking the flow of matter and energy in the model, students may begin to track the transfer of energy flow through the system.

Say, *It sounds like we have a lot of ideas about what light might be doing. Some of us think it might have to do with energy, but we haven't really distinguished between matter and energy in our models. Let's start by adding labels for anything that we know is matter.*

Suggested prompts	Sample student response
Which inputs or outputs on our model are matter that could be used to make food for plants? *How do you know?*	*We know that carbon dioxide and water have atoms that are similar to those in food.*

On the model, label water, carbon dioxide, glucose, and oxygen as "Matter." Students should add this to the models they have in their notebooks.

Point out that we don't have much evidence, yet, for where *energy* could be found in our models. We probably need to account for energy in our models to figure out why the sun is so important in this reaction, but we are going to need some evidence to figure out which inputs and outputs in our models might also have energy.



Additional Guidance

Students may struggle to suggest ways to figure out how different inputs and outputs in the model have energy. If they do, focus specifically on data they have collected in previous units, by burning food and analyzing food labels such as in *Inside our Bodies*. Guide students to examine food labels to determine whether the input/output provides energy.

Suggested prompts	Sample student responses
How could we know whether glucose (sugar) provides energy for us? We know food provides us with energy, but how can we figure out how much energy food provides us?	*We would have to measure it.*
What evidence could we use to figure out whether sugar could provide us with energy?	*We could burn it as we did in the Inside our Bodies Unit.* *We could look at the food labels again to see if there is other information to help us figure this out.*
Why would looking at food labels for human food help us understand about the energy in plants?	*We eat the plants and we figured out in Inside our Bodies that food can provide energy and matter for animals, including humans.*

Additional Guidance

In *Reading: How do scientists measure energy in food?*, students will read about calories as a measure of how much energy food can provide the body. It is okay for us to use calories, how much energy food provides for humans, right now, because we began the unit looking at where our food comes from. Even though we are looking at the outputs of a chemical reaction that produces food inside plants, this unit will not get into what the plant does with that food until Lesson 9 when question how a tree can survive without leaves. Then in Lesson 10 we see that plants do not do photosynthesis in the dark, and in Lesson 11 we see that plants also produce carbon dioxide.

Say, *Perhaps we could figure out how much energy certain foods provide by examining the amount of energy provided by food in each input and output.*

2. Read: How do scientists measure energy in food? 12 MIN

Materials: *Reading: How do scientists measure energy in food?*

Introduce the reading. Show **slide C**. Distribute *Reading: How do scientists measure energy in food?*. Say, *I came across this article that explains how food scientists make food labels. Let's take a few minutes to use what we see and read about food labels to help us clarify our claims about matter and energy for our inputs and outputs of plants doing photosynthesis.*

Individually read *Reading: How do scientists measure energy in food?* and answer the questions. Give students several minutes to read about the scientific information in food labels and answer the Making Sense questions. To help students gather information from the text and images, have them use *Obtaining Information from Scientific Text Checklist*.*

*** Supporting Students in Engaging in Obtaining, Evaluating, and Communicating Information**
The descriptions of food labels are mirrored in the images of each food label. The repetition of this detailed scientific information in various media is intended to help students clarify their understandings about how calories are used as a way to measure the energy food can provide the body, as well as give them an opportunity to evaluate how information presented in various media compares to what they have figured out so far about the matter and energy in food.

Assessment Opportunity

On *Reading: How do scientists measure energy in food?*, look for students to describe which source of information was most helpful in revising their thinking about which inputs/outputs from photosynthesis provide energy that the body can use. If students are struggling to integrate information from text, images, and what they figured out previously, guide them to focus on just one source, such as the caloric data from the food label or the explanation of calories from the text.

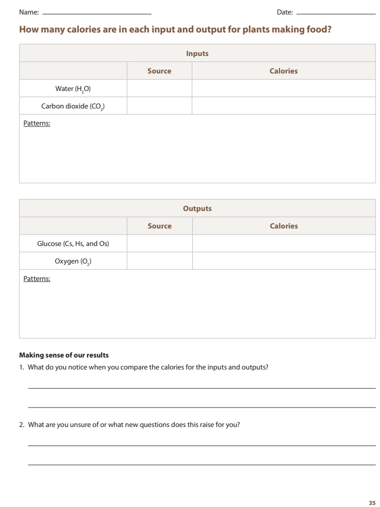
Share findings about food labels and energy. During the discussion walk over and have students point out the inputs on the classroom consensus model.

Suggested prompts	Sample student responses	Follow-up questions
Can someone remind me why we wanted to look at food labels in the first place?	*We want to see if any of our inputs to the plant (such as carbon dioxide and water) could provide the body energy.*	*Can anyone add on to that idea?*
What are some things you figured out from the information in the article about energy in food and how it is measured or represented?	*Calories are a measure of energy that we could get from the different foods we eat.* *Foods have different amounts of food molecules that make up the number of calories.*	*Can anyone take that idea about energy and push it a little bit further?*
If a food label measured zero calories, what claim could you make about how much energy this food would provide our body?	*Zero calories would mean that a food provides zero energy for our bodies!*	*So let me see if I've got what you're saying: If a food has zero calories then it wouldn't act as an input that provides our bodies with any energy?**
Let's look back at the food labels to see if any of the inputs for the plant provide energy for the body. What inputs and outputs would we want to see in the food labels we examine?	*water, carbon dioxide, glucose, and oxygen*	*Okay, let's see in any of those inputs have calories.*

*** Attending to Equity**
Students who are learning English benefit from redundancy of content and vocabulary. One way to give students the opportunity to hear ideas again is to revoice them. For example, after students have shared what we figured out last time, check to clarify what students agree upon by asking, *So I'm hearing ______ and _____. Do I have that right?* For all science students, but particularly those who are learning English, the opportunity to hear scientific language in varied contexts is fundamental to the development of disciplinary literacy.

3. Examine food labels for evidence that the inputs to the plant system provide energy. 10 MIN

Materials: *How many calories are in each input and output for plants making food?*, *Nutrition Labels: What is in food?*, tape


Name: ______ Date: ______

How many calories are in each input and output for plants making food?

Inputs		
	Source	Calories
Water (H_2O)		
Carbon dioxide (CO_2)		
Patterns:		

Outputs		
	Source	Calories
Glucose (Cs, Hs, and Os)		
Oxygen (O_2)		
Patterns:		

Making sense of our results

1. What do you notice when you compare the calories for the inputs and outputs?
2. What are you unsure of or what new questions does this raise for you?

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Prepare students to analyze food labels. Project **slide D**. Remind students that their goal is to figure out whether water, carbon dioxide, glucose, and oxygen could provide energy to us. We decided that we could use food labels as a source of evidence for energy in food since we just figured out calories are a measure of the amount of energy a food could provide us.

Distribute *How many calories are in each input and output for plants making food?* to each student. Tell students that if we are going to use food labels to figure out how much energy water, carbon dioxide, glucose, and oxygen might have in them, we are going to have to find *food* sources of water, carbon dioxide, glucose, and oxygen that have food labels. Have students brainstorm food sources for water, carbon dioxide, glucose, and oxygen. Students will likely generate the idea to look at the food label of bottled water as evidence for water. Students may also recommend looking at a sugar label for glucose, like we did in *Inside our Bodies*. If students recommend sugar, respond by saying that you have heard of people buying glucose to help with blood sugar, so we might be able to look at the food label.

Students may struggle to recommend food labels for carbon dioxide or oxygen. If students struggle, plant the idea about carbon dioxide sometimes being found in soda or sparkling water, like we used in *Inside our Bodies*. Suggest looking at a food label for carbonated (sparkling) water, which is the combination of water and carbon dioxide.

Say, *I have a label we can use for carbon dioxide. Sparkling water has water and carbon dioxide in it. Let's use that to look at it as a source of carbon dioxide.*

Finally, tell students that there isn't a food source for pure oxygen. Have students record "None available" in the "Source" box for oxygen.

Have students fill in the "Source" column on *How many calories are in each input and output for plants making food?* by listing bottled water as a source of evidence for water, sparkling water (carbon dioxide and water) as a source of evidence for carbon dioxide, and glucose tablets as a source of evidence for glucose.

Introduce three images of food labels for water, sparkling water, and glucose tablets. Have students take out the collection of food labels found in *Nutrition Labels: What is in food?*. Remind students that calories are a measure of energy for us, so if something has 0 calories, it means that it doesn't provide any energy for us from the food. Give students time to work in groups to record on *How many calories are in each input and output for plants making food?* what they notice and what they wonder about the food labels. Students should add wonderings for the "Oxygen" row even though they don't have a food source.

Students will likely notice that water or sparkling water does not provide any calories, but that glucose does have calories.

Make sense of our findings. Have students respond to the questions in the "Making sense" section of *How many calories are in each input and output for plants making food?*. Students should work to figure out whether carbon dioxide can provide energy for our bodies and should record any new questions that they have.

4. Argue from evidence in a Scientists Circle about the role of sunlight.

12 MIN

Materials: science notebook, *How many calories are in each input and output for plants making food?*, consensus model, colored markers

Gather students in a Scientists Circle for a Building Understandings Discussion. Show **slide E.** Make sure that students have their science notebooks and *How many calories are in each input and output for plants making food?* with them. Begin by having students share out the patterns they noticed from the food labels. Make sure that you draw out the ideas that students noticed that water and sparkling water had zero calories and that glucose tablets had some calories. Remind students that calories are a measure of energy and that more calories means more energy. Students should note that water and sparkling water don't provide energy for our bodies, while glucose can provide energy for our bodies.*

Key Ideas

Purpose of discussion: To support the claim that plants need light for energy because none of the other inputs to the plant provide any energy for the body.

Listen for these ideas:

- Sparkling water had zero calories and glucose tablets had some calories. Thus, water and sparkling water don't provide any energy from food, while glucose seems to provide energy.
- Calories are a measure of energy that can be used in the human body.
- More calories mean more energy.

Ask students whether carbon dioxide provides any energy for the body. Connect the ideas that both sparkling water and water don't have any calories, so carbon dioxide must not provide any energy for the human body. In other words, if sparkling water doesn't have any calories reported on the food label, then carbon dioxide does not provide us any energy.

Suggested prompt	Sample student response
Can carbon dioxide provide us energy?	*No. We can't use carbon dioxide for energy because on the food label for sparkling water (which represented carbon dioxide) there weren't any calories listed in it.*

Return to the inputs-and-outputs model that you created at the beginning of class. Engage students in a discussion in which they must argue from evidence about whether any of the inputs or outputs provide *or* are a source of energy. Give students a minute to write down their initial thinking about these claims in their science notebooks.*

Suggested prompt	Sample student response
So where do we need to add energy to our consensus model?	*We can add energy to sugar (glucose) in our consensus model because it has calories.*

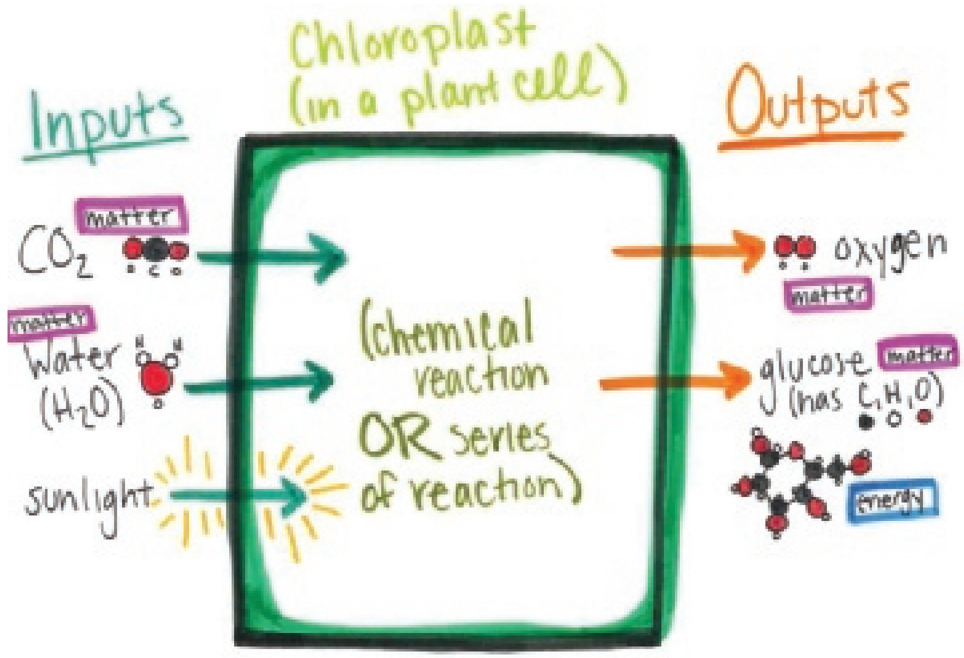
*** Supporting Students in Developing and Using Energy and Matter**

We say food provides energy, rather than food has energy in it or that a single molecule provides energy, to help students see in future lessons these food molecules as only one part of a system of interactions that provide us energy. The other input for that system is oxygen and the interaction between these inputs is needed for atomic rearrangement through chemical reactions. All of these together are needed for a food to be part of a system that provides us energy.

*** Supporting Students in Developing and Using Energy and Matter**

There are a few living things such as certain species of bacteria that can metabolize molecules like CO_2, so that's why we are focusing on analyzing the food labels as being a source of energy for humans. This distinction is outside of the realm of this unit, but we are careful to use the food labels to be representations of the caloric value, and thus potential energy, for our bodies (not all living things).

Students should be able to argue from evidence that carbon dioxide and water aren't sources that can provide us with energy. Once the class has agreed that glucose can be a source of calories (energy for us) and that carbon dioxide and water are not sources of energy for us, add the label "Energy" next to glucose in the model.



Suggested prompts	Sample student responses	Follow-up questions
Now that we have analyzed some food labels for the inputs that we know plants need to make food molecules that can provide our body energy, what is the issue we are trying to account for between the inputs and outputs?	*Our inputs of matter that are used to make food molecules, carbon dioxide, and water do not have calories. But calories are found in the outputs. So since calories are a measurement of energy, we are trying to identify where the energy is coming from for the plant.*	*Do both the inputs and outputs have calories? So then what are we trying to figure out?*
How do carbon dioxide and water along with sunlight interact in a plant to help it be able to make sugar which contains matter and energy?	*Plants must be doing chemical reactions.* *We know that energy and matter are needed to break apart molecules, rearrange them, and put them back together in chemical reactions.*	*What do people think about what ______ said about chemical reactions making sugar?*

Suggested prompts	Sample student responses	Follow-up questions
Where do you think the energy comes from for the chemical reaction to occur and rearrange the atoms to create new (or) different molecules?	*The sun must be the energy source.* *We don't see any of the atoms in food inside sunlight.* *In the simulation we saw that all the pieces of matter for inputs could be there (carbon dioxide and water) but needed sunlight for glucose to be made.* *Without the sunlight, the chemical reaction would not happen.*	*What evidence from earlier lessons and units supports these claims?*
Can someone summarize our ideas we have for where the plant is getting the energy to make the food molecules (outputs) and what is happening during this chemical reaction that makes food?	*We think plants get energy from the sun, or grow light.* *Light provides the energy needed for chemical reactions to happen in the chloroplast and carbon dioxide and water provide the matter needed to make glucose and oxygen.* *The glucose provides energy the body can use.*	*What makes you think that?*

Additional Guidance

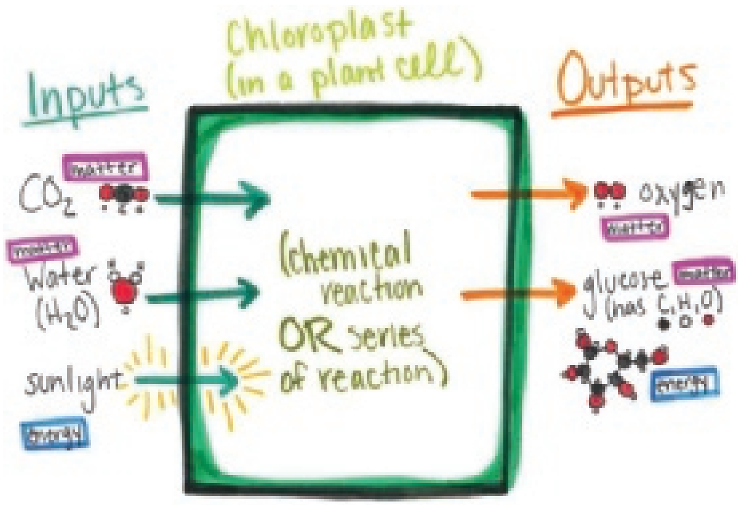
If students have done the 6th grade Unit 6.2: *How can containers keep stuff from warming up or cooling down?* (Cup Design Unit) and the 7th grade Unit 7.1: *How can we make something new that was not there before?* (Bath Bomb Unit), they should have some conceptual models of what happens when sunlight is absorbed and heats up objects. They should also know that one way to know a chemical reaction has occurred is when different molecules from the reactants are made from, or produced from, these atoms that have rearranged.

Students should be able to argue from evidence that light *can* be absorbed and transfer energy as we saw in the *Storms* Unit. One of the outputs, glucose, provides energy from food for the body, and yet the two inputs (carbon dioxide and water) do not contain calories and thus do not provide energy from food that the body can use. The energy glucose provides has to come from *somewhere*, so if we are thinking sunlight must play a role and maybe it provides plants with energy.

When students have come to a consensus that light must have energy and provide energy to the plant system, add the label "Energy" next to light in the model.

Encourage students to trace both the matter *and* the energy inputs and outputs to see that matter (carbon dioxide and water) can only be rearranged when energy (light) is added.

Finally, engage students in a discussion about oxygen. As previously mentioned, we don't have evidence from a food label showing calories (energy that can be used by the body) for oxygen. But, knowing whether oxygen can provide us with energy does not affect our conclusions about whether light could be a source of energy. We know that at least one of the matter outputs can provide us with energy and the two matter inputs in the model can't provide us with energy. So regardless of whether oxygen provides us energy, our conclusion that light is the likely source of energy for the plant does not change.



Suggested prompt	Sample student response	Follow-up question
Can we still make these claims even though we were not able to examine a food label for oxygen?	*Oxygen is an output, not an input for the plant. So we know that we still need an input of energy for the chemical reaction to occur, so light must be energy.*	*How did you arrive at that conclusion?*

5. Update our Progress Trackers.

5 MIN

Materials: science notebook

Individually update the Progress Tracker. Show **slide F.** Have students return to their seats.

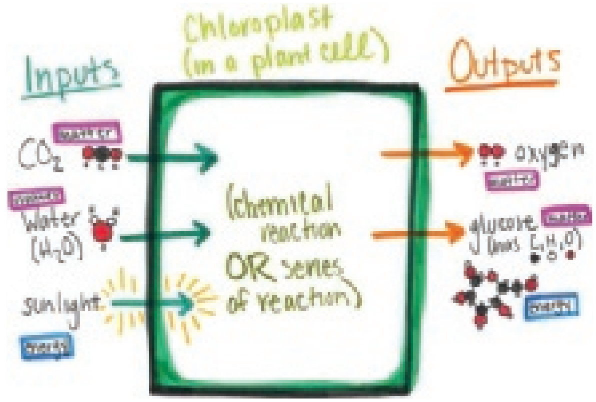
Say, *Take a few minutes to capture in your Progress Tracker what we just figured out.*

In their notebooks, students should draw a 3-box Progress Tracker using what the class came to consensus on in the previous discussion. First, have students write down the question they have been trying to answer, *Why do plants need light?* Ask students what evidence they have been working with to answer this question (e.g., food labels).

Give students an opportunity to generate a list of ideas they have figured out now.

On the next page is one suggested representation.

Question	Source of Evidence
Why do plants need light?	• Food labels from water, sparkling water, and glucose tablets

What we figured out in words and pictures	
• Water and carbon dioxide don't provide energy (measured in calories) for the body, but glucose does. • The plant must be getting energy from the light. • Plants must use sunlight as an input for energy so that they can have the chemical reaction to make sugar (glucose and other complex food molecules).	

Assessment Opportunity

The 3-box Progress Tracker is a great formative assessment to see if students are individually processing what was discussed in the Building Understandings Discussion. Walk around as students are writing and drawing. Students should label carbon dioxide, water, and oxygen as matter, sunlight as energy, and glucose as matter and energy in their Progress Trackers. They should explain that they know glucose provides energy for the plant to use because it has calories. If students struggle to label both matter and energy and explain how they know which inputs and outputs are energy, matter, or both, ask them what evidence they have for whether or not each input/output can provide (this should refer them to the *Composition of Air* and *Food Molecule Cards*).

Say, *Wow! We have made so much progress on our driving question about how plants get their food and where the food in plants coming from. Let's take some time next class to put the pieces together to not only include inputs and outputs to the system for the plant and follow matter and energy.*

ADDITIONAL LESSON 7 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

Students engage with a short text to learn more about calories as a measure of the amount of energy the body can use when it takes in nutrients through food which also includes images of food labels. Students practice **CCSS.ELA-LITERACY.RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table) because they must integrate what they read in the text to correctly read and interpret the content of the food label. Information from both sources must be used to answer the reflection questions.

LESSON 8

Where are plants getting food from?

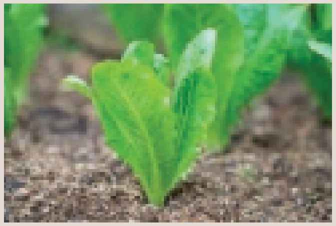
Previous Lesson

We knew sunlight is needed for plants to make food, but we were not sure what it was doing. So we decided to investigate the role of sunlight. We examined food labels to figure out how much energy water, carbon dioxide, and glucose provide for our body. We argued from evidence that since glucose (an output of plants) provides energy for our bodies in the form of calories, but inputs of plants water and carbon dioxide do not have energy in the form of calories, the energy must be coming from some other input. The sunlight must be the source of the energy for plants to rearrange the Cs, Hs, and Os.

This Lesson

Putting Pieces Together

2 DAYS



This lesson marks the end of the first lesson set. We develop a Gotta-Have-It Checklist to highlight the key ideas that we figured out in Lessons 1–7. On day 2, students take an individual assessment, applying what we have learned to explain new phenomena. We revise our consensus model by drawing and explaining what we figured out in Lessons 1–7 to explain how plants get food molecules. Our models include key inputs and outputs and differentiate between matter and energy.

Next Lesson

We will apply our models to try to explain how sugar can come out of maple trees when leaves aren't present. We will realize that our models can't yet explain how food molecules can be found in plants when all the inputs or structures aren't present.

Building Toward NGSS

MS-LS1-6, MS-LS2-3, MS-PS1-3

What Students Will Do

Develop and use models based on multiple sources of evidence to show that plants use energy from light to make sugars (food) from carbon dioxide and water through the process of photosynthesis and release oxygen as an output and that energy is transferred from the sunlight to the plant through this process.

Argue from evidence that carbon dioxide is an input for plants and oxygen is an output.

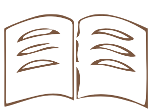
What Students Will Figure Out

- Plants use energy from the sun to make sugars (food) from carbon dioxide and water. Plants release oxygen as an additional output in this process. This process is called photosynthesis.
- During the process of photosynthesis, energy is transferred from the sunlight to the plant.
- All plants make their own food molecules through the process of photosynthesis.
- Photosynthesis occurs in the chloroplasts of plant cells.

Lesson 8 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION: LOOKING BACK** Review the phenomenon (the sugar in the maple tree) and the related phenomena (food molecules in plants) and what questions we are trying to answer about them, namely, *How do plants get their food molecules? Where do the food molecules come from?*	A–B	*How Plants Get Food Initial Model*, colored markers, chart paper
2	17 min	**CREATE A GOTTA-HAVE-IT CHECKLIST** Work in groups to review their Progress Trackers from Lessons 1 to 7 and to decide on ideas to include in their new models to answer the lesson question.	C	*How Plants Get Food Initial Model*, *Lesson 8: Gotta-Have-It Checklist*
3	18 min	**REVISE THE CLASS CONSENSUS MODEL** Revise the class consensus model for how plants get their food molecules and where food molecules in plants come from.	D-E	*Individual Midpoint Assessment*, chart paper, colored markers
4	5 min	**UPDATE OUR PROGRESS TRACKERS (OPTIONAL)** Update our Progress Trackers with what we have figured out about our driving questions: *How do plants get their food molecules? Where do the food molecules come from?*	F	
				End of day 1
5	45 min	**CHECK FOR UNDERSTANDING USING THE EMBEDDED MIDPOINT ASSESSMENT** Work individually to revise initial models by creating a new model, using ideas from their Gotta-Have-It Checklists, and argue from evidence on how a scientist could survive in a container with just plants.	G	*Lesson 8: Gotta-Have-It Checklist*, *How Plants Get Food Initial Model*, *Individual Midpoint Assessment*, colored markers, tape
				End of day 2

Lesson 8 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• *How Plants Get Food Initial Model* • science notebook • colored markers • *Lesson 8: Gotta-Have-It Checklist* • *Individual Midpoint Assessment*		• chart paper • colored markers • tape

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 markers and chart paper for the class consensus model.

Make sure students have access to *How Plants Get Food Initial Model* in their science notebooks from Lesson 1.

Online Resources

Lesson 8 • Where We Are Going and NOT Going

Where We Are Going

This lesson builds off of 5-LS1-1 ("Support an argument that plants get the materials they need for growth chiefly from air and water") and 5-PS3-1 ("Use models to describe that energy in animals' food [used for body repair, growth, motion and to maintain body warmth] was once energy from the sun").

All students' ideas generated during Lessons 1–7 will be relevant in this lesson. This lesson is a putting the pieces together lesson. It includes a midpoint assessment along with a scoring guide for the assessment. This lesson brings together key ideas from NGSS Disciplinary Core Ideas LS1.C and PS3.D. By pulling together confirmed inputs and outputs involved in the process plants undergo when making food molecules and differentiating between matter and energy, students solidify their ideas that plants need light, carbon dioxide, and water to make sugar (food). Student initial models most likely show that plants get food (whole food molecules) from the soil, water, commercially sold "plant food," and/or light. At this point students should be able to put these ideas together to represent that in order for plants to produce food, a plant must absorb energy from the sun and take in carbon dioxide and water. Plants take in a small amount of mineral matter from the soil/hydroponic plant food but that matter does not make up sugar, or the main components of food, such as carbon.

Where We Are NOT Going

This lesson does not add cellular respiration in plants to the model or return to the maple tree. That will happen in Lesson 9 and 10. This lesson does not yet explain that all food comes from plants, which will happen in Lesson 12, when students examine processed foods, synthetic foods, and food from animals. In Lessons 9–12 students will investigate what happens to plants when not doing photosynthesis (when they have no leaves in the winter or in the dark) and look further at the processing of maple sap into maple syrup in Lesson 12.

LEARNING PLAN FOR LESSON 8

1. Navigation: Looking Back

5 MIN

Materials: *How Plants Get Food Initial Model*, science notebook, colored markers, chart paper

What have we been up to? Project **slide A**. This navigation takes stock of where the class is by reviewing the aspects of the phenomenon we're trying to explain. Have students open their science notebooks to the page where they have their *How Plants Get Food Initial Model*. Recall that each student may have selected different plants to use for the initial model. Discuss the focus of our investigations over the course of Lessons 1–7.

Suggested prompts	Sample student responses
What are we trying to figure out about maple trees and plants in general?	*We are trying to figure out how plants get food molecules and where food molecules in plants are coming from.*
Turn to your partner and tell them one thing that we have noticed we figured out so far in our investigations.	*Answers will vary and possibly be one of the ideas below:* *We found out that there are sugar and other food molecules (such as other carbohydrates, proteins, and fats) in plants.* *We found out that plants don't take in any sugar or other whole food molecules. Instead, they take in parts of food molecules and rearrange the parts into food molecules.* *We figured out that plants take in water and carbon dioxide and give off oxygen.* *We figured out that there are structures in leaves that allow gases to move into and out of the plant.* *We also figured out that there are structures called chloroplasts in plant cells that move around in response to sunlight.* *We figured out that carbon dioxide, water, and sunlight are all needed for chemical reactions to take place in the chloroplasts in order for the plant to make sugar.* *We argued that the sunlight gives the plant energy so that the plant can do chemical reactions to rearrange the atoms and make food molecules.*

Return to our initial model and driving questions. Display **slide B.** Have students summarize some of the big questions we've been working on in the previous seven lessons before presenting the new lesson question. Then present **slide B** and remind students of our original driving question, *How do plants get their food molecules? Where do the food molecules come from?*

Students do not need to write this question yet, but they should use it to reflect on their *How Plants Get Food Initial Model*. Have students use a different-colored pencil or pen to highlight parts of their original models where they've done investigations.

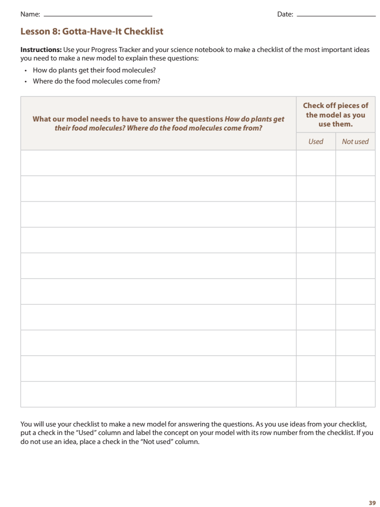
Additional Guidance

Lessons 1–7 focus on explaining how plants get food molecules and where food molecules in plants come from. One fundamental concept that students should develop by the end of Lesson 7 is that plants use sunlight (energy), water, and carbon dioxide to do a series of chemical reactions to make glucose (food molecules) and oxygen. Students were introduced to the term "photosynthesis" in Lesson 6, but in this lesson, students should clearly explicate the matter and energy inputs and outputs of photosynthesis. In this lesson, students should move beyond an initial understanding of photosynthesis to a deep conceptual understanding of what is actually happening during the process.

2. Create a Gotta-Have-It Checklist.

17 MIN

Materials: science notebook, *How Plants Get Food Initial Model*, *Lesson 8: Gotta-Have-It Checklist*


Name: ______ Date: ______

Lesson 8: Gotta-Have-It Checklist

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

- How do plants get their food molecules?
- Where do the food molecules come from?

What our model needs to have to answer the questions *How do plants get their food molecules? Where do the food molecules come from?*	Check off pieces of the model as you use them.	
	Used	*Not used*

You will use your checklist to make a new model for answering the questions. As you use ideas from your checklist, put a check in the "Used" column and label the concept on your model with its row number from the checklist. If you do not use an idea, place a check in the "Not used" column.

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Preview the Gotta-Have-It Checklist. Display **slide C.** Explain to students that they will create a Gotta-Have-It Checklist where they decide which ideas from their Progress Trackers (in their science notebooks) they believe are most important for explaining food molecules in plants. They will use their Gotta-Have-It Checklists next when they develop models to answer the questions, *How do plants get their food molecules? Where do the food molecules come from?*

In order to develop their checklists, students will need to determine which ideas from their Progress Trackers are most necessary for explaining food molecules in plants. Direct students to find their Progress Trackers in their notebooks. Tell students that these are important ideas they have figured out over the past seven lessons and that some ideas may be more critical than others for explaining how plants get their food molecules and where the food molecules in plants are coming from.

Tell students that they will be responsible for developing individual models for one specific plant or food. As a class, we will use individual models to generalize to a broader model for plants.

Create the Gotta-Have-It Checklist. Distribute *Lesson 8: Gotta-Have-It Checklist* to each student. This will be taped into students' science notebooks. Preview how to build the checklist. Students will complete only the left-hand column right now. They should leave the right-hand columns blank for now.

Have students gather in groups of two or three to develop their Gotta-Have-It Checklists. In their groups, they will note the ideas from their Progress Trackers that may help explain the questions, *How do plants get their food molecules? Where do the food molecules come from?* Students record the ideas they want to use on *Lesson 8: Gotta-Have-It Checklist*. They do not need to record every idea from their Progress Tracker, only the ones they want to include in their new models. Students should spend up to 10 minutes working in their groups.

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 they plan to include and why it's important. Ask groups to not repeat the same idea. 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 their Progress Trackers.

Suggested prompts	Sample student responses
Can someone suggest an idea we've figured out from Lessons 1 through 7 that will help us explain how plants get their food molecules and where food molecules in plants come from?	*Plants have sugar and other food molecules in them (Lesson 1).* *Plants don't take in any "whole" food molecules (Lesson 2 and 3).* *Plants take in parts of food molecules from below the surface (water and hydroponic plant food) (Lesson 3) and from above the surface (carbon dioxide) (Lesson 4).* *Plants also give off outputs (oxygen and water) (Lesson 4).* *There are structures on the surface of leaves through which gases can enter and exit (Lesson 5).* *There are also structures in plant cells called chloroplasts that move around in response to sunlight (Lesson 5).* *Plants must do a chemical reaction or a series of chemical reactions in the chloroplasts to rearrange the molecules in water and carbon dioxide in order to make glucose and oxygen (Lesson 6).* *Plants must need sunlight to use as energy to make glucose (Lesson 7).*
Can someone suggest an idea we do not think helps us explain how plants get their food molecules and where food molecules in plants come from?	*Energy can be measured in calories in food (Lesson 7).* *Nitrogen and phosphorus can also be found in plant food for hydroponics (Lesson 2).*

Alternate Activity

An alternative to doing the Gotta-Have-It Checklist using *Lesson 8: Gotta-Have-It Checklist* is to construct the checklist together as a class with a public representation of the ideas the class agrees should be part of the consensus model. If you modify the current activity, keep in mind the following important components to make this activity a productive one:

- The process should be collaborative and involve students arguing from evidence for their ideas.
- There should be a public record, or artifact, of the ideas students agree to include in their models, such as on a white board or chart paper.

3. Revise the Class Consensus Model.

18 MIN

Materials: science notebook, *Individual Midpoint Assessment*, chart paper, colored markers

Form a Scientists Circle for a Consensus Discussion. Display **slide D.** Gather around the initial class consensus model or other public records you might have of how the class represented ideas they figured out in the previous lessons. Have students bring their *Individual Midpoint Assessment* and their science notebooks to the discussion circle. The purpose of this discussion is to put the pieces together about what we've figured out from Lessons 1–7.

Tell students, *We're going to take stock of the ideas in everyone's Gotta-Have-It Checklists and try to build a class consensus model that everyone agrees upon to to show what we have figured out about how plants get food molecules and where food molecules in plants come from. We have begun to answer some of the questions we had represented on our our initial consensus model. Let's work together to represent our thinking now.* **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 they're not sure about or to disagree with someone's or a group's idea. Ask students to pick one of the classroom norms that they feel personally connected with to work on today.*

Facilitate a Consensus Discussion. Display **slide E.** Have students 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 the whiteboard or on chart paper, create a public representation of agreed-upon ideas as the class puts them together.**

Key Ideas

Purpose for discussion: Build a common, class-level model to explain how plants get their food molecules and where food molecules in plants come from, drawing on all the ideas learned in Lessons 1–7. The students' role is to offer proposals 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.

Listen for these ideas:

- Plants have sugar and other food molecules in them (Lesson 1).
- Plants don't take in any "whole" food molecules (Lesson 2).
- Plants take in *parts* of food molecules from below the surface (water and hydroponic plant food) (Lesson 3) and from above the surface (carbon dioxide) (Lesson 4).
- Plants also give off outputs (oxygen and water) (Lesson 4).
- There are structures on the surface of leaves through which gases can enter and exit (Lesson 5).
- There are also structures in plant cells called chloroplasts that move around in response to sunlight (Lesson 5).
- Plants must do a chemical reaction or a series of chemical reactions in the chloroplasts to rearrange the molecules in water and carbon dioxide in order to make glucose and oxygen (Lesson 6).
- Plants must need sunlight to use as energy to make glucose (Lesson 7).
- There are both matter and energy inputs and outputs of the plant system (Lesson 7).

*** Attending to Equity**
Having students select a personal norm for their work today will help to reinforce to them that the class norms are important. This also creates an opportunity for students to actively participate in group work following norms and to self-regulate their participation in group activity. Over time, these norm-reinforcing strategies can help to build a positive group-work culture by encouraging students to identify their resources that can strengthen their group, as well as systems to ensure that all students are actively participating in sense-making.

*** Strategies for This Consensus Discussion**
Taking the time here to take stock of the progress we have made on our model provides an opportunity for the class to synthesize ideas and motivate our next steps of figuring out how the plant stays alive when it is dark or does not have leaves. It also provides an opportunity to reconsider the ideas that students used in their assessment and to clarify any lingering confusion.

*** Attending to Equity**
The key ideas are suggestions for important ideas the model could include. It is important, however, to appropriate the words and ideas that your students use and agree upon during this discussion. Your

class's list of key ideas could be articulated differently and may include other ideas not listed here. Actively look for different ways students share and represent their ideas as an opportunity to communicate to your students that different ways of representing our thinking are valuable.

Additional Guidance

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

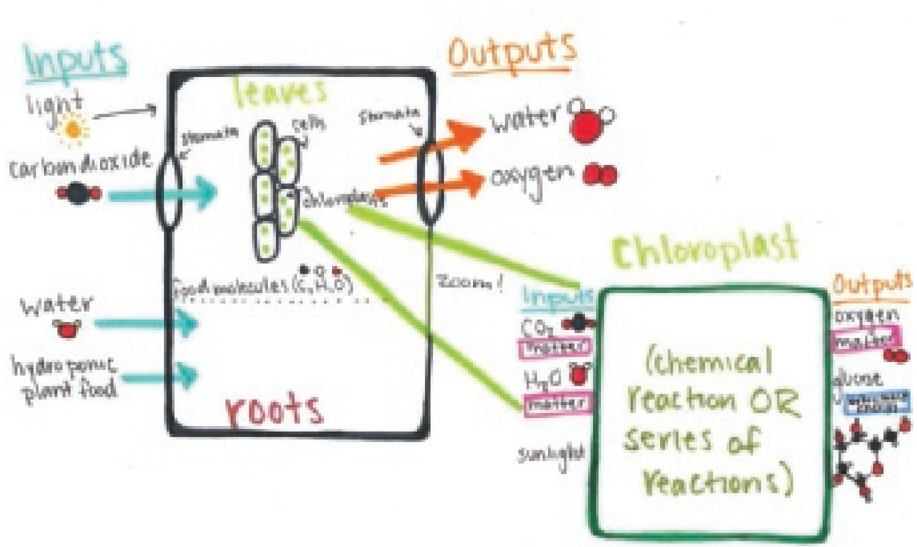
- *How can we represent the inputs and outputs for plants?*
- *How can we distinguish between matter and energy?*
- *How can we represent the rearrangement of molecules?*
- *How can we represent where in the plant all of this is taking place?*

Prompts to ask students to support or challenge proposals:

- *What ideas are we in agreement about?*
- *Are there still places we disagree? Can we clarify these?*
- *Have we missed anyone's ideas or misrepresented anyone's ideas?*

Prompts for proposing modifications or coming to consensus with conflicting ideas:

- *How are these explanations similar? How are they different?*
- *How could we modify what we have so that we can account for the evidence we agree is important to consider?*
- *Is more evidence or clarification needed before we can come to an agreement? What is that?*



At this point in time, we have confirmed inputs and outputs based on evidence to trace where plants are getting their food molecules from. The matter building blocks (carbon dioxide and water) have to make it to the leaves of plants to be rearranged using energy from the sun so that chemical reactions can turn those matter building blocks into a food molecules (sugar). An additional matter output is oxygen. This chemical reaction can only happen in chloroplasts, which are specialized structures in plant cells.

Additional Guidance

In Lesson 4, students noticed that humidity increased in our leaf chambers. This seems to indicate that water is also an *output*. We haven't accounted for this observation in our models yet. Some students may include the increasing humidity in their models. Encourage students to mark the increasing humidity as a part of the model that we may need to investigate further.

4. Update our Progress Trackers (optional). 5 MIN

Materials: science notebook

(Optional) Have students record the final representation of the class consensus model in their Progress Trackers. Students may wish to represent the final representation of the class consensus model by modifying their Progress Trackers from Lesson 7. Taking some individual time to make sense of the class consensus discussion will help them prepare for the upcoming assessment.

Additional Guidance

This lesson is intended to fit within one 45-minute class period, which does not allow time for students to update their individual two-column Progress Trackers. If your class moves through the learning activities faster and/or your have a longer class period available to you, consider giving students the opportunity to complete this update to their Progress Trackers in their science notebooks. **Slide F** is an optional slide provided to you for this purpose. Have students write and draw what they have figured out about the lesson question, *Where are plants getting food from?*

While they are updating their Progress Trackers, ask students, *How does your initial model compare to the class consensus model? What places do we still have questions about on our model? Where are we not yet in consensus? Add your questions to the side of your model.*

Question	Source of Evidence
How do plants get their food molecules? Where do the food molecules come from?	• Investigations from Lesson 1–7
What we figured out in words and pictures	
• Plants have sugar and other food molecules in them (Lesson 1). • Plants don't take in any "whole" food molecules (Lesson 2). • Plants take in parts of food molecules from below the surface (water and hydroponic plant food) (Lesson 3) and from above the surface (carbon dioxide) (Lesson 4). • Plants also give off outputs (oxygen and water) (Lesson 4). • There are structures on the surface of leaves through which gases can enter and exit (Lesson 5). • There are also structures in plant cells called chloroplasts that move around in response to sunlight (Lesson 5).	

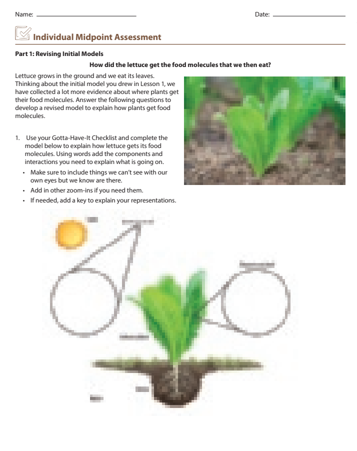
*** Supporting Students in Engaging in Developing and Using Models**
Individual time gives students an opportunity to synthesize evidence and formulate their ideas. As students work, circulate among them, prompting them to defend their models (or part of their models) using evidence collected during investigations in Lessons 1–7. This can help students think through where their models may have a hole before the upcoming assessment.

- Plants must do a chemical reaction or a series of chemical reactions in the chloroplasts to rearrange the molecules in water and carbon dioxide in order to make glucose and oxygen (Lesson 6).
- Plants must need sunlight to use as energy to make glucose (Lesson 7).
- There are both matter and energy inputs and outputs of the plant system (Lesson 7).

End of day 1

5. Check for understanding using the embedded midpoint assessment. 45 MIN

Materials: science notebook, *Lesson 8: Gotta-Have-It Checklist*, *How Plants Get Food Initial Model*, *Individual Midpoint Assessment*, colored markers, tape


Name: ______ Date: ______

Individual Midpoint Assessment

Part 1: Revising Initial Models

How did the lettuce get the food molecules that we then eat?

Lettuce grows in the ground and we eat its leaves. Thinking about the initial model you drew in Lesson 1, we have collected a lot more evidence about where plants get their food molecules. Answer the following questions to develop a revised model to explain how plants get food molecules.

1. Use your Gotta-Have-It Checklist and complete the model below to explain how lettuce gets its food molecules. Using words add the components and interactions you need to explain what is going on.
   - Make sure to include things we can't see with our own eyes but we know are there.
   - Add in other zoom-ins if you need them.
   - If needed, add a key to explain your representations.

MATTER CYCLING AND PHOTOSYNTHESIS | 329

Prepare for the *Individual Midpoint Assessment*. Show **slide G** while students are entering the classroom. Have students take out their *Lesson 8: Gotta-Have-It Checklist* from last class and *How Plants Get Food Initial Model* from Lesson 1. Have students tape or glue their *Lesson 8: Gotta-Have-It Checklist* into their notebooks. Students are now ready to begin the new model for explaining how plants get their food molecules and where the food molecules in plants come from.

Ask students to complete the assessment. Have students individually complete ***Individual Midpoint Assessment***. While this is an embedded assessment that should be answered individually, students can use their Progress Trackers to help recall what evidence, ideas, and models are useful for each question.*

Students should then use their Gotta-Have-It Checklists to create a new model using pictures, symbols, and words to explicate different ideas that help them explain where food molecules in plants are coming from. As they use an idea from their checklists, students should check the appropriate column on their lists. If they decide not to include an idea from their lists, they can check that on their lists as well. Then, encourage students to identify the matter and energy inputs and outputs as they did in Lesson 7.*

*** Attending to Equity**
Some students may benefit from using other modalities, such as a drawing to show their thinking for any or all of the questions on this assessment. You may consider allowing some students to present their answers verbally with you and having a student scribe their thinking on paper. This might allow students to also use gestures to help articulate their understanding about how the cycle of matter and flow of energy is in the system as they explain their thinking. Encouraging students to use other modalities to show their thinking creates an equitable pathway for all students to demonstrate proficiency.

*** Supporting Students in Engaging in Developing and Using Models**
Students are provided pieces of the model (such as the drawing of the plant and the zoom in boxes) to help focus on the components and interactions and not get distracted by drawing non-essential components of the model (such as the plant shape).

ADDITIONAL LESSON 8 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

In this lesson, students construct a written scientific argument in *Individual Midpoint Assessment*. This addresses **CCSS.ELA-LITERACY.WHST.6-8.1** as students must introduce and support a claim about why the scientist was able to survive in the sealed box. Students are provided a scaffold with the components of a strongly written scientific argument to ensure that they include each element outlined in parts A-E of the standard.

LESSON 9

Where do the food molecules in the maple tree come from?

Previous Lesson

We developed a Gotta-Have-It Checklist to highlight the key ideas that we figured out in Lessons 1–7 before we took an individual assessment, applying what we learned to explain new phenomena. We built a consensus model by drawing what we figured out in Lessons 1–7. Our models explained how plants get food molecules and where food molecules in plants come from.

This Lesson

Problematizing

1 DAY

We apply our models to try to explain how maple trees can produce sap in the winter, but we realize that there are some problems with our models. Our models predict that plants only make food molecules when leaves are present, but sugar comes out of maple trees when leaves aren't there. We realize that our models can't yet explain how food molecules can be found in plants when all the inputs or structures needed are gone. We develop initial explanations for how food molecules can be found in plants when leaves aren't present. Then we add new questions to our Driving Question Board (DQB).

Next Lesson

We will use our model to predict that plants don't make food molecules at night and confirm this by analyzing first- and secondhand data. Evidence that plants in the dark take in oxygen and release carbon dioxide and water will push us to wonder whether plants also do cellular respiration.

Building Toward NGSS

MS-LS1-6, MS-LS2-3, MS-PS1-3

What Students Will Do

Ask questions to refine our model of plants to show the inputs and outputs, and energy and matter flows over time to explain how food molecules can be present during times that plants do not have leaves or chloroplasts.

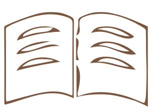
What Students Will Figure Out

- Maple trees are tapped in early spring before there are any leaves.
- Maple trees have sap, or food, even in the winter when there aren't leaves on the tree.
- People have been tapping trees for sap for a long time.
- Besides maple trees, there are other trees that produce sap, which can be collected and made into syrup.

Lesson 9 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	10 min	**NAVIGATION** Revisit some of students' questions on the DQB and develop answers to them.	A–B	Driving Question Board
2	7 min	**APPLY OUR MODELS TO EXPLAIN WHY SUGAR IS FOUND IN MAPLE TREES** Consider how our models can be used to explain why sugar is found in maple trees after collecting more information about how and when trees are tapped.	C–D	revised classroom consensus model from Lesson 8, *Reading: The History of Maple Tree Tapping*, computer and projector to show the video clip Maple Tree Tapping - Unit 7.4 Matter Cycling & Photosynthesis Lesson 1 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)
3	12 min	**DEVELOP INITIAL EXPLANATIONS FOR WHY SUGAR IS FOUND IN MAPLE TREES** Use our models to try to explain why sugar is found in maple trees. Realize that our models cannot help us explain why sugar is found in maple trees during times when the trees do not have any leaves.	E–F	revised class consensus model from Lesson 8
4	16 min	**ADD TO OUR DRIVING QUESTION BOARD** Revise the driving question and add new questions to the DQB.	G–H	sticky notes, colored markers, Driving Question Board
				End of day 1

Lesson 9 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• science notebook • revised classroom consensus model from Lesson 8 • *Reading: The History of Maple Tree Tapping* • revised class consensus model from Lesson 8 • sticky notes • colored markers		• Driving Question Board • computer and projector to show the video clip Maple Tree Tapping - Unit 7.4 Matter Cycling & Photosynthesis Lesson 1 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-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.

Gather materials for the DQB: sticky notes, markers, strips of paper for students to attach answers to questions that can be removed from the DQB.

Test the video of where maple syrup comes from. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Prepare student access to *Reading: The History of Maple Tree Tapping*.

Online Resources

Lesson 9 • Where We Are Going and NOT Going

Where We Are Going

This lesson motivates future investigations to figure out why plants need food molecules like proteins, carbohydrates, and fats in the first place. Such investigations are essential in helping students understand that the sugars created in photosynthesis can be used immediately (through cellular respiration) or stored for later use. It is important to note that maple trees aren't actually making sugar during the winter; they are simply releasing stored sugar that are stored in their roots. During the summer months, maple trees store sugar made during photosynthesis as starch. In the late winter and early summer, the starches are broken down into sugars and flow through the tree to aid with the growth of new leaves. The difference in temperature during the late winter/early spring (cool nights and warm days) creates a freeze-thaw cycle in the springtime that causes the sap in the maple tree to flow freely up through the trunk of the tree from the roots, thus allowing trees to be tapped and sap to be collected.

Where We Are NOT Going

A key realization in this lesson is that our models do not yet account for sugar (and other food molecules) found in trees during times when leaves are not on the trees. In later lessons, students will figure out that plants store sugars for later use, which explains why sugar can be found in maple trees. A competing explanation that students may develop and want to test is that sugar can be made elsewhere in trees besides the leaves.

1. Navigation

10 MIN

Materials: science notebook, Driving Question Board

Take stock of questions we've answered from the Driving Question Board. Have students relocate into a Scientists Circle around the Driving Question Board (DQB) and show **slide A** to take stock of questions answered. Have students select two questions from the DQB to answer. Have students record their answers to the questions in their science notebooks.*

Share out questions and responses to the selected DQB questions. Project **slide B.** As students share their responses, have the class decide whether the question was fully answered, partially answered, or still needs more work. If the question was fully answered, move the sticky note to a new section of the DQB labeled "Questions we have answered." If the question was partially answered, put a check mark on the question to keep track of questions we are making progress toward but are not fully answered yet, but leave it on the DQB.

Additional Guidance

At the end of the lesson, students will be adding additional questions to the DQB. It is important to capture any new questions that students have, but don't spend too much time adding additional questions to the DQB until the end of this lesson.

Assessment Opportunity

You may wish to expand this activity into an opportunity for assessment by having students develop more extensive responses to the questions from the DQB. Consider selecting several central questions as a class and have all students respond to those central questions using evidence collected up until this point in the unit. Provide students with feedback on their progress toward making sense of the questions. You may wish to post student responses (as evidence) under "Questions we have answered" on the DQB.

*** Supporting Students in Engaging in Asking Questions and Defining Problems**
Revisiting the DQB helps students track the progress the class is making toward answering questions that were important to them. This helps build and sustain student buy-in, keeps learning relevant to students, and can generate new questions that may continue to motivate new directions to pursue.

2. Apply our models to explain why sugar is found in maple trees.

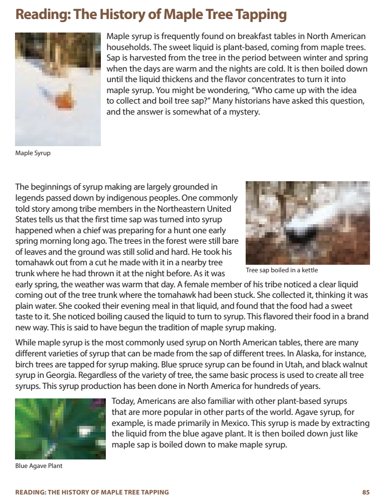
7 MIN

Materials: science notebook, revised classroom consensus model from Lesson 8, *Reading: The History of Maple Tree Tapping*, computer and projector to show the video clip. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Recall the anchoring phenomenon. Project **slide C.** Say, *Last time, we revised our class consensus model to capture all we have figured out about how a plant gets food based on our investigations so far. Remember, though, that our anchoring question was about maple trees. We wondered, "How can sugar be found in a maple tree?" Let's return to that question now. What are some of your initial ideas about how our models can be used to explain why sugar is found in maple trees?*

Rewatch the video of the maple tree being tapped. Suggest that it might be helpful to rewatch the video that we watched in Lesson 1 of the maple tree being tapped. Show **slide D** and have students open to the next blank page of their science notebooks. Tell students to title this page, "Tapping Maple Trees". Instruct students to create a Notice and Wonder T-chart to use while rewatching the video. After students have prepared the tables in their science notebooks, rewatch the video. After watching the video, give students a couple minutes to silently record their noticings and wonderings.

Introduce an article about the history of maple tree tapping. Pass out *Reading: The History of Maple Tree Tapping*. Share with students that you have an article that might provide some more information about maple trees when they are tapped for sap. Encourage students to think about what we know so far about the structures and inputs that are necessary for trees to make food molecules when they are reading and recording noticings and wonderings.



Reading: The History of Maple Tree Tapping

Maple syrup is frequently found on breakfast tables in North American households. The sweet liquid is plant-based, coming from maple trees. Sap is harvested from the tree in the period between winter and spring when the days are warm and the nights are cold. It is then boiled down until the liquid thickens and the flavor concentrates to turn it into maple syrup. You might be wondering, "Who came up with the idea to collect and boil tree sap?" Many historians have asked this question, and the answer is somewhat of a mystery.

Maple Syrup

The beginnings of syrup making are largely grounded in legends passed down by indigenous peoples. One commonly told story among tribe members in the Northeastern United States tells us that the first time sap was turned into syrup happened when a chief was preparing for a hunt one early spring morning long ago. The trees in the forest were still bare of leaves and the ground was still solid and hard. He took his tomahawk out from a cut he made with it in a nearby tree trunk where he had thrown it at the night before. As it was early spring, the weather was warm that day. A female member of his tribe noticed a clear liquid coming out of the tree trunk where the tomahawk had been stuck. She collected it, thinking it was plain water. She cooked their evening meal in that liquid, and found that the food had a sweet taste to it. She noticed boiling caused the liquid to turn to syrup. This flavored their food in a brand new way. This is said to have begun the tradition of maple syrup making.

Tree sap boiled in a kettle

While maple syrup is the most commonly used syrup on North American tables, there are many different varieties of syrup that can be made from the sap of different trees. In Alaska, for instance, birch trees are tapped for syrup making. Blue spruce syrup can be found in Utah, and black walnut syrup in Georgia. Regardless of the variety of tree, the same basic process is used to create all tree syrups. This syrup production has been done in North America for hundreds of years.

Today, Americans are also familiar with other plant-based syrups that are more popular in other parts of the world. Agave syrup, for example, is made primarily in Mexico. This syrup is made by extracting the liquid from the blue agave plant. It is then boiled down just like maple sap is boiled down to make maple syrup.

Blue Agave Plant

READING: THE HISTORY OF MAPLE TREE TAPPING 85

Say, *I have an article to share with you that includes some information about maple trees being tapped for sap. As you read through it, keep our question "How can sugar be found in a maple tree?" in mind and continue to add to your Notice and Wonder chart.*

Have students share out their noticings and wonderings. During this discussion, make sure that the idea that sugar can come out of maple trees in the form of sap during a time of year when leaves are not found on the trees emerges.

Suggested prompts	Sample student responses
What did you notice from the article?	*Responses will vary.*
According to legends from indigenous peoples, when did they first find that sap came out of the trees?	*In spring they found that something was dripping down from the trees where a tomahawk was thrown the night before.*
Describe what the trees looked like when this happened.	*The trees were bare, which means they didn't have any leaves.*

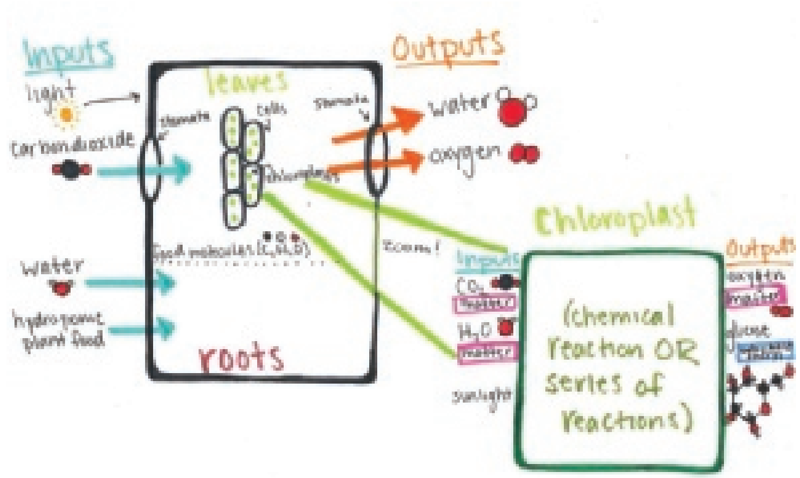
Additional Guidance

Although it is important that the idea that sugar can come out of maple trees during times when leaves are not on the trees emerges in this discussion, it is not important that students identify this idea as a problem in their models just yet. In the next step in this lesson, students will attempt to use their models to develop an explanation for why sugar is found in maple trees. At that point, problematizing the idea that sugar comes out of maple trees during times when leaves aren't found on the trees will become central to the discussion.

3. Develop initial explanations for why sugar is found in maple trees.

12 MIN

Materials: science notebook, revised class consensus model from Lesson 8



Lead a whole-class Consensus Discussion to help students use and apply our classroom consensus model from Lesson 8 to construct explanations for why sugar is found in maple trees. Show **slide E** and begin the discussion by asking students to use our models to explain how maple trees produce sugar.

Key Ideas

Purpose:

Transition into a discussion about what our classroom consensus model cannot explain. During this discussion, emphasize the idea that our model predicts that plants can only make food when leaves or chloroplasts are present, but sugar flows out of maple trees when there aren't any leaves on the tree. Furthermore, the sugar in the trees is found in the trunk (woody part), not in the leaves.

Listen for:

- Sap comes out of trees after the weather starts warming up. Maybe the tree can make food somewhere else.
- Our model shows that maple trees can only make food when there is sunlight, water, and carbon dioxide, which they have in the winter.
- But we also saw that the maple tree needed leaves and there are no leaves on the tree in the winter, so maybe our model is missing something?
- We might need to figure out how the tree can have sugars in the woody trunk part.

Our models predict that the sugar would be found in the leaves. This may also be a key moment to return to the observation that plants have an output of water that we haven't yet accounted for (the humidity went up in our leaf chamber). Further, students may recognize that our list of related phenomena includes many different kinds of food molecules, but our models have only accounted for sugar.

Suggested prompts	Sample student responses
What do our models help us explain?	*Maple trees can make sugar when they get carbon dioxide, water, and sunlight. Maple trees can only make food molecules when they have leaves or chloroplasts present.*
What do our models help us not explain?	*Our models aren't helping us explain how a maple tree can have sugar inside of it when it doesn't have any leaves. We made the observation that maple trees produce sugar in the winter when they don't have any leaves. That observation isn't consistent with our models, which show that plants can only produce sugar when the leaves are present. Maybe there is an issue with our models. Or maybe something else is going on (such as food molecule storage).* *Our models aren't helping us explain how the sugar can be found in the wood of the tree. We expected that the sugar would be found in the leaves.* *We also noticed that on our list of related phenomena, plants produce many different kinds of food molecules. So far, we are only talking about sugar. What about the different food molecules?*
What alternative explanations do you have to explain why sugar is found in maple trees?	*We might need to modify our models. Maybe plants can make food even without leaves and our models are wrong since they predict that sugar should not be made without green chloroplasts.*
If we think back to the Unit 7.3: How do things inside our bodies work together to make us feel the way we do? (Inside our Bodies Unit), what do our bodies do with excess food molecules? Could plants do something similar?	*If we use our current models, maybe food can be made in the summer and then transported or stored during the winter. That might help us explain why the sugar seems to be in the woody part of the tree.*

Summarize the problem that students uncovered in this lesson. Be sure to emphasize the idea that our models predict something different from what we are observing. Highlight the three problems with the model: (1) Our models predict that plants can only make food molecules when the leaves are present, but we see sugar come out of the maple tree when the maple tree doesn't have leaves. (2) Our models only explain how plants make sugar, but we saw other food molecules in plants. (3) Our models don't yet account for the output of water, but we noticed that humidity increased in our leaf chambers.

Say, *Our models predict that plants can only make sugars when there are leaves on the plant. But we saw something weird in the video—we saw sugar coming out of maple trees when there were NO LEAVES on the tree. This observation isn't consistent with our models.*

We also noticed that in our list of related phenomena we have plants with all sorts of food molecules in them (sugar, carbohydrates, fats, and proteins), but so far, our models only account for plants making sugar. Where are the other food molecules coming from? Finally, we made the observation that plants seem to be giving off water in addition to taking in water. We haven't explained why plants give off water yet. It sounds like we have some more work to do!

Develop initial explanations for the questions, "How can plants have food molecules in them when all the inputs or structures needed to make food molecules aren't present? Why do plants need food molecules?" Project **slide F** and introduce these guiding questions. Orient students to the focus for the next lesson set.

Say, *OK, so we are a little stumped with the maple tree. It is also really weird that the maple tree has sap in it in the first place. I wonder, why might plants be making food molecules?*

Have students share their initial explanations to the following questions: "How can plants have food molecules in them when all the inputs or structures needed to make food molecules aren't present? Why do plants need food molecules?"

Suggested prompts	Sample student responses
How can plants have food molecules in them when all the inputs or structures needed to make food molecules aren't present?	*It seems like plants must be able to make food molecules at a certain time of year (when they have leaves) and then somehow store the food molecules.*
Why do plants need food molecules?	*Maybe plants use food for energy, just like we learned in the Inside our Body Unit. Maybe plants use some food immediately and store some for later.*
	Maybe plants can make food without leaves and our models are wrong.

4. Add to our Driving Question Board.

16 MIN

Materials: sticky notes, colored markers, Driving Question Board

Post the new "big" questions to the DQB: "How can plants have food molecules in them when all the inputs or structures needed to make food molecules aren't present? Why do plants need food molecules?"

Generate new questions for the DQB. Show **slide G** and have students write down new questions they are now thinking about. Students should write down one or two questions on sticky notes 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 a partner.

Relocate to the DQB and show **slide H**.

Assessment Opportunity

This is a key time to revisit the DQB since we have just figured out the model we thought we had completed at the end of Lesson 8 is incomplete. We have new information from the video and the reading that leads to use having more questions about how and why plants make food. As students share their questions with the class and place them on the DQB, you can ask them to put their name or initials on the back of the sticky note. Then you can use these questions to collect formative assessment data about each students ability to ask testable questions that will help us collect data and figure out how to refine and/or revise our plant model.

Review these steps for forming the DQB:

- The first student comes up to the DQB with their sticky note, faces the class, and remains standing. The student reads their question off the note and then posts it on the DQB near the section of the consensus model or related phenomena it is most related to. *(Note: If the model is off to the side, students can post their notes in a new space on the board.)*
- The 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 and says what other question on the board it relates to and why or how. Then the student places his or her question near the question it most relates to and selects the next student. This process continues until everyone has had a chance to post a question.

Organize questions into groups. As students share, questions will naturally start clustering into similar parts of the model or 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.

The big questions for the DQB should now be: "How can plants have food molecules in them when all the inputs or structures needed to make food molecules aren't present? Why do plants need food molecules?"

Student questions may include the following:

- Why would plants be making food molecules?
- Are plants making them to eat them somehow?
- What are the plants using them for?
- Did they really come from the leaves to here?
- Can plants make sugar without leaves?
- If plants need sun to make sugar, what happens at night? Do they stop making sugar?
- What happens in the winter?
- If plants stop making food, do they stop taking in CO_2 and giving off O_2?
- Why don't plants die in the dark?
- Why don't plants die when they don't have leaves?

Summarize new territory the class has questions about:

Say, *We really have many questions about how can plants have food molecules when they don't have everything they need! Let's dig into some of these new questions next time.*

LESSON 10

Why don't plants die at night?

Previous Lesson

We applied our models to try to explain how sugar can come out of maple trees when leaves aren't present, but we realized that our models can't yet explain how food molecules can be found in plants when all the inputs or structures aren't there. We added new questions to the Driving Question Board.

This Lesson

investigation

2 DAYS

We use our model to predict when plants don't make food molecules and wonder why plants don't die at night. We conduct an investigation and produce data showing that plants release carbon dioxide and water when in the dark. We analyze and interpret secondhand data and discover that plants take in oxygen in the dark. We argue that, indeed, photosynthesis doesn't happen in the dark, but now we are curious about what is happening. We wonder, are plants breathing like us? We compare our findings to humans and theorize that maybe plants burn stored food through cellular respiration when they can't make food molecules through photosynthesis.

Next Lesson

We will plan and carry out an investigation to see whether plants without leaves (sprouting seeds) do cellular respiration. We will read about where this happens in plant (and animal) cells and what plants do with extra food they produce from photosynthesis. We will explain what happens to a maple tree in a time-lapse video over many years.

Building Toward NGSS

MS-LS1-6, MS-LS2-3, MS-PS1-3

What Students Will Do

Use a model of the plant system to predict that plants do not do photosynthesis in the dark.

Analyze and interpret data to identify patterns that show that in the dark, plants take in oxygen and release carbon dioxide and water.

Communicate information about the relationship between energy and the cycling of carbon dioxide and oxygen (matter) in and out of plants.

What Students Will Figure Out

- In the dark, plants do not do photosynthesis.
- Instead, they do some kind of chemical reaction that takes in oxygen and releases carbon dioxide and water (cellular respiration).

Lesson 10 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	10 min	**NAVIGATION** Use the consensus model to predict what conditions would lead to plants not making food molecules and consider real-world examples when this happens. Realize that plants don't die right away when they aren't photosynthesizing and wonder why not.	A–B	class consensus model, chart paper, colored markers
2	20 min	**PLAN AND INVESTIGATE PHOTOSYNTHESIS IN THE DARK** Set up a closed system to monitor carbon dioxide and water levels within a closed system in the dark for 10 minutes. Record what the patterns show.	C–G	
3	12 min	**MAKE SENSE OF OUR RESULTS** Compare patterns from this investigation and Lesson 4 and discuss findings as a class. Decide that this could be evidence that photosynthesis is not happening but we still need to know what's happening with oxygen.	H–I	*Data Table for Leaves in the Dark*, *Investigating Above the Surface Inputs* (should be taped into student's science notebook), chart paper, colored markers
				End of day 1
4	20 min	**ANALYZE SECONDHAND DATA** Evaluate second hand data produced by other students who measured carbon dioxide, water, oxygen, and light. Analyze and interpret these data using the I^2 strategy and discuss patterns.	J–O	*Another Plant Experiment in the Dark*, *Secondhand Data for Leaves in the Dark*, *Data from Leaves in the Light* (should be taped in science notebook), tape
5	7 min	**COMMUNICATE OUR FINDINGS** Communicate findings about what is happening with photosynthesis in the dark by creating a 1-minute news release.	P	*Communicating Information from Scientific Text Checklist*, notecard, tape
6	13 min	**BUILDING UNDERSTANDINGS DISCUSSION** In a Scientists Circle, make claims that photosynthesis is not happening, based on evidence from first- and secondhand data. Review what happens when people burn food as fuel and, based on evidence from first- and secondhand data, wonder whether the same thing is happening in plants when they can't make food molecules.	Q–S	chart paper, colored markers
7	5 min	**GENERATE NEXT STEPS** Discuss other times when plants are not doing photosynthesis and could be burning stored food instead. Record ideas on an exit ticket about how to investigate this idea when plants don't have leaves or aren't getting water.	T	notecard
				End of day 2
		SCIENCE LITERACY ROUTINE Upon completion of Lesson 10, students are ready to read Student Reader Collection 3 and then respond to the writing exercise.		Student Reader Collection 3: *Our Changing Planet*

Lesson 10 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide** **Student Work Pages**	• science notebook • *Data Table for Leaves in the Dark* • *Investigating Above the Surface Inputs* (should be taped into student's science notebook) • *Another Plant Experiment in the Dark* • *Secondhand Data for Leaves in the Dark* • *Data from Leaves in the Light* (should be taped in science notebook) • *Communicating Information from Scientific Text Checklist* • notecard		• class consensus model • chart paper • colored markers • tape

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.

Watch Lesson 10 Video demo of setup. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Online Resources

Test the experiment setup yourself before class.

Day 1: Carbon dioxide/water lab

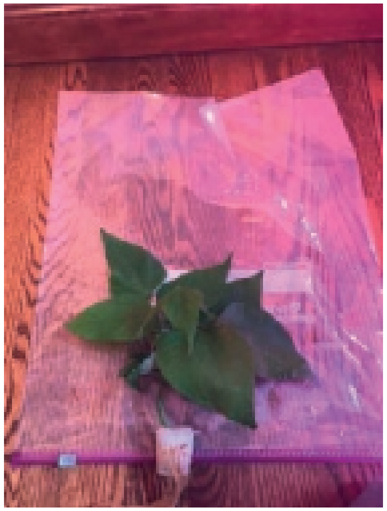
- **Group size:** whole class
- **Setup:** Watch video for a demo of the setup. Gather materials for the lab. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)
  1. Decide what plant leaves to use.
     - You will need 40+ square inches of leaf area (~10-12 leaves) to get a noticeable change in carbon dioxide level in 10 minutes.
     - Fresh spinach leaves work best, so purchase them no more than 1-2 days before the investigation.
     - Alternatively, use your hydroponically grown spinach or radish leaves (if available) or store bought hydroponic plants (like green leaf lettuce). You may need to use 1 or 2 plants to get the necessary leaf area.
  2. Conduct a trial run to see whether you can get a reliable increase in carbon dioxide levels. If not, consult *Tips for teachers on the CO_2/RH detector experiment* for troubleshooting.
     - Check to make sure that the carbon dioxide detector is working properly.
     - Lay out and test the lab materials as suggested in video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**).

- The image shows the piece of aluminum foil with the spinach leaves used in the video on a 1-gallon ziplock bag. If your spinach leaves take up more area, it may be difficult to reseal the bag and have enough room for the detector.
- If the carbon dioxide level is decreasing, make sure that you are keeping the spinach leaves in the dark as much as possible prior to placing them in the bag. Keeping the arranged spinach leaves under a box prior to placing them in the bag and/or turning off the overhead lights should help.
- You want to see an increase in carbon dioxide of at least 50 ppm after the leaves are in the dark bag for 10 minutes.
- Alternate activity: If you are using hydroponically grown plants, only place the leaves in the bag and keep the roots outside. Depending on the size of the plant, you may need to use a 2-gallon ziplock bag as shown on the right. You can place the roots in a cup of hydroponic plant food solution during the experiment (optional).

- **Notes for during the lab:** Use the setup from your trial that gave measurable changes in carbon dioxide (~50 ppm increase) and water levels after 5-10 minutes. Use a new ziplock bag and new spinach leaves for each class or data collection if you do the experiment more than once per class.
- **Disposal:** Ziplock bags and used spinach can go in the wastebasket. You will not need any remaining spinach leaves for future lessons.
- **Storage:** To keep spinach leaves fresh, store in refrigerator until needed.

Lesson 10 • Where We Are Going and NOT Going

Where We Are Going



In the Unit 7.3 *How do things inside our bodies work together to make us feel the way we do?* (Inside our Bodies Unit), students should have developed the idea that people burn food as fuel through cellular respiration as well as the idea that matter cannot spontaneously appear or disappear. This lesson starts to introduce the key idea from NGSS Disciplinary Core Idea PS3.D, that the burning of fuel and cellular digestion in plants involves chemical reactions with oxygen that release stored energy and produce carbon dioxide and water.

Students may come in with ideas that plants "breathe in" carbon dioxide and "breathe out" oxygen. In this lesson, through first- and secondhand data analysis, they will see that, in fact, plants also take in oxygen and release carbon dioxide in the dark, just like humans. This may be counterintuitive to students, but producing and analyzing these data should help convince students that it is also happening, even if they can't yet explain why.

Where We Are NOT Going

Students start to develop ideas that plants are using oxygen to burn food molecules and release energy, water, and carbon dioxide when they are not doing photosynthesis. However, by the end of this lesson, students are not yet sure about this and will confirm this idea after gathering more evidence in Lesson 11. In Lesson 11, they will also figure out that plants do this chemical reaction, cellular respiration, all the time and not just when it's dark.

LEARNING PLAN FOR LESSON 10

1. Navigation

10 MIN

Materials: science notebook, class consensus model, chart paper, colored markers

Revisit ideas about why plants are making food molecules (slide A).

Remind students, *We know plants make food molecules, and last session, we started wondering why. We came up with a lot of new questions to explore. Let's think hypothetically about what would happen to a plant if it stopped making food molecules. And, using our model to make a prediction, is this even possible? Could a plant stop making food molecules?*

Have students stop and jot ideas, drawing on the consensus model from Lesson 8 and their initial explanations from Lesson 9 where they explained how plants can have food molecules in them when all the inputs or structures needed to make food molecules aren't present.

Students should think about these questions:

- What would happen to a plant if it stopped making food molecules?
- Could a plant stop making food molecules? What can our model tell us about what might cause a plant to stop making food molecules?

Lead a whole-class discussion using the model to make predictions. Display slide B. Have students share their ideas about what would happen to a plant if it stopped making food molecules and how that could happen, according to our consensus model.*

Suggested prompts	Sample student responses
What would happen to a plant if it stopped making food molecules?	*It might die.* *It would stop growing but survive.*
Could a plant stop making food molecules? What can our model tell us about what might cause a plant to stop making food molecules?	*when one of the inputs to the chemical reaction is not available (e.g., no light, no water, no carbon dioxide)* *when the place for the reaction is not available (e.g., no leaves means no chloroplasts)*

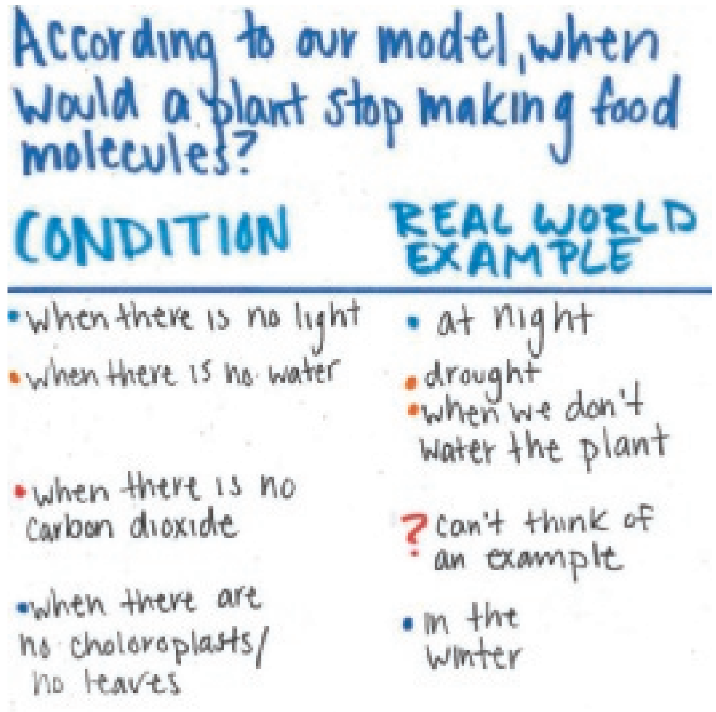
Additional Guidance

If students only consider conditions where an input for the reaction is not available (e.g., light, water, carbon dioxide), ask them, *Where in the plant does the photosynthesis reaction happen?* This will help students think about how a plant would stop making food molecules if not all the inputs for the reaction were available, and also if the the location where photosynthesis happens (i.e., in chloroplasts within leaves) is also not on the plant.

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

The consensus model the class developed in Lesson 8 is a useful tool because students can apply it to make predictions. Help students recognize that the models they are developing are helpful thinking tools by saying, *Let's use our consensus model to help us think about when a plant might stop making food molecules.*

As students share conditions under which our model predicts that plants would stop making food molecules, record these on a chart in a public place.



Suggested prompts	Sample student responses
Do these conditions ever happen in the real world?	*Yes, there's no light at night.*
	There's no water during drought or when we don't water our plants.
	There's always carbon dioxide. But maybe if the mouths (stomata) were closed for some reason, the gas couldn't go in.
	There are no chloroplasts when there are no leaves. That happens in the winter, like in the maple tree or when a plant is a tiny seed and hasn't made any leaves yet. (It's OK if students don't bring up seeds. We will motivate that at the start of Lesson 11.)
How do plants respond?	*Plants seem OK at night.*
	Plants get droopy without water and eventually die.
	Plants seem OK without leaves, like the maple tree. The leaves grow back the next year.

Problematize what our model predicts and what we know about how plants respond when they are without light, water, carbon dioxide, or chloroplasts/leaves.

Say, *Our model predicts that plants would stop making food molecules when there is no light, water, carbon dioxide, or chloroplasts. We think plants might need food molecules to grow and survive. But we also know from our experience that plants don't die at night, they don't die immediately when they don't have water, and they don't die without leaves, like in the maple tree. So, why not?*

Tell students we'll have a chance to investigate some of our other questions, and for now we'll start with light, asking *Why don't plants die at night*?

2. Plan and investigate photosynthesis in the dark. 20 MIN

Materials: None

Have students turn and talk to plan an investigation. Project **slide C** and have students talk about how we can test to see what is happening with photosynthesis at night.

Have students share their ideas for how to investigate this with the class. The purpose of this discussion is for students to think through how they could investigate our class question using similar methods from the Lesson 4 investigation when they looked at gases going into and out of plant leaves under light, only they will monitor gas levels every minute and place the plants in the dark.

Suggested prompts	Sample student responses	Follow-up questions
How could we test what is happening with photosynthesis at night?	*measure the gases going into and out of leaves in the dark*	*(If students struggle to generate ideas, ask:) How did we gather evidence for what was happening with photosynthesis before? (And if they don't suggest using a carbon dioxide detector, ask:) What tools did we use, and what gases did we measure?*
Have we done any investigations in the past where we monitored what was going into or out of leaves?	*Oh yeah! We used that detector to measure the amount of water and* CO_2 *in leaves.*	*How could we modify our experimental design that we've used before to test what is happening at night?*
How exactly should we set up the closed system?	*Put the leaves into the ziplock bag with the carbon dioxide detector. Then cover it with something so it's in the dark. Measure it for 10 minutes.*	*(If students don't suggest what gases to measure or how long to measure them for, ask:) Which gases should we record? or How long did it take us last time to see changes?*
How frequently should we record levels of carbon dioxide and water?	*Every minute? Last time it changed within 10 minutes.*	*(If students don't suggest recording data every minute, ask:) How often did we record data in Leeson 4? How could we get more information?*

Slide D provides a reference to remind students about what the carbon dioxide detector measures.

Place the carbon dioxide detector in the 1-gallon ziplock bag and seal it. Remind students that the carbon dioxide detector needs some time to stabilize, so you'll put the carbon dioxide detector into the bag now.

Additional Guidance

You want the carbon dioxide detector to sit inside the ziplock bag for about five minutes so the reading can stabilize. It will fluctuate initially because of students breathing nearby. Placing the detector in the bag now gives some time for the reading to stabilize.

Alternate Activity

If your hydroponic plants are large enough to put in a closed system and see a change in carbon dioxide and water vapor levels, you can use those. Be sure to test this ahead of time.

Materials needed:

- One or two of your hydroponically grown spinach or radish plants.
- A cup with hydroponic plant food solution that you can place the roots in (optional).
- All the additional materials outlined in the lab setup.

Alternate setup:

- Only place the top part of the plant (the leaves) into the ziplock bag. Leave the sponge, basket, and roots outside the bag.
- Optional: Place the plant roots in the cup of hydroponic plant food and water solution. This is not necessary, but you can do this if students want to.

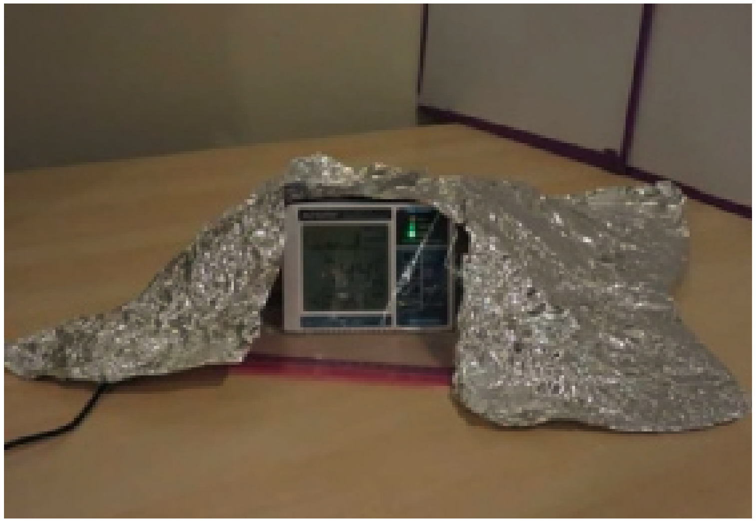
Prepare for data collection. Have students tape their data tables into their science notebooks and fill in the gases they will be monitoring (**slide E**). Create a data table on the board or on chart paper for the class like the one below that includes time (add lines to record measurements for 10 minutes) and two additional columns, one for carbon dioxide and one for water vapor.

Time (minutes)	Carbon dioxide (CO_2) gas, ppm	Water vapor (H_2O), % relative humidity
0		
1		
2		
3		
...		
10		

Have students make a prediction. Have students record a prediction about what will happen to the amount of each substance and why (in part A of *Data Table for Leaves in the Dark* handout and **slide F**). Then have a few students share what their predictions were with the class. A student prediction might look like:

- *Maybe carbon dioxide and water levels will stay the same because photosynthesis isn't happening*.

Invite several student volunteers to prepare for data collection. The system has now been closed for about five minutes, so the carbon dioxide and relative humidity levels should have stabilized. Invite three students up to prepare for data collection. Have one student be ready to record readings on the board, one student be ready to call out one-minute intervals, and one student be ready to call out carbon dioxide and water readings.



Take an initial carbon dioxide reading. Do not take the detector out of the bag for this reading because this is our baseline for within the closed system. Have students record those carbon dioxide and water readings as time 0 on the class chart and in part B of *Data Table for Leaves in the Dark* handout.

Set up the closed system with the plant in it.

- Open the sealed ziplock bag with the carbon dioxide detector inside.
- Uncover the 10-12 spinach leaves (right side up) on the piece of aluminum foil and place them inside the ziplock bag. Be sure that the leaves are not covering each other too much.
- Seal the ziplock bag.
- Quickly cover the ziplock bag with the aluminum foil so no light can get in, but also so you can see the carbon dioxide detector (see image to the right).

Additional Guidance

If the spinach leaves were not kept in the dark prior to placing them in the bag and covering them with aluminum foil, carbon dioxide levels may initially decrease as photosynthesis stops and cellular respiration takes over.

Note that this is not an airtight system, but it will suffice for capturing changes in carbon dioxide and water vapor within the system.

Record measurements for 10 minutes. Have the students record readings every minute for 10 minutes. If students want to keep this setup going, leave it to return to at the end of class. Project **slide G**, and have students fill out parts C and D of their tables.

3. Make sense of our results.

12 MIN

Materials: *Data Table for Leaves in the Dark*, science notebook, *Investigating Above the Surface Inputs* (should be taped into student's science notebook), chart paper, colored markers

Have students work in small groups to compare these findings to the findings from Lesson 4, with the plants in the light. Have students make a table in their notebooks to compare their findings from the investigations in the light (Lesson 4) and in the dark (this lesson) (**slide H**). Have students review their Data Table and notes in their science notebooks from Lesson 4. Prompt students to discuss and record the patterns they saw with carbon dioxide and water in both light and dark conditions. Listen for students discussing how the carbon dioxide pattern is the opposite and the water pattern is the same.

	Light (Lesson 4)	Dark (Lesson 10)
Carbon dioxide	CO_2 decreased, so the plant is taking in CO_2.	CO_2 increased, so the plant is releasing CO_2.
Water	Water increased, so the plant is releasing water.	Water increased, so the plant is releasing water.

Make sense of our results. Have pairs of students respond to the "Making sense of our results" questions on *Data Table for Leaves in the Dark* handout. Then have students share out their ideas with the whole class in a Building Understandings Discussion (**slide I**).

Key Ideas

The purpose of this whole-class discussion is to guide students to come to a consensus that plants are releasing carbon dioxide and water, and that this provides some evidence that photosynthesis might not be happening in the dark, but something different might be happening instead. As students share these important ideas, record them on chart paper so you can circle back to them at the end of the Lesson 11 when they will update the Progress Tracker.

Suggested prompts	Sample student responses
What is happening with photosynthesis in the dark? What claims can you make based on evidence from this investigation and our previous investigation in Lesson 4?	*Plants are releasing carbon dioxide, because carbon dioxide levels in the air inside the bag went up. This is the opposite of what happens with carbon dioxide during photosynthesis.* *Plants are giving off water because the water vapor levels in the air inside the bag went up. This is the same as what we saw during photosynthesis, but we don't think plants releasing water is actually part of photosynthesis. That was a lingering question, and we couldn't explain it yet.* *The carbon dioxide evidence suggests that photosynthesis might not be happening in the dark because the opposite thing is happening.* *The water evidence doesn't tell us much about photosynthesis, but it makes us wonder more about what's happening there.*

Suggested prompts	Sample student responses
What are you unsure of or what new questions does this raise for you?	*Why is carbon dioxide going up now?* *Why are plants producing water in the light and the dark?* *What's happening with oxygen? Is it also changing in the dark? It's an output of photosynthesis.*
(If students don't bring up oxygen, ask:) So we have some evidence that photosynthesis might not be happening because carbon dioxide levels are going up instead of down. What other gases change when photosynthesis is happening that could give us more evidence?	*Oxygen levels go up during photosynthesis.*

Additional Guidance

Highlight the question: *Why are plants releasing water in both light and dark conditions?* Revisit the consensus model from before and remind students that photosynthesis doesn't help us explain why plants release water. And now we have evidence that plants release water in the dark also. Leave this as a lingering question that we really need to answer. We will revisit this evidence at the end of Lesson 11 and will use it to help explain that plants release water all the time when they burn sugars as fuel through cellular respiration.

Tell students, *I have data and graphs from the same group of students whose data we looked at in Lesson 4. They did a similar experiment in the dark, and they measured carbon dioxide, water, and oxygen, so we can see whether oxygen is also changing. This will help us be more certain about whether photosynthesis is really not happening in the dark.*

End of day 1

4. Analyze secondhand data.

20 MIN

Materials: science notebook, *Another Plant Experiment in the Dark*, *Secondhand Data for Leaves in the Dark*, *Data from Leaves in the Light* (should be taped in science notebook), tape

Navigate from the previous class and motivate a need to look at secondhand data. Project **slide J** and have students turn and talk to review what we're trying to figure out and what new data we need.

Suggested prompt	Sample student responses
What question were we trying to answer with our investigation in the last class? What are we trying to figure out?	*Why don't plants die in the dark?* *If plants need light to do photosynthesis and make sugar, what happens to plants in the dark?*

*** Supporting Students in Engaging in Analyzing and Interpreting Data**
Encourage students to discuss larger patterns as well as what variation within these messy data means. At this point in the unit, they will be able to compare the data collected for plant leaves in the light (Lesson 4) with data

Suggested prompt	Sample student responses
What did we say we needed to know more about?	*We need more evidence about what other gases are changing when plants are in the dark, like oxygen.* *Oxygen levels also changed when plants were in the light. We want to see whether that is changing in the dark too.*

collected for plant leaves in the dark (this lesson). Encourage students to think about what these different data sets, along with data collected in other lessons, imply about the effect of light (e.g., light causes photosynthesis to occur since when light is present carbon dioxide levels decrease while oxygen levels increase).

Situate the secondhand data set. Have students find the reference *Another Plant Experiment in the Dark* in the Student Procedure Guide and give students time to read through the experimental setup. Project **slide K** and discuss as a whole class how the other students' data were produced in similar and different ways to the data the class collected in the previous session. This is the same setup as Lesson 4, except it is placed under a sweatshirt with no light, instead of under a grow light, so the discussion should be fairly quick.*

Tell students that because these students collected data every second, this led to a very large database. Tell students that you have an example of this table for reference as well as a simplified table and graphs made from data taken every second.

Have students make a prediction. Have students make a chart in their notebooks (**slide L**) and record their predictions in their science notebooks about how carbon dioxide, water vapor, and oxygen levels will change. Have students share some of their ideas. Most students will predict that carbon dioxide will go up and water will go up, based on the experimental results from the previous class. Some students may think that oxygen will also change in the same amount of time.

Introduce and prepare for the Identify and Interpret (I^2) sensemaking strategy. Present **slide M** and remind students how to use the I^2 strategy to analyze and interpret data. Tell them that this time, instead of recording their notes, they can discuss their "What I see" (WIS) and "What it means" (WIM) comments. Arrange students in groups of three. Pass out to each student a copy of *Secondhand Data for Leaves in the Dark* handout. Have students tape this into their science notebooks.

Have students make observations of the graph using "What I see" comments. As they review the data, prompt students to first discuss WIS comments in their small groups. After four to five 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 initially on patterns of increasing and decreasing substances, but then broaden it to other observations students made, such as noise in the oxygen data. Record some of the WIS comments on the board or in an electronic document with a table similar to the one below. **Slide N** provides a reference.*

Interpret observations using "What it means" comments. Have students discuss "What it means" (WIM) for each of their "What I see" comments. These comments are students' initial explanations of what they think is happening to cause the change in data. Give groups four to five 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 carbon dioxide and oxygen. Record some of the WIM comments on the board or in an electronic document.

*** Attending to Equity**
As students share their ideas, acknowledge their sensemaking by recording the WIS and WIM comments in a public place. This will validate the contributions of individual students and help students organize their ideas.

Example WIS and WIM comments:

WIS	WIM
Carbon dioxide steadily increases.	*Plants are releasing carbon dioxide.*
Water vapor steadily increases until it flattens out at 100 percent.	*Plants are releasing water vapor. Once enough is released, the level stays at 100 percent.*
Oxygen levels decrease.	*Plants are taking in oxygen.*
Oxygen level data are noisy.	*Maybe the oxygen sensor is sensitive?*
Light stays constant.	*Light is not causing these changes because it remains constant.*
Light level fluctuates between 0 and 8 lux.	*Maybe the light sensor is sensitive?*

Compare these secondhand data of plants in the dark to the secondhand data from plants in the light in Lesson 4.

Remind students, *We're trying to figure out what is happening with photosynthesis in the dark. We've noticed some weird things happening with carbon dioxide, water, and oxygen. We should compare these data to data we know are evidence of photosynthesis.*

Project **slide O** and have small groups of students compare patterns they notice (WIS) and what they mean (WIM) for oxygen, carbon dioxide, and water from the secondhand data in both light and dark conditions. Have students add a line for oxygen in their comparison data table and record their ideas for all three gases. Encourage students to review their WIS and WIM comments Lesson 4.

	Light (Lesson 4)	Dark (Lesson 10)
Carbon dioxide	CO_2 decreased, so the plant is taking in CO_2.	CO_2 increased, so the plant is releasing CO_2.
Water	Water increased, so the plant is releasing water.	Water increased, so the plant is releasing water.
Oxygen	Oxygen increased, so the plant is releasing oxygen.	Oxygen decreased, so the plant is taking in oxygen.

5. Communicate our findings.

7 MIN

Materials: *Communicating Information from Scientific Text Checklist*, notecard, science notebook, tape

Create a 1-minute news release about what is happening with photosynthesis in the dark. Project **slide P** and have students tape *Communicating Information from Scientific Text Checklist* into their science notebooks. Ask them to work with a partner and use *Communicating Information from Scientific Text Checklist* to plan a 1-minute news release to explain what they think is happening with photosynthesis in the dark to the principal and/or other teachers. Give each pair of students a notecard and tell them their news release must fit on it.**

*** Supporting Students in Engaging in Obtaining, Evaluating, and Communicating Information**
Creating a 1-minute news release provides students a chance to engage in communicating scientific information about the plant (system)

Say, *We are seeing some interesting patterns in the data for carbon dioxide and oxygen collected in the light and in the dark. What is causing those patterns? This is so exciting! It would be great to share it with the principal and other teachers. Work with a partner to create a 1-minute news release to share with them and be sure to include one new question that our findings have raised for you.*

Additional Guidance

Slide P asks students to include inputs and outputs (matter and energy) as well as an explanation in their news release. As mentioned earlier, the data from this lesson and Lesson 4 show water as an output of plants leaves in the light and dark. This will be further addressed in Lesson 11. If students are struggling to see that the processes happening in the light and dark are opposite, ask them to focus on carbon dioxide, water and energy.

Honor students' excitement about creating a 1-minute news release for the principal and other teachers by inviting them to join the beginning part of the Building Understandings Discussion that follows. If they are not available, you can share the notecards with them or ask students to share their new release with another adult.

in writing. The *Communicating Information from Scientific Text Checklist* handout supports students in planning effective written communication by explicitly asking them to consider their audience, the purpose, the constraints, and mode of communication. This task also helps students prepare for the Building Understandings discussion that follows.

*** Attending to Equity**
In the *Communicating Information from Scientific Text Checklist*, students are asked to choose a communication medium (e.g., text, images, tables, diagrams, graphs, equations) and consider what each medium communicates, which gives opportunities for students to use linguistic (oral and written language) and nonlinguistic (drawings, graphs, symbols) modes to engage in sense-making. These opportunities allow multilingual students to create greater meaning than just using one mode over another and demonstrate their knowledge in less language-embedded tasks.

6. Building Understandings Discussion — 13 MIN

Materials: science notebook, chart paper, colored markers

Have students bring their science notebooks and gather in a Scientists Circle for a Building Understandings Discussion about what is happening with photosynthesis in the dark. Invite students to share the claims and supporting evidence from their 1-minute news releases. Then draw out lingering questions.

*** Attending to Equity**
It is important for all students to think through and reason about this idea, as it is a key connection for them to make. Having students turn and talk provides a socially safe space for multilingual students to share their ideas before sharing with the whole class.

Key Ideas

Purpose of this discussion: See what we can agree on regarding whether or not photosynthesis is happening in the dark and raise ideas about what might be happening instead.

Listen for these ideas:

- For photosynthesis, light and carbon dioxide need to go into the leaves and oxygen needs to be released.
- In the dark, carbon dioxide and water were released and oxygen went in.
- Photosynthesis is not happening in the dark.
- Water is released from plant leaves in the light and in the dark but we are not sure why.
- When we breathe, we take in oxygen and release carbon dioxide (cellular respiration) just like plants in the dark.
- Maybe plants do cellular respiration in the dark to stay alive.

Suggested prompts	Sample student responses
What is happening with photosynthesis in the dark?	*Photosynthesis can't be happening in the dark. For photosynthesis, you need carbon dioxide and light to be going into the plant and oxygen to be coming out. What we saw in the dark was carbon dioxide leaving the plant and oxygen going in. It was the opposite. We didn't think photosynthesis could be happening without light, and now we're really sure because it also can't happen without carbon dioxide going in.*
What do you feel uncertain about? What questions do you have?	*It is still really confusing that water is coming out in both light and dark. Water was an input for photosynthesis. Why are leaves releasing water in both light and dark conditions?*

Discuss what could be happening if it's not photosynthesis.

Summarize and transition, saying, *In the dark, plants are taking in oxygen and releasing carbon dioxide and water. We definitely don't think that photosynthesis is happening, but that is really weird because it looks like the opposite of photosynthesis. We still have lingering questions about water, so let's hang on to those. For now, let's think together about what we definitely know is happening. Oxygen is going into leaves, and carbon dioxide is coming out. What could be going on here?*

Suggested prompt	Sample student response	Follow-up question
How could oxygen be going into leaves and carbon dioxide be coming out?	*must be a chemical reaction*	*(If students don't bring up chemical reactions, ask:) If oxygen goes in and carbon dioxide comes out, and we know atoms can't just appear out of nowhere, where could that carbon atom have come from?*

Suggested prompts	Sample student responses	Follow-up question
Let's think about this reaction. Oxygen goes in, and carbon dioxide goes out. Does this happen anywhere else? Have we seen this before?	*It happens in us. We breathe in oxygen and breathe out carbon dioxide.*	*(If students struggle, ask:) We're seeing plants take in oxygen and release carbon dioxide. Are there other living organisms that take in oxygen and release carbon dioxide?*
Could plants be breathing like we breathe?	*Maybe, but that's weird because we thought plants breathe in carbon dioxide and release oxygen.*	

Turn and talk to review what happens in human bodies when we breathe in oxygen and breathe out carbon dioxide. Stay in a Scientists Circle and have students turn and talk about this question at the scale of a cell (**slide Q**).*

Share ideas as a whole group. As the class discusses what is happening with cellular respiration in humans, have students suggest how to represent that, and create a class representation of this on chart paper or the board.

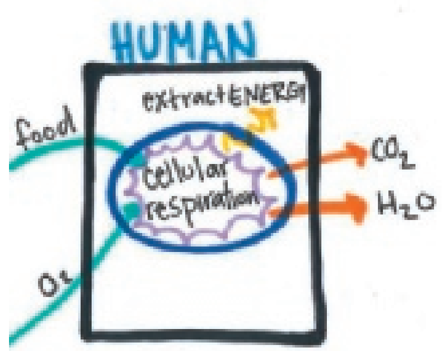
Suggested prompts	Sample student responses
Let's zoom in to the scale of cells in our bodies. What is happening inside cells in our bodies when we breathe in oxygen and breathe out carbon dioxide?	*We learned in Inside our Bodies, that we are burning food as fuel.*
What does that mean, "we are burning food as fuel"? What is happening with that chemical reaction?	*We are taking food (glucose) and oxygen and rearranging them into carbon dioxide and water.*
Why do our bodies burn glucose through this reaction?	*Our body uses food, or glucose, for energy* *Energy is released through that reaction.*
What components would we want to represent in a model of cellular respiration?	*We would need to show that oxygen and food (glucose) are inputs, carbon dioxide, water are outputs, and energy is extracted.*

Discuss whether plants could be doing cellular respiration when it's dark. Display **slide R.** The purpose of this discussion is for students to share their thinking on whether or not plants could be doing cellular respiration to get energy and to consider that plants might store food to burn when they can't make food molecules through photosynthesis. We will gather further evidence in Lesson 11 that plants are indeed doing cellular respiration, so it is OK if students are not completely convinced yet.

Suggested prompts	Sample student responses
Could plants be doing the same thing as us? When it's dark, could plants be burning stored food through cellular respiration the same way we do as humans?	*Yes, it could definitely be happening because the same gases are changing outside the leaves. We also think that plants also need energy to grow, so they need to get energy somehow. They're not making any sugar at night, so maybe they are burning it for energy to stay alive like we burn sugar for energy.* *Maybe, we're not really sure, but the evidence we have suggests that it is possible because gases are changing in the same way as they do in people.* *No, that is really weird that plants would do the same things that people do.*
If we don't agree or aren't completely convinced yet, that's fine. But let's do a thought exercise for a minute: ***If*** *plants were doing cellular respiration, why would it be happening at night?*	*Maybe that's when they can't do photosynthesis? Maybe they have some kind of stored sugar or food reserves that they can burn at night that gives them energy to live through the night.*

Additional Guidance

If students say that plants could not be doing cellular respiration, ask, *So we burn glucose to get energy to live. Where are plants getting their energy to live from?* Students will likely say from the sun. Then ask, *So what do plants do with the sunlight?* Students will likely say, *They use it in photosynthesis to turn carbon dioxide and water into glucose*. Then ask, *So why did we think plants were making glucose/food molecules in the first place?* Have students revisit their ideas from Lesson 9, that plants are using the glucose to grow somehow and that all living things need food to grow.



Co-construct a model of a human cell going through cellular respiration. Display **slide S.** As the class agrees on the components of the model record their ideas on chart paper and tell students that any ideas we agree on as a class get added to a model in their notebook.

Tell students that they will be recording this consensus model in their notebook after it has been agreed upon. It is important to explain to them where to record this model as it will be added to in Lessons 11, 12, and 13. Explain to students that they should open their notebooks to the next blank two pages so that both the left and right hand pages are blank. They should record this model on the top half of the right hand page. The left page will be blank at this point. Tell students that is okay, we will be developing more of a model as we go through the next lessons. Refer students to the image on slide S for how this should look in their notebook.

Additional Guidance

If you have completed the Inside our Bodies Unit, you can pull out the models from that unit to remind students about what is happening at the scale of cells. If you have not done that unit, but have already discussed metabolic reactions, cue students to remember what is happening in cells. Students may also have used ideas about cellular respiration while working on *Individual Midpoint Assessment* in Lesson 8 when they tried to explain why a scientist in an airtight container full of plants was able to survive. Making a visual representation now will help students later in Lesson 11 as they add cellular respiration to their plant models.

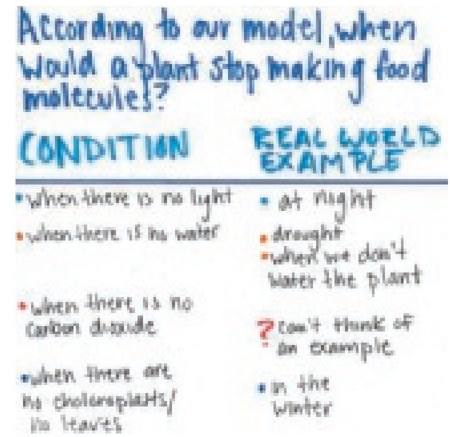
7. Generate next steps.

5 MIN

Materials: notecard

Revisit and update conditions when plants are not doing photosynthesis and could be doing cellular respiration using stored food instead.

Summarize: *We think that we have evidence that plants could be doing cellular respiration and burning stored food when they're not doing photosynthesis. So, does this only happen at night? Are there other times in a plant's life cycle when our model predicts that plants would not be making food molecules and have to use stored food?*



Revisit the conditions generated at the start of this lesson under which our model predicts that plants would not be making food molecules and might need to use stored food. Go over each condition and cross out things we have already looked at (e.g., no light) or do not have real world examples (e.g., no carbon dioxide).

Exit ticket. Display **slide T.** On a notecard, have students generate ideas about how to investigate whether plants are using stored food as fuel when they don't have leaves or don't have any water. Prompt students to think about:

- *How could we investigate if plants are using food as fuel like we do in cellular respiration?*
- *How would we know? What evidence would we look for?*

ADDITIONAL LESSON 10 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

Students craft a news release and are encouraged to incorporate visuals to enhance readers' comprehension of the text, which addresses **CCSS.ELA-LITERACY.WHST.6-8.2.A**. By working with both written language and visuals such as graphs or pictures, students also increase their own capacity for sensemaking.

SCIENCE LITERACY: READING COLLECTION 3

Our Changing Planet

1 **Plant Sap and Resin Products**

2 **Dissolved Oxygen and Aquatic Life**

3 **Will a Greening Earth Slow Global Warming?**

Literacy Objectives

- ✓ Distinguish cause(s) and effect(s) related to oxygen and carbon dioxide in Earth systems.
- ✓ Identify a claim and list the evidence that supports it.
- ✓ Translate text to visual/graphic representation of ideas.

Literacy Exercises

- Read varied text selections related to the topics explored in Lessons 7–10.
- 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 graphic organizer in response to the reading.

Instructional Resources

Student Reader

Collection 3

Science Literacy Student Reader, Collection 3
"Our Changing Planet"

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 7: Why do plants need light?
- Lesson 8: Where are plants getting food from?
- Lesson 9: Where do the food molecules in the maple tree come from?
- Lesson 10: Why don't plants die at night?

Standards and Dimensions

NGSS

Disciplinary Core Idea PS3.D: Energy in Chemical Processes and Everyday Life The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen.

LS1.C: Organization for Matter and Energy Flow in Organisms Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (MS-LS1-6)

Science and Engineering Practice: Obtaining, Evaluating, and Communicating Information

Crosscutting Concepts: Cause and Effect; Structure and Function; Energy and Matter

CCSS

English Language Arts

RST.6-8.1: Cite specific textual evidence to support analysis of science and technical texts.

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. No Core Vocabulary terms are highlighted in the text of Collection 3.

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.

acidification	**anoxic**
dissolved oxygen	**mass mortality**
resin	**sap**

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

1. Plan ahead.

Exercise Page

EP 3

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.

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 Matter Cycling and Photosynthesis 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.
  - *First, you will explore a gallery of photos with captions showing how humans use plants' fluids.*
  - *Then, you'll read a science report on the relationship between water temperature and dissolved oxygen from a fictitious team of 12th graders.*
  - *Lastly, you'll read a magazine-style article about "the greening effect" and some mock social media posts reacting to the article.*

- 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 graphic organizer to highlight three science ideas from the readings that surprised or amazed you.*
- 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 difference in function between plant sap and plant resins?	*Sap carries nutrients and sugar from one part of the plant to other parts of the plant, while resin is used to heal places where the plant is injured.*
What did Mr. Flight's 12th grade students find was the relationship between water temperature and the amount of dissolved oxygen in the water?	*When water temperature was lower, dissolved oxygen was high, and when water temperature was higher, dissolved oxygen was lower.*
As warmer temperatures cause an increase in the length of the growing season, how will it affect terrestrial plants, those that grow on land?	*Terrestrial plants will have more days to grow, which means they will be able to grow bigger and make more leaves.*

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
You have learned that maple trees are tapped to collect sap in the late winter. If the trees have been without leaves for months, where is the sugar in the sap coming from?	*The trees probably store the sugar somewhere inside the tree, perhaps in the roots, which are protected underground.*
Think about our discussion of oxygen in Lesson 10. Why do anoxic conditions often result in fish mass mortality?	*because, like plants, animals use oxygen to perform a chemical reaction (cellular respiration) needed to stay alive*
What happens to the energy in sunlight as Earth is greening?	*As plants grow more leaves, more energy is transferred from sunlight to the plants.*

- 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 draw a graphic organizer to highlight at least one idea from each of the readings that surprised or amazed you.*
  - *That means you'll have at least three sentences on your organizer.*
  - *Consider lightly sketching your graphic in pencil so that you can adjust the layout to make space for the sentences you'll write.*
  - *Don't forget to add color to make your organizer attractive!*
  - *The important criteria for your work are that you share an interesting—and accurately stated—idea from each reading and that your organizer is attractive and easy to read.*
  - *Remember: what surprises you is probably different from what surprises other students. So, your organizers will likely be very different.*
- Answer any questions students may have relative to the reading content or the exercise expectations.

Exercise Page

EP 3

4. Facilitate discussion. (Friday)

Facilitate class discussion about the reading collection and writing exercise. Students begin the reading activity by learning about human-designed uses of plant saps and resins.

Student Reader

Collection 3

Online Resources

Pages 24–33 Suggested prompts	Sample student responses
What is the general purpose of the first selection, "Plant Sap and Resin Products"?	*It describes seven products people use that are made from plant sap or resin. Is also explains what sap and resin are.*
How is the source of the shellac resin different from the other resins featured in this gallery?	*Only shellac involves an insect in producing the resin.*
If sugar can be found in sugar maple and birch trees, what can you infer about the sap of other kinds of trees?	*Probably all trees have sugar in their sap because all plants need sugar (food) to live.*

Pages 24–33 Suggested prompts	Sample student responses
How did you decide which fact from this reading to include in your graphic organizer?	*I reread about all seven materials and looked at the images. The image of the bug stuck in amber really grabbed me—I didn't know DNA could be preserved that way!*
What is the general purpose of the second selection, "Dissolved Oxygen and Aquatic Life"?	*It reports and discusses the procedure and data of a high school science investigation into the causes of fish kills in a river.*
What did the students hypothesize were two causes of low oxygen levels in the river?	*bacteria consuming decaying dead organisms using the oxygen and a lack of plants producing oxygen at certain times of the year*
What evidence did the students use to support their claim that climate change may make fish kills worse?	*They knew that as the climate warms, the water in the river will also warm and that warmer water can hold less dissolved oxygen than cooler water.*
What was your reading strategy for finding a surprising idea in this selection?	*First, I skimmed the reading. Then, I read it more carefully and tagged three surprising ideas to choose among.*
What is the general purpose of the third selection, "Will a Greening Earth Slow Global Warming?"	*This reading has two parts. The first part is an online article meant to explain a phenomenon related to climate change called "greening." The second part is a series of social media comments discussing the effects of greening.*
What might be some effects of a greening Earth for farming?	*A longer growing season means some crops can be planted earlier in the year and harvested later in the year.* *If temperatures are warmer, some crops may be more difficult to grow where they have grown in the past.* *Farmers can start farming farther north of where they can farm now.*
Bill Howard posted about the "acidification of the ocean." How could you find reputable sources to learn more about the effects of ocean acidification?	*I could search for this term using my browser and read only websites from universities or science agencies.* *I could ask a science teacher or reference librarian to help me find sources.* *I could submit my question to a website that connects you with experts.*

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—Guide students in learning how to submit questions to science expert websites. For example, Science Buddies "Ask an Expert" is a good place for K–12 students to get help in planning science projects and in getting science assignment guidance.

EXTEND—Take students on a video field trip to join a New York State environmental educator testing the Hudson River water for dissolved oxygen and temperature. Have students report details of how the video adds more information to what they read in the second selection. For example, one detail is that dissolved oxygen can be described as a certain number of parts per million.

Pages 24–33 Suggested prompt	Sample student responses
Look at the Spot the BS box. Can you detect which social media comments are misrepresenting the roles that carbon dioxide plays in different systems?	*Joe said, "CO_2 is plant food." It is not. Plants do not use CO_2 as food. They make their food (sugar) using CO_2 and H_2O during the process of photosynthesis.* *Bill agreed with Joe that CO_2 is plant food.*

5. Check for understanding.

Evaluate and Provide Feedback

For Exercise 3, students should use the model provided on the Exercise Page to draw their own graphic organizers and communicate scientific ideas from Collection 3 that surprised them. Because the exercise requires a personal response, there should be an interesting variety among students' work. Look for evidence that all three readings are represented in the organizer. Sample scientific ideas students may highlight are

From "Plant Sap and Resin Products"

- . . . dinosaur DNA can be found in fossilized tree resin.
- . . . in addition to trees making resins, a bug can do it, too.
- . . . sugar maple sap has only 2 percent sugar in it.

From "Dissolved Oxygen and Aquatic Life"

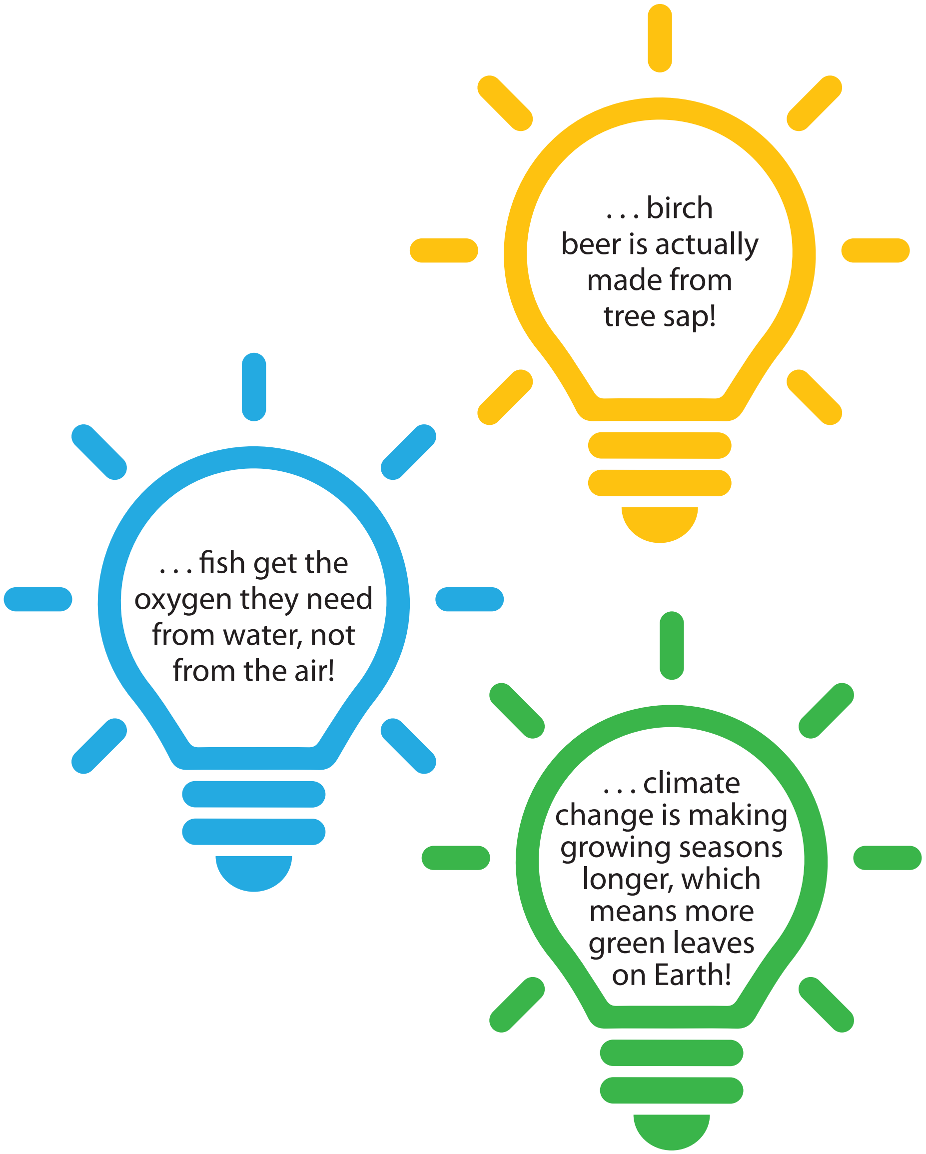
- . . . the oxygen fish need comes from molecules of oxygen dissolved in water, not by breaking apart the H_2O molecule.
- . . . when you see a lot of dead fish in a river or pond, it may be because there was not enough oxygen for them to live.
- . . . water temperature affects the amount of dissolved oxygen in water.
- . . . different species of fish have different needs for oxygen.
- . . . warming global temperatures will cause some fish populations to decline.
- . . . 12th graders are allowed to go collect data in a river for science class.

From "Will a Greening Earth Slow Global Warming?"

- . . . the more CO_2 a plant gets, the bigger it will grow.
- . . . as the growing season gets longer, plants grow larger or more plants grow.
- . . . plants can take carbon out of the atmosphere and store it.
- . . . trees are better for storing carbon than crops that are harvested every year.

An example of an exemplary student response is shown below. Consider having students who score a 1 work with a peer tutor to revise their organizers.

I Didn't Know That . . .



LESSON 11

Why don't plants die when they can't make food?

Previous Lesson

Our model predicted that at night, plants don't make food molecules through photosynthesis. We confirmed this by using first- and secondhand data to figure out that in the dark, plants take in oxygen and release carbon dioxide and water. We compared our findings to humans and theorized that maybe plants are also burning stored food through cellular respiration.

This Lesson

Investigation

3 DAYS

We plan and carry out an investigation to see whether plants without leaves (i.e., sprouting seeds) are doing cellular respiration. We use the results to argue from evidence that the food plants make is able to provide them energy (just as in humans). We read about where this happens in plant (and animal) cells and what plants do with extra food they produce from photosynthesis. We use the ideas from this and the evidence we collected to construct an explanation of what is happening to a maple tree in a time-lapse video filmed over many years.

Next Lesson

We will obtain information from ingredients lists for common processed foods, nutrition facts, and data about animal diets. We will argue that processed foods are made of matter from plants and/or animals.

Building Toward NGSS

MS-LS1-6, MS-LS2-3, MS-PS1-3

What Students Will Do

Plan and carry out an investigation collecting data of relative concentration of carbon dioxide changes over time in different closed systems to answer the question, *Why don't plants die when they can't do photosynthesis?*

Obtain and evaluate information from scientific texts to clarify the claim that the plant system doesn't die when it can't do photosynthesis because the sugars it produced can be stored for later use in the form of starches. The stored food molecules can be used for energy via cellular respiration or for growth.

Construct an explanation by applying scientific ideas and evidence to explain: (1) why a tree that loses leaves in the winter doesn't die, (2) where it gets its energy during that time, and (3) where it gets the matter to grow new leaves and wood in the spring.

What Students Will Figure Out

- Plants do cellular respiration. This is how their cells (and our cells) get energy to survive and grow.
- If plants make sugar (through photosynthesis) faster than their cells use it for energy (through cellular respiration), they store up that extra food by converting it to starches (or fats). These can be used later for fuel or building blocks.
- Plants use their stored food as building blocks by reassembling the atoms in that food to make new substances (e.g., cellulose for cell walls).

Lesson 11 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	7 min	**NAVIGATION** Recall ideas students generated at the end of the last lesson about whether plants are using stored food as fuel.	A	Progress Tracker
2	7 min	**WATCH A VIDEO OF SPROUTING CHILI SEEDS** Introduce sprouting seeds as a potential plant that can't be doing photosynthesis because they don't have green leaves yet.	B-C	computer and projector to show Timelapse of Chili Seeds Sprouting - Unit 7.4 Matter Cycling & Photosynthesis Lesson 11 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)
3	10 min	**PLAN THE BTB BEAN SPROUT INVESTIGATION** Discuss how the class could use sprouting seeds and BTB to test our ideas.	D-F	*Beans and BTB Investigation Data Table*, tape, 20 mL Bromothymol Blue Solution 0.04% Aqueous (BTB), clear container, straw (optional)
4	15 min	**INVESTIGATE BEAN SPROUTS WITH BTB** Conduct an investigation to figure out what plants do if they can't do photosynthesis because they don't have green leaves.	G	*Beans and BTB Investigation Data Table*, BTB Bean Sprout Lab
				End of day 1
5	3 min	**NAVIGATION** Recall the ideas generated about plants and cellular respiration	H	
6	16 min	**RECORD OBSERVATIONS AND MAKE EVIDENCE-BASED CLAIMS ABOUT THE BTB BEAN SPROUT LAB** Record observations of the BTB experiment and prepare an argument from evidence to present.	I–K	
7	10 min	**MAKE CONNECTIONS ABOUT SIMILARITIES BETWEEN PLANT AND ANIMAL CELLS DOING CELLULAR RESPIRATION** As a class, discuss similarities between cellular respiration in plant and animal cells.	L	
8	15 min	**READ THE ARTICLE "HOW DO PLANT (AND ANIMAL) CELLS USE FOOD?"** Introduce the reading and review the close reading strategies.	M–Q	*How do plant (and animal) cells use food?*, *Close Reading Strategies*
				End of day 2

Part	Duration	Summary	Slide	Materials
9	15 min	**CONSENSUS DISCUSSION ABOUT HOW PLANTS STAY ALIVE WHEN THEY CAN'T MAKE FOOD** Update our consensus model to reflect what the class has figured out from their seedling investigation and reading.	R-S	colored markers, chart paper
10	5 min	**UPDATE OUR PROGRESS TRACKERS** Students use a Progress Tracker in their science notebooks to record evidence of what they've figured out so far about why plants why plants don't die when they can't make food and how plants and animals use food.	S	
11	15 min	**CONSTRUCT AN EXPLANATION FOR HOW A MAPLE TREE LIVES THROUGH THE SEASONS** Explain two aspects of the phenomenon, getting energy and matter to grow, students observe in the time-lapse video of the maple tree.	T-V	*Maple Tree through the Seasons Explanation*, computer and projector to show Timelapse of a Maple Tree over 14 Years - Unit 7.4 Matter Cycling & Photosynthesis Lesson 11 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

End of day 3

Lesson 11 • Materials List

	per student	per group	per class
BTB Bean Sprout Lab materials	• science notebook • *Sprouting Seeds Procedure for BTB Test*	• 3 ziplock bags • permanent marker • 3 mL disposable pipette • 15–20 mL Bromothymol Blue Solution 0.04% Aqueous (BTB) • 4 empty condiment containers • 1 straw • 1 ziplock bag or paper towel with with 10 prepared beans in it • paper towels	

Lesson materials **Student Procedure Guide** **Student Work Pages**	• Progress Tracker • science notebook • *Beans and BTB Investigation Data Table* • *How do plant (and animal) cells use food?* • *Close Reading Strategies* • colored markers • *Maple Tree through the Seasons Explanation*	• tape	• computer and projector to show Timelapse of Chili Seeds Sprouting - Unit 7.4 Matter Cycling & Photosynthesis Lesson 11 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) • 20 mL Bromothymol Blue Solution 0.04% Aqueous (BTB) • clear container • straw (optional) • chart paper • colored markers • computer and projector to show Timelapse of a Maple Tree over 14 Years - Unit 7.4 Matter Cycling & Photosynthesis Lesson 11 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Materials preparation (40 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.

Use sheet protectors or laminate a class set of *Sprouting Seeds Procedure for BTB Test* and *Close Reading Strategies* for students to reuse across classes.

Make copies of *Beans and BTB Investigation Data Table* and *Reading: How do plant (and animal) cells use food?* for each student so that they will be able to mark up the pages with notes.

Watch the Lesson 11 lab setup demonstration video (sprouting seeds and BTB) video. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Prepare computer and projector to show the chili seeds sprouting time-lapse video. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Prepare computer and projector to show the maple tree time-lapse video. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Make sure to soak the bean seeds needed for the lab at least 1 day prior to the lab. It is recommended that after soaking the seeds, you place them in the wet paper towel for at least 24 hours, 36 hours is even better. It is recommended to start soaking the bean seeds 3 days before you will use them with the class.

Day 1: BTB Bean Seed Lab

- **Group size:** 3 students per group
- **Setup:** A variety of bean seeds can be used for this experiment; they do *not* have to come from a seed packet. Lima beans or pinto beans from the grocery store work very effectively, but you can also use various types of other bean seeds from seed packets including bush beans and snap peas.

Prepare bean sprouts

- Soak bean seeds in warm water for at least 12 hours, optimally about 20 hours, but no more than 24 hours.
  - Soak enough bean seeds so that each group will have 10.
- About 20 hours after soaking the bean seeds, prepare enough paper towels for each student group. Wet the paper towel with warm water until it is damp but not soaking wet.
- Sprinkle 10 of the previously soaked bean seeds on half of each paper towel. Fold the towel over to cover the top of these seeds.
  - Press the top of the towel so the seeds are in full contact with the damp towel on both sides of each seed.
- Place the folded towel inside a plastic ziplock bag. Seal the bag and set it in a warm area, such as on top of a refrigerator or under the grow lights from the hydroponics kit.
  - You can keep multiple paper towels containing seeds in a single, larger ziplock bag, but you will have to distribute a paper towel containing bean seeds to each student group.

Prepare supplies for each student lab group. Each group of 3 students will need:

- 1 wet paper towel with 10 prepared bean seeds
- 4 empty condiment containers (no lids)
- 3 sandwich-size ziplock bags
- 3 mL disposable pipette (other sizes work too)
- 15-20 mL Bromothymol Blue Solution, 0.04% Aqueous (BTB)
  - It should be noted that this is the *non-diluted* form. You will *not* dilute it in this lesson; you will use it straight from the bottle.
- 1 straw
- permanent marker
- paper towels
- Optional: if you have students who want to take the bean seeds home after the investigation to continue to watch them sprout and grow:
  - 3 sandwich-size ziplock bags (1 per student)
  - 3 paper towels (1 per student)

- **Notes for during the lab:**
  - Students will see an immediate color change (from a dark blue-green to a brownish-yellow color) of the BTB solution in bag B (exhaling through a straw). The bean sprout color change (bag C) happens at a slower rate, but if the beans have external sprouts, you will likely see a noticeable color change within 30 minutes. Allowing the original soaked beans to stay in the wet paper towel in a warm area for at least 24 hours before the lab will greatly increase the number of externally sprouted beans.
  - If students are analyzing the results of the experiment the following day or week, the BTB solution in bag B will likely have returned to its original blue-green color. Since the ziplock bag is *not* a completely closed system, the carbon dioxide will likely leak out of microscopic holes in the plastic bag and the BTB will return to its original color. Students can exhale with a straw into bag B again, and it will show another immediate color change to which they can compare to the bag C results.
- **Disposal:** As long as local and state regulations have been confirmed and the sink is connected to a sanitary sewer system, BTB solution can be washed down the drain, flushing with a twenty-fold excess of water.
- **Storage:** Tightly seal the bottle and store container of BTB in a cool, dark place reserved for chemical storage.

Lesson 11 • Where We Are Going and NOT Going

Where We Are Going

In previous 6th grade units, students should have seen cells under the microscope and should be familiar with the idea that animals and humans are made of cells. Through their work in the 7th grade Unit 7.3: *How do things inside our bodies work together to make us feel the way we do?* (Inside our Bodies Unit), students will have ideas that gases can enter into and out of cells through permeable membranes and that chemical reactions take place in human cells. If you did not teach the Inside our Bodies Unit, students might not have the experience that animals do cellular respiration and will need to spend more time investigating cellular respiration during this unit.

This lesson helps students figure out that, like humans, plants are doing cellular respiration all the time. It also helps them further develop understandings about how and why plants store food molecules and how they are able to use those stored food molecules when photosynthesis cannot be done (e.g., when a tree has no leaves or when a seed just sprouts).

Students may be confused when trying to integrate the results of Lesson 4, where the saw the levels CO_2 decrease, and the fact that cellular respiration is always happening. They may also think that when doing both photosynthesis and cellular respiration that the output levels of CO_2 and O_2 should be stable and not increasing or decreasing. You may need to talk more about *rates* of photosynthesis versus cellular respiration to help them see that when we say plants are making sugar in the light, we mean they are making more sugar through photosynthesis than they are using in cellular respiration, resulting in a net sugar gain.

In the next lessons, students will figure out the role of decomposers, how they fit into the system we are building together, and how things like fungi also have mitochondria, allowing them to use food for fuel via cellular respiration.

Where We Are NOT Going

While this lesson focuses on the cycle of matter and flow of energy of the inputs and outputs of photosynthesis and cellular respiration, the biochemical mechanisms of these processes are beyond the assessment boundary for this gradeband.

LEARNING PLAN FOR LESSON 11

1. Navigation

7 MIN

Materials: Progress Tracker, science notebook

Have students recall the ideas they generated at the end of the last lesson about how to investigate whether plants are using stored food as fuel when they don't have leaves or don't have any water. Show **slide A**.

Say, *We saw evidence last time that plants might be doing cellular respiration in the dark. We also brainstormed examples of other times when plants can't do photosynthesis, like when they have no leaves. When are times that plants have no leaves, but still might need energy to grow or survive?*

Turn and talk with a partner about these ideas. Remind students to use their Progress Tracker if they need help remembering what they've figured out and give them a minute or two to talk out their ideas. Listen in to a few of those discussions before bringing the class back together. Ask partners to share some of their ideas with the whole class.

Suggested prompts	Sample student responses
When are times that plants have no leaves, but still might need energy to grow or survive?	*in the winter* *when plants are just starting to grow from seeds*
So, in these times where plants can't make their own food, do you think that plants are getting energy in different ways? What ways? Why do you think that?	*They've got to be getting energy somehow otherwise they would die.* *In the winter the trees kind of look like they are dead, but then they come back in the spring. So they have to have something to tide them over in the meantime.* *Last lesson we saw data that showed plants might be doing cellular respiration in the dark when they can't make their own food. Maybe they are doing cellular respiration again when they have no leaves?*
So we have some evidence from last lesson that plants are taking in oxygen and giving off CO_2 just like humans burn food molecules for fuel at nighttime. *But are you convinced that plants could be doing this for many days in a row when they don't have leaves? Like all winter or for days when a plant is starting to sprout? Why or why not?*	*We saw the CO_2 levels go up and the O_2 levels go down with the plant in the dark. But nighttime is only a few hours. Winter or when a seed starts to grow is a lot longer. I'm not sure we have enough evidence for this yet.*

Assessment Opportunity

This conversation is a great opportunity to check in where students are in their understandings about what plants are doing under different conditions. During this formative assessment opportunity, students should be able to identify that plants are producing carbon dioxide when they are not doing photosynthesis, and that they are probably doing cellular respiration like we do. This can also provide information about where student thinking is at the beginning and end of this lesson.

Say, *So it seems kind of weird that plants could also be burning food for energy like our bodies do. It sounds like we have some evidence that suggests this is possible, but it seems like we need more evidence to be convinced. I have some plants we can use that might help us to see what plants are doing when they have no leaves. Let's see if they may be useful for testing whether they are doing something else like cellular respiration.*

2. Watch a video of sprouting chili seeds.

7 MIN

Materials: computer and projector to show Timelapse of Chili Seeds Sprouting - Unit 7.4 Matter Cycling & Photosynthesis Lesson 11 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Introduce sprouting seeds as a potential plant that can't be doing photosynthesis. Say, *I found a time-lapse video of some seeds when they just start sprouting that I'd like to share with you. I think the video might help us figure out another way to test a plant that doesn't have what it needs to do photosynthesis for an extended time. The video also reminded me of what I saw happening when I soaked the radish seeds and spinach seeds in water for a few days before I put them in the hydroponic bin. The time-lapse video shows the same sort of changes in chili pepper seeds over a few days that I saw after soaking my seeds in water.*

Show slide B and play the video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**). You may want to show it a second time so students can focus on making noticings the second time through.

Show slide C and turn and talk about the two questions. Make sure that students connect that this chili seed time-lapse shows basically the same patterns we would expect from any plant—growth, some movement—and that the chili seed plant could be a good stand-in for any plant for our investigations. Additionally, as you listen in to students' conversations, you should hear them mentioning that one of the things these sprouts are missing is green leaves, especially at the very beginning of the video.

Suggested prompt	Sample student responses
What did you observe happening in the video?	*The beans are growing on just a sheet with some water on it.* *The plants move around while they're growing.* *The plant grows up out of the bean toward the light.* *The plant gets longer and taller and starts to turn green after if pops out of the bean.*

Suggested prompt	Sample student responses
What are some plant structures that are missing from the sprouts shown here that we would expect to see on a fully grown plant?	*It doesn't have any roots.* *There are no big green leaves like those on our hydroponic plants or the spinach leaves we used in the dark carbon dioxide/water experiment.*

3. Plan the BTB bean sprout investigation.

10 MIN

Materials: *Beans and BTB Investigation Data Table*, tape, 20 mL Bromothymol Blue Solution 0.04% Aqueous (BTB), clear container, straw (optional)

Discuss how we could use sprouting seeds to test our ideas. Summarize that you heard students mentioning a few things that these sprouts were missing and one of those was green leaves. Recall that they suggested that plant seeds still need energy to grow, but that they can't do photosynthesis.

Say, *I soaked some bean seeds in water for a couple days, and they are just beginning to sprout. We can use them to experiment with, but we need to figure out if they are using cellular respiration to stay alive when they have no leaves.* Show **slide D**.

Suggested prompts	Sample student responses
What happens in cellular respiration that we could measure or observe?	*We know that cellular respiration uses oxygen and produces carbon dioxide. Maybe we can measure those gases.*
How have we measured gases before? How could we measure them with the beans?	*We can use a detector in a bag like before.* *We could add the CO_2 detector to a bag with some of the beans in it.*
We know that our bodies do cellular respiration. How did we demonstrate that our bodies were doing it?	*In the Inside our Bodies Unit we figured out that oxygen is taken in through our lungs and carbon dioxide is exhaled through them. We tested this by exhaling into a solution that is an indicator for CO_2 and saw it change color.*
Are there other indicators of CO_2 besides the indicator that we can use so that more than one group could do an experiment?	*We tested to see if we made carbon dioxide as an output. We tested it by blowing bubbles into a solution.*

Students will likely suggest that we put these sprouts in a bag with a carbon dioxide detector, similar to what we did in earlier lessons, and see whether the carbon dioxide levels increase in the bag (and/or whether the oxygen levels decrease in it). Validate the idea that we need some sort of detector or indicator to see whether carbon dioxide levels change.

Say, *I was hoping that everyone would be able to test this for themselves, but then I realized we only have one digital carbon dioxide detector. However, I remembered from our previous unit that we have a lot of bromothymol blue, or BTB, and that we have all used that before to detect carbon dioxide changes.*

Recall what BTB solution looks like with the class. Pour out a small quantity (~20 milliliters) of BTB into a clear container and hold it up for students to see. Show **slide E** and remind students of how we used BTB in the past to detect carbon dioxide changes by looking for a color change and of the type of color changes it showed the last time we used it.

Say, *Remember from our previous investigations that the substance bromothymol blue (BTB) is an indicator that turns a different color when it mixes with carbon dioxide (CO_2). Does anyone remember how BTB reacts with CO_2?*

Additional Guidance

In the Inside our Bodies Unit, students blew bubbles into BTB solution with a straw and saw the solution change to a yellow color. They also demonstrated how BTB shows a color change when mixed with sparkling water (which had listed these two ingredients on its food label: water and carbon dioxide). If students do not recall this, you could take a minute to demonstrate this again, as it is a fast demonstration.

As a whole class, discuss how we could use BTB to test whether plants are doing cellular respiration. Write the last two questions and responses on the board or chart paper for students to refer to while they are conducting the investigation.

Suggested prompts	Sample student responses
Does anyone remember how BTB reacts with CO_2?	*When BTB interacts with carbon dioxide, like when someone blows into BTB with a straw, the substance turns from blue to green to yellow with each color change indicating a higher concentration of CO_2.*
If we were to put seeds when they are just starting to sprout into BTB, how would we know if they are doing cellular respiration or not? What would we expect to see?	*If the BTB changed color to green/yellow we would know they are releasing CO_2 and probably doing cellular respiration.*
How would we ensure that we're just testing the sprouting seeds and not something else?	*The container should be a closed system that doesn't let air in or out.*
If we want to detect CO_2, how can we make sure the gas doesn't escape before we can detect it?	
Why would we want to do this test in a closed system?	*It ensures that the gases the plant might be producing don't escape and the BTB can detect them.*
So what will it tell us if the BTB doesn't change color?	*Carbon dioxide wasn't produced.*
What will it tell us if the BTB does change color?	*Carbon dioxide was produced.*

Additional Guidance

During this discussion about testing with BTB, you should write a key on the board that indicates how BTB changes in the presence of CO_2.

Introduce the role of including some control conditions in our investigation.

Say, *Scientists often include additional trials in their experiments to check that their indicators are working as predicted. When they conduct a trial with the independent variable missing or held constant under its normal circumstances, it is called a control condition. This is similar to what we did with our simulation for photosynthesis where we ran a trial as a starting point before we started changing other variables. And, since we already know how BTB should react to the air we breathe out from the Inside our Bodies Unit, let's plan on confirming that it's working as expected.*

Suggested prompts	Sample student responses
What control conditions should we include in our investigation plan?	*We should show that the BTB solution is working.*
How would we show that the BTB won't just react with everything?	*We could put the BTB in a bag with regular air from the room and no bean sprouts.*
How would we show that the BTB will have a color change in the presence of CO_2?	*We could put some BTB in a bag and fill the bag with air we breathe out since we know that has CO_2 in it.*
Okay, so if we confirm our indicator is working by breathing into the bag, then what would we want to do with the seed sprouts to see if they too are releasing CO_2?	*We could put seeds in a bag with the BTB, so it would be a closed system and the BTB would show that they are making CO_2.*

Say, *Great! Let's add these to our investigation plan. Since we want to collect data from our investigation, let's set up a data table so we can record our observations. Let's also make some predictions about what we expect we will see in all these different bags in our data table.*

Make predictions about what will happen to the BTB in each case. Show **slide F.** Distribute *Beans and BTB Investigation Data Table* and instruct students to tape it into their science notebooks. Tell students to fill in their predictions for the first row.

Name: ______ Date: ______

Beans and BTB Investigation Data Table

	Bag A: Classroom air	Bag B: Exhaled air	Bag C: Beans in classroom air
Color of BTB in the beginning			
Predict: What color will the BTB be at the end?			
Observations Day 1: What did you see?			
Observations Day 2: What did you see?			
What does the final color of BTB tell you?			

Assessment Opportunity

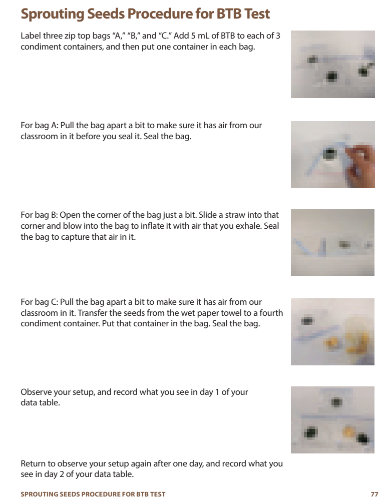
Having students record some predictions of what they'll see in each of the bags serves as a checkpoint to make sure they understand what should be happening in each bag. The bag with exhaled air (bag B) should show a change because it contains carbon dioxide, and bag A should show little to no change. This also allows students to engage with whether or not they believe plants are doing cellular respiration. *This should only be used as a formative assessment opportunity.*

With extra time, you could have students share their predictions with elbow partners or as a class make a table of what we think might happen.

4. Investigate bean sprouts with BTB. 15 MIN

Materials: BTB Bean Sprout Lab, science notebook, *Beans and BTB Investigation Data Table*

Investigate the bean sprouts. Show **slide G** and provide students with a copy of *Sprouting Seeds Procedure for BTB Test* as a reference to use when they set up their investigations. Allow students time to analyze the procedure and ask them how it connects to the discussion about controls.


Sprouting Seeds Procedure for BTB Test

Label three zip top bags "A," "B," and "C." Add 5 mL of BTB to each of 3 condiment containers, and then put one container in each bag.

For bag A: Pull the bag apart a bit to make sure it has air from our classroom in it before you seal it. Seal the bag.

For bag B: Open the corner of the bag just a bit. Slide a straw into that corner and blow into the bag to inflate it with air that you exhale. Seal the bag to capture that air in it.

For bag C: Pull the bag apart a bit to make sure it has air from our classroom in it. Transfer the seeds from the wet paper towel to a fourth condiment container. Put that container in the bag. Seal the bag.

Observe your setup, and record what you see in day 1 of your data table.

Return to observe your setup again after one day, and record what you see in day 2 of your data table.

SPROUTING SEEDS PROCEDURE FOR BTB TEST 77

Observe initial BTB color changes after 5 minutes and record data in their science notebooks. Once students are finished with their 3 BTB setups, show them where they can store their experimental bags, so they can refer back to them in the next class.

Alternate Activity

If your seeds haven't sprouted yet, this experiment will still work. In this case, you might want to encourage students to dissect one of the seeds to look for evidence of that sprouting starting. And you could give students the option to each take three seeds from the investigation home (when they are completely done on day 2), put them back in a wet paper towel in a ziplock bag as they were when students got them, and tape the bag to a window in their house to watch them sprout.

Remind students to leave those bags open to the air (don't seal them) when they do this, so the seeds don't run out of the type of molecules they need from the air to keep growing. (Students will find out by the end of this lesson that these molecules are oxygen when the plants are seedlings and carbon dioxide when they get green leaves and start doing photosynthesis.)

Additional Guidance

Students should see color change in bag B within a couple of minutes after blowing into the bag and sealing it. Students may not see a color change in bag C until the next day. Have them record what they see both on day 1 and day 2. Bag B will lose the BTB color change overnight since ziplock bags are not *completely* airtight and the carbon dioxide will leave the bag through microscopic holes. It is OK if the bags need to remain sealed for more than a day before you return to looking at them, but you may need to have a conversation about why bag B no longer shows the color change. Students can initiate another color change by exhaling air into the bag once again.

Check to make sure that all students have finished their predictions, day 1 observations, and that they have placed their experimental setups in the correct location. If students finish early, have them revisit the DQB to see if we have made progress on any of our questions.

End of day 1

5. Navigation

3 MIN

Materials: None

Recall ideas about how we decided to test whether plants are doing cellular respiration. Show **slide H**. Have students summarize the investigation we started and what we are looking for in order to determine whether cellular respiration is happening.

Suggested prompts	Sample student responses	Follow-up questions
Why did we put bean sprouts in BTB? What are we testing?	*We decided to test whether bean sprouts are doing cellular respiration like we do by putting them in a bag with air and BTB.* *We know that our bean sprouts don't have green leaves yet, so they don't have any chloroplasts. This means they can't be doing photosynthesis, so we were wondering how they got their energy to live and thought maybe they do the same things we do, like cellular respiration.*	*Why did we decide to test seed sprouts this time?*
What did we say we should be looking for when we make observations of our three bags?	*We are looking for a color change in the BTB, from blue to green or yellow, as evidence that cellular respiration is happening, because cellular respiration produces carbon dioxide and that is what BTB detects.*	*How will we know if cellular respiration is happening?*

6. Record observations and make evidence-based claims about the BTB bean sprout lab.

16 MIN

Materials: None

Record day 2 observations in your science notebook and clean up. Show **slide I**. Remind students that after recording their observations, they should dispose of the BTB solution correctly, discard any other lab materials in the trash, and return to their seats. Tell students that they will have a few minutes to do these things, and then we will summarize our results. This data collection should not take long. Give groups no more than 5 minutes to do it.

Make an evidence-based claim and argue from evidence about the question: *How does a plant get energy when it has no leaves to do photosynthesis?* Show **slide J.** In their science notebooks or on a separate sheet of paper, have students individually record a claim and a summary of evidence to support that claim. Give students about 4 minutes to complete this argument.

*** Attending to Equity**
As you see students coming to agreement, you can leave a token (chip, card, piece of paper) with that partnership indicating that you would like that partnership to prepare to share its argument with the whole class in a bit. Select three partnerships to leave a token with that you haven't heard from in

Assessment Opportunity

This is an opportunity to collect formative assessments of students developing arguments based on evidence they collected. One way to do this is to ask students to write these on a separate sheet of paper (rather than in their notebooks) and have them give these to you to review and provide feedback on before the next class. *Rubric: Engaging in Argument from Evidence* is provided to guide your feedback to students.

Swap claims and evidence with a partner and resolve differences. Show **slide K**. Give partners one minute to swap their written claims and evidence summary with a partner and read them, and another three minutes to discuss similarities and differences and come to consensus.*

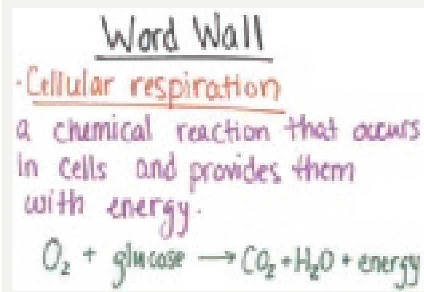
Additional Guidance

If your students are having trouble sharing and listening to one another's claim and reasoning, you can implement a talking stick (pencil, token, sticky note, etc.) to provide some guidance. Each student will get one minute with the talking stick to share their claim and evidence. During this time there is no comparing going on, and students really get to listen to one another. The stick goes back to the first person to share similarities and differences between the two claims and then second person has a turn to share. After each student has shared twice, they can then discuss how they would resolve any differences between the two arguments (which might include either revising one or both of them, or merging them).

Bring the class together and have each chosen partnership present its argument. At the end, ask for a show of hands of everyone in the room who agrees with the arguments they are hearing. There should be general consensus around the idea that these seeds or seedlings are doing cellular respiration.*

a while, rather than just those you know will have the right answer.

*** Attending to Equity**
At this point in time, students should have a conceptual understanding of what cellular respiration means. They know this word from the Inside our Bodies Unit, but it is a good idea to call it out again. Bringing attention to it at this point, will help the class decide on a common definition before they begin the reading and begin making connections to plant and animal cells. If the class does not know all of the inputs and outputs for cellular respiration, you may want to wait to add the chemical equation to the entry. Add *cellular respiration* to the word wall. A sample representation is below:



7. Make connections about similarities between plant and animal cells doing cellular respiration. 10 MIN

Materials: science notebook

Guide the class by remembering what they saw in M'Kenna's case and how it relates to what we're seeing in plants. Project **slide L.** Open a discussion with each of these questions, one at at time:

Suggested prompts	Sample student responses
How is what the plant is doing similar to what our bodies do, as we saw with M'Kenna?	*M'Kenna's body and our bodies do cellular respiration, too, to provide us with energy.* *We also saw that other animals can do cellular respiration.*
When do the cells in our bodies do cellular respiration?	*Our bodies are doing cellular respiration all the time. That is why we are breathing.*
What do the cells in our bodies use to do respiration?	*We use food molecules as fuel.*
How is that related to our breathing?	*Our cells also use oxygen and produce carbon dioxide when they burn the food molecules as fuel.*
But we aren't always eating. And often we go for a while between meals. Where do the cells of our bodies get that fuel from during those times?	*from food in the blood* *from stored fuel reserves (glycogen, fats)*
Where is the seed sprout getting its stored food from to use as fuel?	*From the seed? From stored food in the seed?*

8. Read the article: How do plant (and animal) cells use food?

15 MIN

Materials: science notebook, *How do plant (and animal) cells use food?*, *Close Reading Strategies*

Have students help you summarize what we know so far and motivate the need for the reading.

Say, *We argued that plants are doing cellular respiration to use food as fuel when they can't do photosynthesis, just as the cells in our bodies do. And we have started identifying the ways in which cellular respiration is similar in both organisms. But how similar is that process? Let's try to figure out more details about what is the same and what is different about how plants use their fuel compared to us.*

Introduce the reading and review the close reading strategies. Write "How do plants use their food for fuel compared to us?" on the board, and say, *Let's keep this question at the forefront of our thinking for what we still need to figure out. I have a short reading that may provide information that can help answer that question in greater detail.*

Additional Guidance

Students are about to read a two-page reading. If the time remaining seems too short to complete all of it in one period, you could have students do the five steps of the close reading strategies on the first page during today's class and have them use the strategies on the second page at the start of the next class. Or you could assign the second page as home learning.

Hand out *How do plant (and animal) cells use food?* and *Close Reading Strategies*. Project **slide M**. Use this overview to remind students that as we prepare to do a close reading of a text, it is important to remember the close reading strategies that can help us get the most out of that information source. Show students what this includes by going over the steps with them as they do their close reading.

Project **slide N**. Ask students what the main question is in this reading that we are trying to answer. This question should be written on the board for them to refer to. Students should say, “How do plants use their food for fuel compared to us?” Remind students that writing this at the top of the reading is a key strategy, because it reminds us what the purpose is of what we are trying to do and the type of information we are looking for in the reading. Have students write this question at the top of their reading.

Project **slide O**. Give students about six minutes to read the text on their own.

Project **slide P**. Give students five or six minutes to highlight or underline key ideas on their own. Remind students to be selective about what they highlight, keeping in mind that they are trying to find things that help answer the question they wrote at the top of the reading.

Project **slide Q**. Have students work with a partner to complete these last two steps, by adding annotations to their readings. See *Key: Annotations for How do plant (and animal) cells use food?* for an example.

Pause students at the end of the period and tell them to put their annotated readings in their science notebooks so that we can use them to update our Progress Trackers next time.

Additional Guidance

If needed, build time into the next day of this lesson to continue working with the reading and *Maple Tree through the Seasons Explanation* can be done as a home learning assignment. If sending home, allow students to take their science notebooks with them so they can access their Progress Trackers and investigation data.

End of day2

9. Consensus Discussion About How Plants Stay Alive When They Can’t Make Food

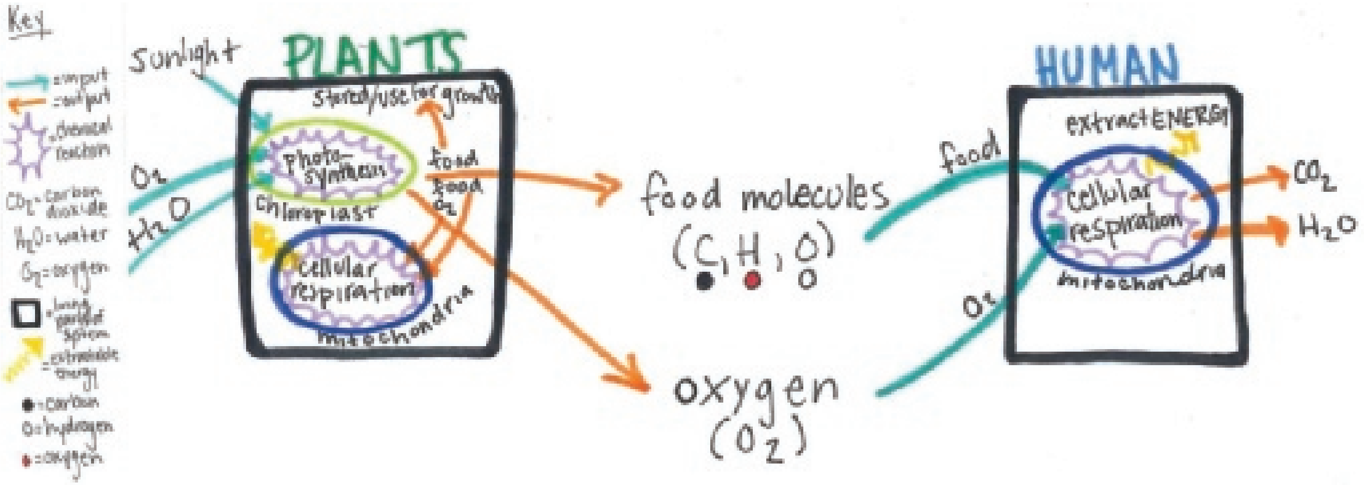
15 MIN

Materials: science notebook, colored markers, chart paper

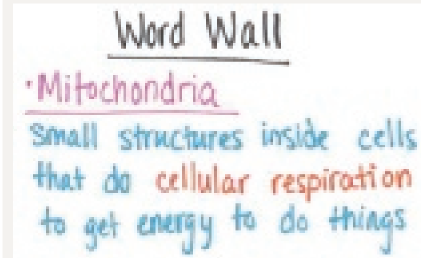
Convene students in a Scientists Circle for a Consensus Discussion. Say, *Let’s see if we can pull together what we figured out about our two main questions we have been investigating. Let’s first see whether we have some agreement about why plants don’t die when they can’t make food.*

Conduct a discussion about how plants are able to stay alive and grow when they can’t make food. Ask students to propose ideas based on the different claims they can make from the BTB investigation first, and discuss how and why plants store food using the information they obtained from *How do plant (and animal) cells use food?*. While discussing, develop a model together summarizing the role that chloroplasts and mitochondria play within plant cells. This model should include the inputs and outputs for chloroplasts and mitochondria within a plant cell.

*** Attending to Equity**
When new scientific words, like *mitochondria* 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.



You may also need to go back to *cellular respiration* and add the chemical equation to the entry if your students weren't clear when they added it the first. At this point in time, add *mitochondria* to the word wall. Students might suggest the following representation*:*



Key Ideas

Purpose of this discussion: See what we can agree on about why plants don't die when they can't make food and how plants use their stored food molecules.

Listen for these ideas:

- Plants do cellular respiration to get energy to live and grow, like us.
- When plants do photosynthesis, they end up making more glucose than they are using for cellular respiration, so they store it as food molecules.
- Plants can use stored food molecules to build new plant parts.

Suggested prompts	Sample student responses	Follow-up questions
What are some claims we think we can say about how plants can stay alive when they can't make food?	*We know plants can do cellular respiration to get energy.* *We know that plants store extra food, so they can use it later.*	*How do we know this?* *What evidence do we have?*
How did the plants get the extra food that they could store?	*When plants have leaves and sunlight, they can do a lot of photosynthesis and create extra food molecules.* *Plants create more sugars during photosynthesis than they use for cellular respiration.*	*Who can build on that idea about plant cells making more sugar than they need?*

Suggested prompts	Sample student responses	Follow-up questions
In what ways do plants use the extra food molecules that they have stored?	*Plants can rearrange the food molecules and do cellular respiration to extract energy.* *Plants can use the food molecules as matter to build new plant parts.*	*Who can rephrase this in their own words?*
How could we update our model to represent these things?	*We could add mitochondria to our model to show the plant doing cellular respiration.* *We could show how the chloroplasts create sugar for the mitochondria to use.*	*What else would we add to that?* *How should we describe the inputs and outputs in our model to explain how the tree stays alive even when it does not have light?*
How well does this model fit the evidence we've gathered so far?	*It makes sense because we know that plants produce carbon dioxide in the dark from cellular respiration.* *We know that plants produce food molecules during photosynthesis, and we figured out that they can do chemical reactions to use the food molecules to extract energy.*	*Is there anything else we haven't included that needs to be included in our model?*
Is there anything we can add to our model of the human cell from what we have figured out today?	*We can add in that the human cell has mitochondria to do cellular respiration!*	*Let's add all of these components to our model!*

Additional Guidance

When students are talking about plants storing food, it may be a good idea to remind them of when we looked at food labels in Lesson 1. This can help them think about the types of food molecules that plants are storing, and how those molecules are rearranged to make new plant parts. There are multiple food labels of different seeds that students may have not realized prior. It may be helpful to make a connection between these food label seeds and the beans used in the BTB investigation. Students will also be able to think more deeply about the maple seed question on *Maple Tree through the Seasons Explanation*.

Draw the model on the top half of the left-hand page of their notebooks across from the human cell drawn in Lesson 10 using colored markers or colored pencils. Show **slide R.** Have them draw a vertical line down the left page margin. The key will go to the left of this line. They will continue to add to this model in the next three lessons and will need the space on the bottom of the left page and the bottom of the right-hand page to do that.*

Assessment Opportunity

This is a great opportunity for students to self-assess on their engagement in classroom discussions using *Self-Assessment for Classroom Discussions*. This discussion rubric can be used anytime after a discussion to help students reflect on their participation in the class that day.

10. Update our Progress Trackers.

5 MIN

Materials: science notebook

Individually update their 3-box Progress Trackers. Show **slide S**. Have students return to their seats.

Say, *Take a few minutes to capture in your Progress Tracker what we just figured out.*

In their notebooks, students should draw a 3-box Progress Tracker using what the class came to consensus on in the previous discussion. First, have students write down the questions they have been trying to answer, *Why don't plants die when they can't make food?* and *How do plants use their food for fuel compared to us?* Ask students what evidence they have been working with to answer these questions (e.g., the seedling investigation and reading on how plants and animals use food), the references to the sources of evidence, and what we have figured out in relation to each lesson questions.

Give students an opportunity to generate a list of ideas they have figured out now.

One suggested representation is below:

Question	Source of Evidence
Why don't plants die when they can't make food? How do plants use their food for fuel compared to us?	• Investigation of bean seeds/sprouts in bag with BTB • Reading on how plant cells (and animal cells) use food

What we figured out in words and pictures
• Plants do cellular respiration. This is how their cells (and our cells) get energy to do things. • If they make sugar (through photosynthesis) faster than their cells use it for energy (through cellular respiration), they store up that extra food by converting it to starches (or fats). These can be used later for fuel or to make new plant parts grow. • (see model on page _ in my notebook)

11. Construct an explanation for how a maple tree lives through the seasons. 15 MIN

Materials: science notebook, *Maple Tree through the Seasons Explanation*, computer and projector to show Timelapse of a Maple Tree over 14 Years - Unit 7.4 Matter Cycling & Photosynthesis Lesson 11. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Students record observations about a related phenomenon. Show **slide T**, and have students return to their regular seats.

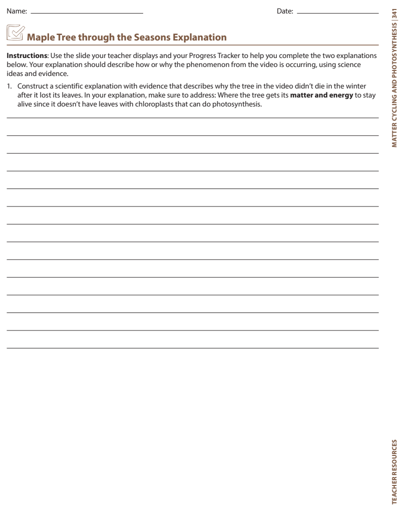
Say, *We agreed that plants are storing extra food, just like we do. We know that they're using that extra stored food to provide energy to do stuff* and *matter so that they can produce new cells and grow. Let's see if we can put all the things we've figured out together and find evidence that these happen in a maple tree.*

Have students prepare their notebooks for observations. Show **slide U**. Show the maple tree time-lapse video once. Then give students a couple of minutes to record observations. They should underline the ones that are evidence of the plant using energy to do something and put a star (✶) near the ones that are evidence of the plant using inputs, or molecules, as building blocks to grow.

Show the video a second time and encourage students to add to their observations anything related to what they underlined or starred.

Show **slide V**. Distribute *Maple Tree through the Seasons Explanation* for students to write an explanation in response to the two questions. Tell students that you want to assess their explanations. Remind them that a scientific explanation should not only make claims that answer the questions, but it should also use ideas from the models we developed. These models should help them include important scientific ideas we think are at work as well as evidence obtained from students' own experiments and from the phenomenon (the video).*

Encourage students to refer to their science notebooks, Progress Trackers, and notes from *How do plant (and animal) cells use food?* as they write this explanation.


Name: ______ Date: ______

Maple Tree through the Seasons Explanation

Instructions: Use the slide your teacher displays and your Progress Tracker to help you complete the two explanations below. Your explanation should describe how or why the phenomenon from the video is occurring, using science ideas and evidence.

1. Construct a scientific explanation with evidence that describes why the tree in the video didn't die in the winter after it lost its leaves. In your explanation, make sure to address: Where the tree gets its **matter and energy** to stay alive since it doesn't have leaves with chloroplasts that can do photosynthesis.

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TEACHER RESOURCES

*** Supporting Students in Engaging in Constructing Explaining and Designing Solutions**
Depending on students' experience with writing evidence-based explanations, you may want to provide additional scaffolds for each prompt. The scaffolds should ask them to first identify the sources of evidence that they can cite from the video as well as the sources of evidence they can cite from their labs. Then, second, they should ask students to identify the important science ideas from their Progress Trackers that they think are relevant. If you have a general rubric providing feedback on students' scientific explanations, you may want to provide that to students as well.

Assessment Opportunity

Collect *Maple Tree through the Seasons Explanation* and provide feedback to students before the next lesson. Where possible, give them an opportunity to revise and resubmit their explanations. This can help them refine their understanding of the key ideas from this lesson before they get to activities in the next two lessons, where they will need to put together bigger parts of the puzzle to explain where all our food comes from and where it goes to.

Collect *Maple Tree through the Seasons Explanation* and any class reference materials.

Alternate Activity

This explanation can be done in class or as a home learning assignment. If sending home, allow students to take their science notebooks with them so they can access their Progress Trackers and investigation data.

ADDITIONAL LESSON 11 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

Students are provided with a set of close reading strategies to accompany *How do plant (and animal) cells use food?*, which will assist as they gather information from a complex scientific text. These close reading strategies help to address **CCSS.ELA-LITERACY.RST.6-8.2** by recommending that students summarize the text and tease out any questions they have that relate to their prior knowledge.

LESSON 12

Where does the rest of our food come from?

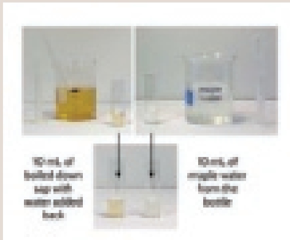
Previous Lesson

We planned and carried out an investigation to see whether plants without leaves (i.e., sprouting seeds) are doing cellular respiration. We read about where this happens in plant (and animal) cells and what plants do with extra food they produce from photosynthesis. We explained what is happening to a maple tree in a time-lapse video filmed over many years.

This Lesson

Investigation

3 DAYS



We obtain information from ingredients lists for common processed foods and argue that they are made of matter from plants and/or animals. We obtain information from nutrition facts and data about animal diets and argue that animals have food molecules in them that come from eating plants or other animals that once ate plants. We argue that processed foods are made of matter from plants and/or animals.

Next Lesson

We will watch videos of decomposers that recycle matter and energy from dead plants and animals. We will examine data from bread mold in the light and dark and read about decomposers around the world. We will revise our model to include decomposers as a living part of the system.

Building Toward NGSS

MS-LS1-6, MS-LS2-3, MS-PS1-3

What Students Will Do

Obtain information from text and a video to determine that the processed foods we eat contain matter (atoms) that came from plants; use this information to communicate and synthesize related information presented to peers.

Engage in argument from evidence (readings about where different sweeteners come from) that all the food we eat contains matter that ultimately came from plants.

What Students Will Figure Out

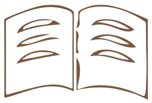
- Everything we eat contains matter that came from either plants or animals.
- Some foods we eat have been processed either physically or chemically, but we can still trace them back to originally coming from plants.
- Most animals, including humans, eat plants, other animals that once ate plants, or both.
- Most animals, including humans, use the food molecules they eat to build up larger molecules for growth, to get energy by burning glucose through cellular respiration, or to store for later use.

Lesson 12 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	2 min	**NAVIGATION** Revisit the categorized foods from Lesson 1 and introduce the lesson question: *Where does the rest of our food come from?*	A-B	consensus model (from Lessons 8 and 11), categorized breakfast or lunch foods poster from Lesson 1
2	15 min	**INVESTIGATE HOW SAP BECOMES SYRUP** Watch a video and analyze data about how sap becomes syrup.	C-G	*What happens when sap is boiled?*, video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)
3	5 min	**INVESTIGATE OTHER SWEETENERS** Watch a video of how corn syrup is made.	H	How Corn Syrup is Made - Unit 7.4 Matter Cycling & Photosynthesis Lesson 12 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**), optional: a bottle of corn syrup and/or label from a bottle
4	20 min	**COMPARE DIFFERENT SWEETENERS** Jigsaw read about different sweeteners and how they are made.	I-J	*Reading: Where else does our food come from?*, *Reading: Agave Syrup* *Reading: High Fructose Corn Syrup*, *Reading: Honey*, *Reading: Stevia*, *Reading: Sucralose*, *Reading: Sugar* *End of day 1*
5	20 min	**CONSENSUS DISCUSSION ABOUT NATURAL VS. SYNTHETIC SWEETENERS** Share about the different sweeteners read about and argue whether the substance is a natural food or synthetic food.	K	
6	10 min	**INVESTIGATE PROCESSED FOODS** Review ingredients lists for several processed foods and determine where they come from.	L-M	1 processed food label (from the “not sure” category), optional: computer and projector to show video clips of How Flour is Made (Optional Video) - Unit 7.4 Matter Cycling & Photosynthesis Lesson 12 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Part	Duration	Summary	Slide	Materials
7	12 min	**INVESTIGATE WHAT IS IN FOODS FROM ANIMALS** Review nutrition facts for common foods from animals (e.g., eggs, milk, chicken, beef) and figure out that they all have food molecules in them.	N-O	*Nutrition Labels: What is in food?*
				End of day 2
8	10 min	**INVESTIGATE ANIMAL DIETS** Read about chicken and cow diets to think about where the food molecules in animal products come from.	P-Q	*Reading: Chicken and Cow Diets*
9	7 min	**REVIEW IDEAS FROM READING** Review ideas from the chicken and cow diet reading and argue that everything these animals eat originally comes from plants.	R	
10	10 min	**REMEMBER WHAT ANIMALS DO WITH FOOD MOLECULES** Discuss what animals do with the food molecules they eat from plants by revisiting the model from a previous unit that helps explain what humans do with food molecules.	S-T	optional: final model from the Inside our Bodies Unit
11	12 min	**UPDATE OUR PROGRESS TRACKER** Convene a Scientists Circle to update the Progress Tracker	U	colored markers, chart paper
12	5 min	**NAVIGATION** Brainstorm what happens to parts of plants we don't use or eat.	V	
				End of day 3
		SCIENCE LITERACY ROUTINE Upon completion of Lesson 12, students are ready to read Student Reader Collection 4 and then respond to the writing exercise.		Student Reader Collection 4: *Producers and Consumers*

Lesson 12 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• science notebook • consensus model (from Lessons 8 and 11) • *What happens when sap is boiled?* • *Reading: Where else does our food come from?* • *Nutrition Labels: What is in food?* • *Reading: Chicken and Cow Diets* • optional: final model from the Inside our Bodies Unit • colored markers	• *Reading: Agave Syrup* • *Reading: High Fructose Corn Syrup* • *Reading: Honey* • *Reading: Stevia* • *Reading: Sucralose* • *Reading: Sugar* • 1 processed food label (from the "not sure" category)	• categorized breakfast or lunch foods poster from Lesson 1 • videos (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) • How Corn Syrup is Made - Unit 7.4 Matter Cycling & Photosynthesis Lesson 12 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) • optional: a bottle of corn syrup and /or label from a bottle • optional: computer and projector to show video clips of How Flour is Made (Optional Video) - Unit 7.4 Matter Cycling & Photosynthesis Lesson 12 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) • chart paper • colored markers

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.

Collect food labels for items that were in the "not sure" category from your class (e.g., snack bags, candy wrappers, sugar free foods). You will need enough for 1 item per pair of students in your class. If you don't have enough, you can have students work in groups of 4.

Check food processing videos to make sure they work:

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

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

Optional: Bring in a package of flour to refer to as students bring up these various ingredients while investigating what is in processed foods and use the flour processing video to analyze how flour is processed.

Lesson 12 • Where We Are Going and NOT Going

Where We Are Going

This lesson addresses parts of Disciplinary Core Ideas LS1.C and PS3.D, that the burning of fuel in most animals involves chemical reactions with oxygen that release stored energy and produce carbon dioxide and that this reaction takes place in mitochondria, as introduced in Lesson 10. Like humans, most animals can store sugars or use them immediately for growth or as fuel. Students had previously developed these ideas in the Inside our Bodies Unit. In this lesson, they generalize these ideas to most animals.

This lesson also addresses part of LS2.B, that food webs are models that demonstrate how matter is transferred between producers and consumers. Most animals eat either plants or other animals that ate plants. This is represented in the start of a food web showing the transfer of matter from plants to animals and the transfer of matter into and out of the atmosphere. Food webs often have multiple levels of consumers to represent animals eating other animals. In the current version of this unit, only one level of consumer is represented, though animals eating animals is discussed. Lesson 13 will introduce the role of decomposers in recycling nutrients from dead plant or animal matter back into the surrounding environment. Ideas about the movement of matter into and out of the physical environment from LS2.B will be made explicit in Lesson 13.

Students may come into this lesson thinking that processed foods are made of chemicals or stuff that isn't natural. In this lesson, they will figure out that the main ingredients in processed foods are actually from plants and that some ingredients also come from animals, that previously ate plants.

In previous 6th grade units, students should have seen cells under a microscope and should be familiar with the idea that animals and humans are made of cells. In Lesson 11, students just learned that cellular respiration happens in animal cells within mitochondria, but Lesson 12 is the first time students will acknowledge the idea that humans are animals, so the same processes that happen in humans also happen in most animals.

Where We Are NOT Going

Students will be introduced to how different sweeteners are made from different plants through a video and a jigsaw of readings. The details of the chemical reactions, or the multiple steps of the chemical reactions, that different substances go through to make artificial sweeteners or processed sweeteners are above grade band and will not be addressed in this lesson. In addition, though the readings contain an example of the prevalent carbohydrate molecule that each sweetener is made of, students do not investigate how the molecules are made beyond reading that the original one breaks apart and rearranges to make a new molecule. The specifics about the chemistry behind bonds between atoms and how they break apart and rearrange is beyond middle school.

LEARNING PLAN FOR LESSON 12

1. Navigation

2 MIN

Materials: science notebook, consensus model (from Lessons 8 and 11), categorized breakfast or lunch foods poster from Lesson 1

Revisit our breakfast foods from Lesson 1. The purpose of this is to take stock of what we've figured out so far and determine what questions we still have left to figure out. Project **slide A** and have students review the food categories you made in Lesson 1 as they answer these questions. Students may also find it useful to look at the class consensus models in their science notebooks that explain where food molecules in plants come from (Lesson 8) and what plants do with those food molecules (Lesson 11).

Introduce the lesson question. Reiterate that we've figured out where food molecules in plants come from and what plants do with them. Emphasize that we still don't know what's in the stuff in animals or the "not sure" category and where all that stuff comes from.

Suggested prompts	Sample student responses
What have we been trying to figure out about our food?	*Where does it come from?*
What have we figured out so far in our investigations?	*There are sugar and other food molecules in plants and that plants make sugar through photosynthesis, using carbon dioxide, water, and sunlight.*
	Plants can store those food molecules.
	Plants burn those food molecules to get energy, just as people do.
	Plants can use those food molecules to grow, just as people do.
What have we not figured out yet?	*Where the stuff in our "not sure" category comes from.*
	Where the food molecules in animals come from.

Then present **slide B** and summarize for the class.

Say, *So we're still wondering where the stuff in our "not sure" category comes from. Our question is "Where does the rest of our food come from?"*

2. Investigate how sap becomes syrup. 15 MIN

Materials: science notebook, *What happens when sap is boiled?*, making sap video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Introduce the video and investigation reference for how sap becomes syrup.

Say, *Okay, we have figured out a lot about maple syrup so far. Let's start there. Where do you think that would go on our breakfast poster?*

Have a few students share what they think and ask them to explain why. As the class works through this lesson, they should gain evidence to help them more confidently argue where different foods should be placed on the breakfast poster. For now, it is just important to get students to begin thinking about this.

Say, *We figured out that the maple tree contains sap and that somehow this can be made into syrup. Though these two substances can be traced back to the maple tree, are these two substances, sap and syrup, the same thing? We have been using food labels throughout our unit to help us determine what different foods are made of and where they come from. Let's look back at the labels for maple sap and maple syrup.*

Suggested prompts	Sample student responses
Do sap and syrup have the same food molecules?	*They do have the same food molecules, carbs, but syrup has a lot more.*
So do you think they are the same thing?	*Maybe because the sap has water in it and the syrup doesn't?* *because it's more concentrated* *I am not really sure.*

Say, *Okay, based on the food labels, we have some ideas of what's in both of these foods, but we might still have some questions.*

Show **slide C.** Say, *Draw three circles on the next page in your notebook and label them "Plants", "Not Sure", and "Animals". Right now if you had to say where sap would go on your food chart, which category would it go in? Where would you categorize syrup on your food chart? Write the food in the proper circle.*

Let's watch a video from a farm about what they do to make syrup from sap to help us figure out if sap and syrup are the same substance. On the next page in your science notebook, make a Notice and Wonder chart. As you watch the video clip keep track of what you notice and wonder in this chart.

Watch the video together as a class. Project **slide D.** Encourage them to record what they notice and wonder about how maple sap is made into maple syrup from the video. Play the video.

Ask, *What are some things you noticed from the video clip? What did these farmers do with the sap to make syrup?*

Suggested prompt	Sample student responses
What process did the sap go through in the video before syrup was made?	*The sap is tapped from the trees and brought to a sugar house.* *In this hut, there is an evaporator where the sap is boiled down until syrup is made.* *After the water is boiled off, the liquid is heated and I think it gets thicker. They said they measure density of the syrup.*

Say, *So do you think sap and syrup are the same substance? How could we tell? What could we do to test our ideas?*

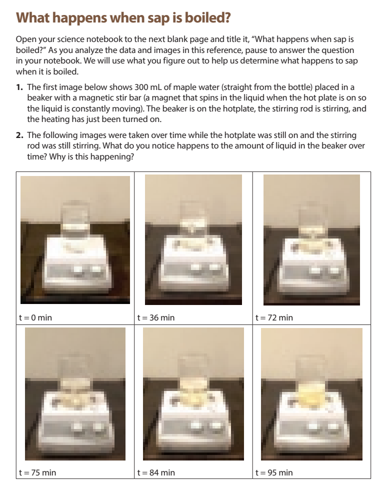
Additional Guidance

In previous units, students have learned that substances can be identified by their properties. Though mixtures can't truly be identified through properties, we want students to use what they have learned from the Unit 7.1, *How can we make something new that wasn't there before?* (Bath Bombs Unit) to help them argue that syrup and sap are two different substances. From the reading, they should pick up on the section that explains the liquid in the pan is heated until the molecules rearrange and form a new molecule. This should be a clue to them that a chemical reaction is occurring based on what they know from Bath Bombs. At this point in the lesson they don't have enough evidence yet to argue this, but they should by the end of the lesson.

Transition students to looking at secondhand data. Show **slide E.**

Say, *Some students in another school argued that since sap is just heated in an evaporator to boil off the water, then sap must just be watery syrup. They decided to try investigating this by boiling maple water down to see if they would get syrup. On* What happens when sap is boiled? *you will see their data. Title the next page in your notebook, "What happens when sap is boiled?" Then, take a few minutes with a partner to analyze this data. As you read through the data, when you reach a question, pause and answer the question in your notebook.*

Hand out a copy of *What happens when sap is boiled?* to each student and give them some time to work through the data with a partner.


What happens when sap is boiled?

Open your science notebook to the next blank page and title it, "What happens when sap is boiled?" As you analyze the data and images in this reference, pause to answer the question in your notebook. We will use what you figure out to help us determine what happens to sap when it is boiled.

1. The first image below shows 300 mL of maple water (straight from the bottle) placed in a beaker with a magnetic stir bar (a magnet that spins in the liquid when the hot plate is on so the liquid is constantly moving). The beaker is on the hotplate, the stirring rod is stirring, and the heating has just been turned on.
2. The following images were taken over time while the hotplate was still on and the stirring rod was still stirring. What do you notice happens to the amount of liquid in the beaker over time? Why is this happening?

t = 0 min
t = 36 min
t = 72 min
t = 75 min
t = 84 min
t = 95 min

WHAT HAPPENS WHEN SAP IS BOILED? 79

Suggested prompts	Sample student responses	Follow-up questions
What were some things you noticed from this investigation? Is sap just syrup with water added?	*I don't think so . . . I think a chemical reaction must have happened.*	*Why do you think a chemical reaction has occurred? What in the data leads you to say this?*
If a chemical reaction has occurred, what can we look for as evidence?	*The properties of the substances would be different if a chemical reaction occurred, like we learned in Bath Bombs.*	*What are some properties we are familiar with that we could test for and compare?*

Suggested prompts	Sample student responses	Follow-up questions
Did any properties of the sap substance change when it became syrup?	*Yeah! The color changed, which is a property.* *In the video of the sap being boiled, one of the people commented on how good it smelled in the sugar house. Maybe the odor changed?* *In the video, it showed that after being boiled, the liquid is heated to a higher degree and they test the density of the liquid. We know density is a property of substances from Bath Bombs, so this could be a clue of a chemical reaction happening.* *In the images the syrup looks like a different color than the sap even when water is added back in. Knowing color is a property, this is a clue that a chemical reaction occurred.*	*So, if sap goes through a chemical reaction when it is heated to make syrup, are sap and syrup the same thing?*
Let's make sense of the processes that sap goes through to make syrup. First the sap is boiled. When something is boiled, is a new substance made?	*No, it is just changing phases. We learned that in Bath Bombs.*	
So what can we conclude? Is sap just watery syrup? What is our evidence?	*No! On the investigation sheet, water was added back to the stuff that was left after the sap was boiled and it looked different. The color had changed, which is a property.*	

Explain to students that besides labeling foods as coming from plants (plant-based), animals, or other, there are different words that people use to describe foods. Some foods are described as being a natural or whole food. Other foods are referred to as artificial or synthetic foods. Show **slide F.** Tells students to turn and talk to a partner about the question on the slide. Then have a few students share their ideas.

Suggested prompt	Sample student responses	Follow-up questions
What does it mean for a food to be natural or synthetic?	*Natural usually means something that is in its original form or not changed somehow.* *I think synthetic means something that is fake, or human made.*	*What have they been referring to?* *What are some examples of natural and synthetic things?*

Say, *So when sap is made into syrup the sap goes through different processes to make the syrup. You all told me that first some water is boiled off, then the leftover liquid is heated longer and the molecules of this liquid rearrange to make new a new liquid. If we look back at our breakfast food poster, we have figured out some things about foods that come from plants. What about the maple syrup? Would we say it still comes from plants?*

Suggested prompts	Sample student responses
Can we say maple syrup comes from a plant still?	*Yes! The sap comes from the tree and then is processed to make it maple syrup, but originally it came from a plant.*
Do you think 100% maple syrup is a natural food or a synthetic (or artificial) food?	*Maybe… If it goes through a chemical change then it is processed, so I think it's synthetic.* *But there is nothing else added, so it's still natural because everything in the syrup came from a plant.* *Sap comes from the tree so I think it is natural.* *Maybe since syrup isn't what comes from the tree, it is artificial.* *We're not so sure… what the difference is… what makes a food natural or synthetic?*
Could this happen with other foods that come from plants? Like, do you think other foods that come from plants go through processes that make a new food that we eat?	*Not sure, but if this happens with sap, maybe there are other foods that can be boiled and heated to make a new type of food molecule.*

Present **slide G.** Tell students to make two more circles in their notebook on the same page. They should label one circle "natural" and the other one "synthetic". Ask students to record sap either in the natural food circle or the synthetic food circle. Then ask them to record maple syrup in one of the two circles too.

Additional Guidance

In this lesson students will read multiple readings to help refine their thinking around what makes a food *natural* or *synthetic*. At this point in the lesson, we just want to have students share what experience they have had with these two words and what they mean to them. When they share their examples of natural and synthetic things, they may not agree with each other on how to label different things. This is okay at this point in the lesson.

3. Investigate other sweeteners.

5 MIN

Materials: How Corn Syrup is Made - Unit 7.4 Matter Cycling & Photosynthesis Lesson 12 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**), optional: a bottle of corn syrup and /or label from a bottle

Show the label and image of corn syrup. If you have a bottle of corn syrup, bring it in and offer to share with students. Have a few students share what they think it is made of/or from.

Say, *This is another type of syrup that is also used as a sweetener, called corn syrup. What do you think this is made from? What are some of your initial ideas about how this is made?*

Present **slide H.** Tell students to return to the page in their notebook with the three circles for plants, animals, and not sure. They should record where they think corn syrup belongs *and* they should predict whether they think it is a natural or synthetic food. Have a few students share their ideas. Then tell students you will watch a short video of the process of making corn syrup.

Ask students to make a Notice and Wonder chart on the next page in their notebook and use this as they watch the video clip. Watch the video together as a class.

Suggested prompts	Sample student responses
What did we see in the video? How is corn syrup made?	*It is made from corn, water, and an acid is added too.* *Then this is heated up.* *After a while, the water boils off and a thick syrup is left.*
How does this compare to maple syrup?	*Maple sap is heated too. And becomes a thick syrup.*
So what do you think now, is this a natural or synthetic food?	*Maybe… I think it goes through a chemical change when it is processed and the acid is added, so I think it's synthetic.* *We're not so sure… what the difference is… what makes a food natural or synthetic?*

4. Compare different sweeteners.

20 MIN

Materials: science notebook, *Reading: Where else does our food come from?*, *Reading: Agave Syrup*, *Reading: High Fructose Corn Syrup*, *Reading: Honey*, *Reading: Stevia*, *Reading: Sucralose*, *Reading: Sugar*

Additional Guidance

There are two copies of each reading. One copy is the color copy located in the back of the Student Procedure Guide behind the reading section. The other copy is a handout to download and print. If you want students to mark the text, they can use the handout version. Otherwise, students can read the text using their Student Procedure Guide. The readings include: *Reading: Agave Syrup*, *Reading: High Fructose Corn Syrup*, *Reading: Honey*, *Reading: Stevia*, *Reading: Sucralose*, *Reading: Sugar*, *Reading: Where else does our food come from?*. There are 6 different readings about different sweeteners. Each small group of 3-4 students needs a copy of one of the readings

Introduce readings about natural and artificial sweeteners. Say, *We have looked at two different syrups that are used as sweeteners. But there are many other substances that are sweeteners too. What are some that you are familiar with?*

Have a few students share their ideas. Then explain that each small group will receive a different reading about a substance that is a sweetener. With their small group, they should read the article and collect evidence about whether it is a natural or synthetic food and why. After they have read through the article, they should record in their notebook their small group's answer to the questions on **slide I**. When everyone is finished, they should be ready to share with the class the following questions:

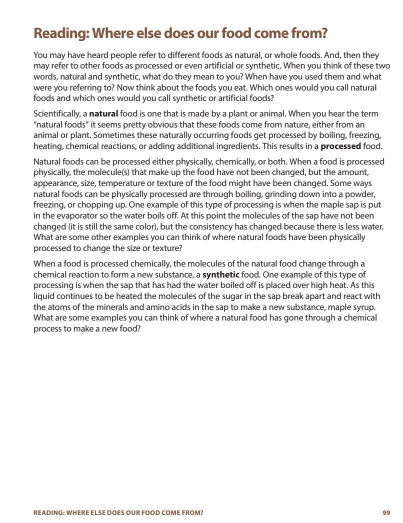
1. Is this a natural or synthetic food? What is your evidence?
2. Where does it come from?
3. How is it made?
4. Record in the circles in your notebook the name of your sweetener in the plant, not sure, or animal circle. And record the name in the natural food or synthetic food circle.

Assessment Opportunity

The answers to the four questions students are answering as they read the article about the different sweeteners can serve as an assessment. Students should include data and evidence to support their claim as to whether the sweetener they read about is a natural food or synthetic food. Their notebook can be collected or spot checked as students work.

When everyone has finished reading, ask each group to share with the class what sweetener they read about, whether they as a group think this is a natural or synthetic food and why.

Show slide J. Say, *It seems like it is difficult to identify whether a food is natural or synthetic. Let's read a little more about the difference.* Introduce *Reading: Where else does our food come from?* and pass out a copy to each student. They should read the article for home learning and come back the next day ready to argue whether the sweetener they read about today is a natural or synthetic sweetener and why.



Reading: Where else does our food come from?

You may have heard people refer to different foods as natural, or whole foods. And, then they may refer to other foods as processed or even artificial or synthetic. When you think of these two words, natural and synthetic, what do they mean to you? When have you used them and what were you referring to? Now think about the foods you eat. Which ones would you call natural foods and which ones would you call synthetic or artificial foods?

Scientifically, a **natural** food is one that is made by a plant or animal. When you hear the term "natural foods" it seems pretty obvious that these foods come from nature, either from an animal or plant. Sometimes these naturally occurring foods get processed by boiling, freezing, heating, chemical reactions, or adding additional ingredients. This results in a **processed** food.

Natural foods can be processed either physically, chemically, or both. When a food is processed physically, the molecule(s) that make up the food have not been changed, but the amount, appearance, size, temperature or texture of the food might have been changed. Some ways natural foods can be physically processed are through boiling, grinding down into a powder, freezing, or chopping up. One example of this type of processing is when the maple sap is put in the evaporator so the water boils off. At this point the molecules of the sap have not been changed (it is still the same color), but the consistency has changed because there is less water. What are some other examples you can think of where natural foods have been physically processed to change the size or texture?

When a food is processed chemically, the molecules of the natural food change through a chemical reaction to form a new substance, a **synthetic** food. One example of this type of processing is when the sap that has had the water boiled off is placed over high heat. As this liquid continues to be heated the molecules of the sugar in the sap break apart and react with the atoms of the minerals and amino acids in the sap to make a new substance, maple syrup. What are some examples you can think of where a natural food has gone through a chemical process to make a new food?

READING: WHERE ELSE DOES OUR FOOD COME FROM? 99

Home Learning Opportunity

Now that students spent some time thinking about what the difference is between natural and synthetic foods, they will read about the difference from a scientific standpoint for home learning. This is a proximal time to add in this reading because students have had an ample amount of time to think about what the difference through reading about how different sweeteners are made and how they change. This reading will serve to help students solidify their conceptual understanding of the difference between natural and synthetic foods.

Additional Guidance

Students have more information about the various processes foods go through before we eat them but they don't have any definitive evidence about the difference between natural and synthetic foods. Up until now they are basing any claims, or arguments, they have about natural and synthetic foods on their prior experience. After each small group shares out, students will read about how scientists define natural and synthetic foods.

Students will use what they figure out from this reading to revisit their argument about whether their sweetener is a natural or synthetic food. By the end of this lesson, students may still not agree on what constitutes a natural food or a synthetic food. Some may want to argue that foods that have been processed physically are still made of the same type of molecule and therefore a natural food. Others may not agree and may argue that if the food isn't used as it was originally made, then it is a synthetic food. This disagreement is okay as they are arguing using evidence they have and how they interpret the evidence.

End of day 1

5. Consensus Discussion About Natural vs. Synthetic Sweeteners

20 MIN

Materials: science notebook

Convene in a Scientists Circle. Ask students to bring their notebooks and readings to the Scientists Circle. Facilitate a consensus discussion about whether the different substances the students read about are natural or synthetic. Project **slide K.** Give each small group 3 minutes to share about their sweetener. When they share they should follow the directions on the slide.

Share:

1. What is the name of your sweetener?
2. Is your sweetener a natural or synthetic food? What is your evidence?
3. What are the prevalent molecules that your sweetener is made of?

Assessment Opportunity

Small groups will orally be communicating with the class their argument as to whether the sweetener they read about is a natural or synthetic food. This argument should be stated as a claim and then they need to support it with evidence from their article. As they share, this can serve as an assessment piece for their ability to state an argument as a claim and whether the evidence shared supports their argument.

Come to consensus about natural vs. synthetic foods. Once each group has had a chance to share, come to a consensus about what makes a food a natural food vs. a synthetic food.

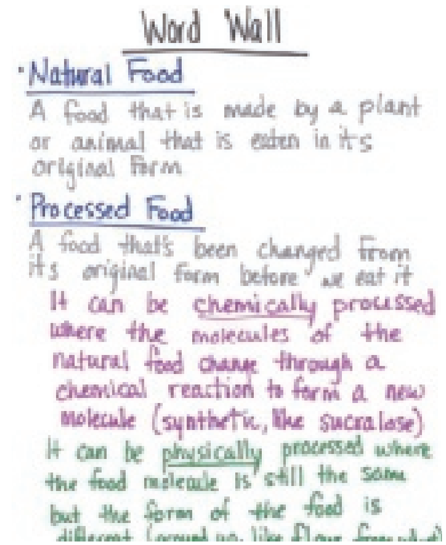
*** Attending to Equity**
Throughout this lesson students developed a deeper meaning for what is meant by *natural* and *synthetic*. By the end of the lesson, these will have become "words we earned." When developing new vocabulary, strategies that may benefit emergent language learners is to use student-friendly definitions, make connections to cognate words when possible, and include a visual representation of the word. Add *natural* and *synthetic* to the word wall so that we can reference it and refer to it as needed across the rest of the unit.

Key Ideas

Purpose of this discussion: Once students have finished reading about the various sweeteners and how they are made they should argue from evidence about whether the sweetener they read about is a natural sweetener or an artificial one. The goal in this discussion is for students to use evidence from the article *Reading: Where else does our food come from?* to support a claim about whether the sweetener they read about is natural or synthetic.

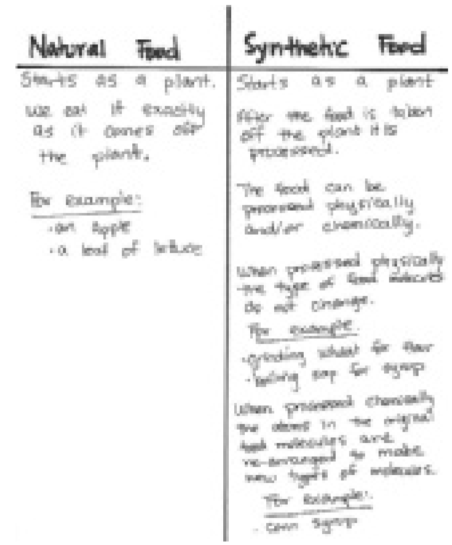
Listen for these ideas:

- Sweeteners that have been processed through heating or adding other substances are synthetic or artificial because they have been changed from the original source.
- Sweeteners that we use right from the plant are natural, like chewing sugar cane.
- Some students may argue that sweeteners that are just ground up or melted are still natural foods because the molecule hasn't changed while others may argue that sweeteners that are ground up or melted are synthetic now because it is in a different state that it was in the plant. Both of these are acceptable answers if students can back them up with evidence from the readings.



Suggested prompts	Sample student responses
So were all the sweeteners you read about the same substance?	*No, they were all different.*
Did they all come from the same source? A plant? An animal?	*No, they all come from different plants, but they were all changed somehow, either physically or chemically. Like sugar cane can be made into a lot of different sweeteners—white sugar, molasses, brown sugar—through doing different things to it.* *Or Truvia comes from a plant too, even though it is a fake type of sugar.* *But none of them came from animals.*
Wait… so you are saying that even though the sugar that we use to make cookies looks very different than sugar cane, we can still say it comes from a plant? *Or Truvia that looks like powdered sugar comes from a plant?*	*Yes, because it originally came from the plant.*
Which of these sweeteners would we call natural? Which of them would we call synthetic?	*I don't think any of them are natural because they have all been changed from how they were originally in plants.* *I think honey is a natural sweetener. It is collected by the bees and put in the honeycomb where we get it from.*

Suggested prompts	Sample student responses
So it seems like it is difficult to clearly label a food as natural. Are there any of our sweeteners that we are sure are synthetic?	*Yes! The fake sugars, like sucralose, are definitely synthetic.* *I think corn syrup is synthetic. It isn't just corn juice… it is actually the starch of the corn broken down with enzymes to make the syrup, so it is chemically changed.*
So even the foods you called synthetic come from plants? What evidence do we have of this?	*Yes, the sucralose comes from the sugar cane plant but goes through chemical changes that change it to a new substance.*
If we trace back to where all the sweeteners came from, whether they are synthetic or natural, where do they all come from? Like the group that read about agave syrup, where does this come from? What about the group that read about Truvia?	*They all come from plants!*
So, even though it seems like a lot of the foods we eat are synthetic, or processed, where do they originally come from?	*Plants!*



Say, *Now that we have some evidence and information about what makes a food natural or synthetic, let's see if we can record what we think is the difference.*

As students share, capture what is agreed on for the difference between natural and synthetic foods on a poster. If students have changed their thinking about where sweeteners go on the 5-circle notebook page, allow them to add these changes on the page.

6. Investigate processed foods.

10 MIN

Materials: science notebook, 1 processed food label (from the "not sure" category), optional: computer and projector to show video clips of How Flour is Made (Optional Video) - Unit 7.4 Matter Cycling & Photosynthesis Lesson 12 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/ckscі-online-resources**)

Revisit the breakfast food poster. Suggest to students that we might now have some evidence to help us answer where the rest of our food comes from and if our foods on our breakfast plate are natural or artificial. We can investigate both categories, but we'll start with the "not sure" category.

Additional Guidance

If students don't bring up the idea that we still don't know where foods in the other two categories come from ("from animals" and "not sure"), return to the categorized breakfast and lunch foods poster from Lesson 1 and ask, *So can we explain where all of our food comes from?* Select an item from the "not sure" category, like a snack food, and ask students if they can explain where that comes from. This will help students realize that we really can only explain where the food molecules in plants come from.

*** Attending to Equity**

If there are students struggling to decide where any of these ingredients come from, such as vegetable oil or flour, use the video here as a reference for them. By this point in this lesson, students should be able to reason out that flour comes from a plant, but if they are not arguing this, then use the videos here as a reference.

Tell students that you have a video that can show us where these sorts

Introduce processed-food labels and explain how to interpret them. Say, *What about some of these other items on our poster, like cereal? Or jam? Or margarine? Where would they go? Take a moment and look back at the breakfast foods you recorded in Lesson 1. Where would you place these foods now? Do they come from plants or animals? Are the foods natural or artificial? Take a moment to add them to the page in your notebook with the plants, animals, not sure circle AND the natural or synthetic food circle. Let's look at the ingredients in some of these foods and see if we can determine where they come from.*

Project **slide L** and introduce the question: *What is in the food items we're not sure about, and where do those ingredients come from?* Show students where the ingredients list is located on a packaged food item.

Additional Guidance

Almost all, if not all, of the foods in the "not sure" category should be some kind of packaged or processed food. All packaged foods have the ingredients list below or next to the nutrition facts. If you have any whole foods in the "not sure" category, you may want to support students to realize that those food items are either from a plant or from an animal.

Tell students, *The ingredients list shown here is an example of the type of thing that you can find on all food packages. This type of list shows all the different ingredients that were used to make the thing in the package. The first thing listed is the ingredient that the manufacturer used the largest amount of in the recipe, and the last thing listed is the ingredient that it used the least amount of in the recipe.*

Investigate the ingredients lists for several foods. Pass out one of the real food labels from the "not sure" category to each pair of students. Tell students you will be reusing these in other classes, so they should open up their notebook to the next page and title it "Food Label Ingredients". Have students pick a food label they are interested in investigating and record the first two ingredients on the real food label you pass out in their notebook. Then have pairs decide where they think these ingredients came from and if the food is natural or synthetic. They should make a record of this on the page in their notebook and be ready to share with the class.

Additional Guidance

Prior to this lesson you can ask students to bring in food labels for the foods in the "not sure" category and/or begin collecting labels for this lesson early on in the unit. If you did not collect enough real food labels for students to look at, you can have them share in groups of four.

Discuss findings as a class. Have students share their ideas about where the main ingredients in these "not sure" foods come from **(slide M)**. Point out that flour, vegetable oil, and sugar seem like common ingredients in things like bread, cereal, and margarine.

Summarize where the main ingredients for things like breads, pancakes, and cereals in our "not sure" category come from. Emphasize the big idea that every food we looked seems to have ingredients that come from plants. Also draw out the idea that some of the ingredients (even if they are farther down the list), like cheese or milk, come from animals.*

of common ingredients found in things like breads, chips, cereals, and cookies come from.

- Flour: Show all of the video. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**).

Additional Guidance

If students get hung up on ingredients they've never heard of (e.g., whey protein, lactic acid, cocoa), assign them to look up where those ingredients come from for home learning. The big idea for students to take away is that almost everything in these processed foods comes from plants or animals.

Suggested prompts	Sample student responses
Where does flour come from? What is it made from?	*Flour comes from ground-up seeds, such as wheat, rice, or corn.*
Where does corn or vegetable oil come from?	*Corn and vegetable oil come from plants, corn, and vegetables.*
Where does sugar come from?	*Sugar comes from a plant… I think sugarcane plants or beet plants.*

7. Investigate what is in food from animals.

12 MIN

Materials: *Nutrition Labels: What is in food?*

Navigate from processed foods to foods from animals. Say, *Wow! We have figured out where most of the foods on our breakfast poster come from. We only have a few left to figure out.*

Suggested prompts	Sample student responses
Where do the main ingredients for foods in our "not sure" category, like breads and chips, come from?	*They come from plants (ground up or squeezed).*
Did you notice any ingredients you recognized that we know are definitely not from plants?	*Milk and cheese. Those are from cows.*

Point to the "not sure" category and ask students, *If most of the stuff in these "not sure" foods comes from either plants, animals, or both, do we still need the "not sure" category?*

Help students realize that if we explain where stuff in animals comes from, then we can explain where all of our foods come from. Recap that we now know where foods from plants and the "not sure" category come from, but we are still unclear about the "from animals" category.

Investigate nutrition facts for foods from animals. Project **slide N.** Problematize what is in foods from animals by asking students what is actually in those food items.

As a class, select three of the food items from animals that have nutrition facts in *Nutrition Labels: What is in food?*. Have students make a chart in their science notebooks to record each food item: what part of the animal we are eating, what is in the food, and where that matter came from. Have student pairs review the nutrition facts, discuss each food item, and record their ideas.*

*** Attending to Equity**
Select animal foods that your students suggest so they are investigating foods that are relevant and interesting to them. There are nutrition facts for milk, eggs, chicken, fish, pork, and beef in *Nutrition Labels: What is in food?* reference section of the student book from Lesson 1. These are listed in alphabetical order.

Food item	What part of the animal are we eating?	What are the types of food molecules?	Where did that matter come from?
Chicken	*Its body*	*Protein, fats, sodium, cholesterol*	*What it ate*
Milk	*Milk that came out of a cow*	*Protein, fats, carbohydrate, sodium, cholesterol*	*The cow made the milk in its body. That came from what the cow ate.*

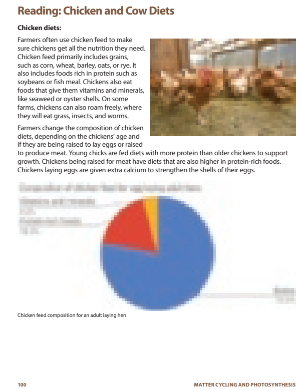
Discuss as a class what is in food from animals. The purpose of this discussion is to draw out student ideas that food molecules are also in animals and to help students start to think about how those food molecules come from eating other organisms. Project **slide O** and have students discuss these questions.

Suggested prompts	Sample student responses	Follow-up questions
What parts of animals do we eat?	*their bodies (e.g., chicken, beef)* *something that came from their bodies (e.g., milk, eggs)*	
What is in the food items from animals?	*protein, fats, cholesterol, sodium (in all the foods)* *carbohydrates (in milk)*	*What do these all have in common?* *They are all food molecules with Cs, Hs, and Os.* *(You can also revisit Nutrition Labels: What is in food? if students are stuck on the idea that these are mostly made of fats and proteins.)*
Where did these food molecules come from?	*from whatever those animals ate*	*How do animals get their food molecules? Plants make food molecules. Can animals make food molecules?*
What about the egg and milk? *Where did the food molecules in those foods come from?*	*from the mother cow or mother chicken's body*	*Where did the food molecules in the mother cow or mother chicken come from?* *From what the animal ate.*
What do chickens, cows, and fish eat?	*Grass, corn, we're not totally sure.*	

End of day 2

8. Investigate animal diets. **10 MIN**

Materials: *Reading: Chicken and Cow Diets*


Reading: Chicken and Cow Diets

Chicken diets:

Farmers often use chicken feed to make sure chickens get all the nutrition they need. Chicken feed primarily includes grains, such as corn, wheat, barley, oats, or rye. It also includes foods rich in protein such as soybeans or fish meal. Chickens also eat foods that give them vitamins and minerals, like seaweed or oyster shells. On some farms, chickens can also roam freely, where they will eat grass, insects, and worms.

Farmers change the composition of chicken diets, depending on the chickens' age and if they are being raised to lay eggs or raised to produce meat. Young chicks are fed diets with more protein than older chickens to support growth. Chickens being raised for meat have diets that are also higher in protein-rich foods. Chickens laying eggs are given extra calcium to strengthen the shells of their eggs.

Chicken feed composition for an adult laying hen

100 MATTER CYCLING AND PHOTOSYNTHESIS

Introduce the reading about chicken and cow diets. Say, *So maybe if we knew a little bit more about what animals like chickens and cows eat, it would help us answer our question about where our food comes from.*

Project **slide P**. Divide students into groups of four and then split the groups into pairs. Have each pair read about either chickens (Group A) or cows (Group B) in *Reading: Chicken and Cow Diets*. Use the handout version for students to annotate. There is a copy of this reading in the Student Procedure Guide for reference as well. Have student pairs answer the following questions:

- What does the animal eat?
- Categorize those foods. Where do those foods come from?

Compare and discuss chicken and cow diets. Project **slide Q**. Have pairs share with the other two members of their group and compare chicken and cow diets.

9. Review ideas from reading. **7 MIN**

Materials: None

Return to the ideas from the reading. Present **slide R**. Lead a class discussion and have students share their categories. The purpose is for students to realize that most of what animals eat comes from plants and from animals that also eat plants.

Suggested prompts	Sample student responses
How are chicken and cow diets similar?	*They both eat a lot of grains.* *Farmers feed them different things based on how old they are or what we will be eating them for.*
How are their diets different?	*Chickens also eat animals, like fish and insects.* *Chickens eat more grains than cows.*
Chickens eat mostly plants, but let's talk about some of the animals that chickens eat. Chickens eat ants. What do ants eat?	*They eat plants like grasses and stuff.* *They might eat some meat scraps too.*

Summarize the big idea. Say, *So, cows eat only plants, and chickens eat mostly plants, but also some animals. And if we trace back what those animals eat, eventually basically everything leads us back to plants. Almost all the food that animals, including ourselves, eat, originally comes from plants.*

Home Learning Opportunity

If students get stuck on what specific animals, like fish or ants, eat, have them look up diets for those animals for home learning.

10. Remember what animals do with food molecules.

10 MIN

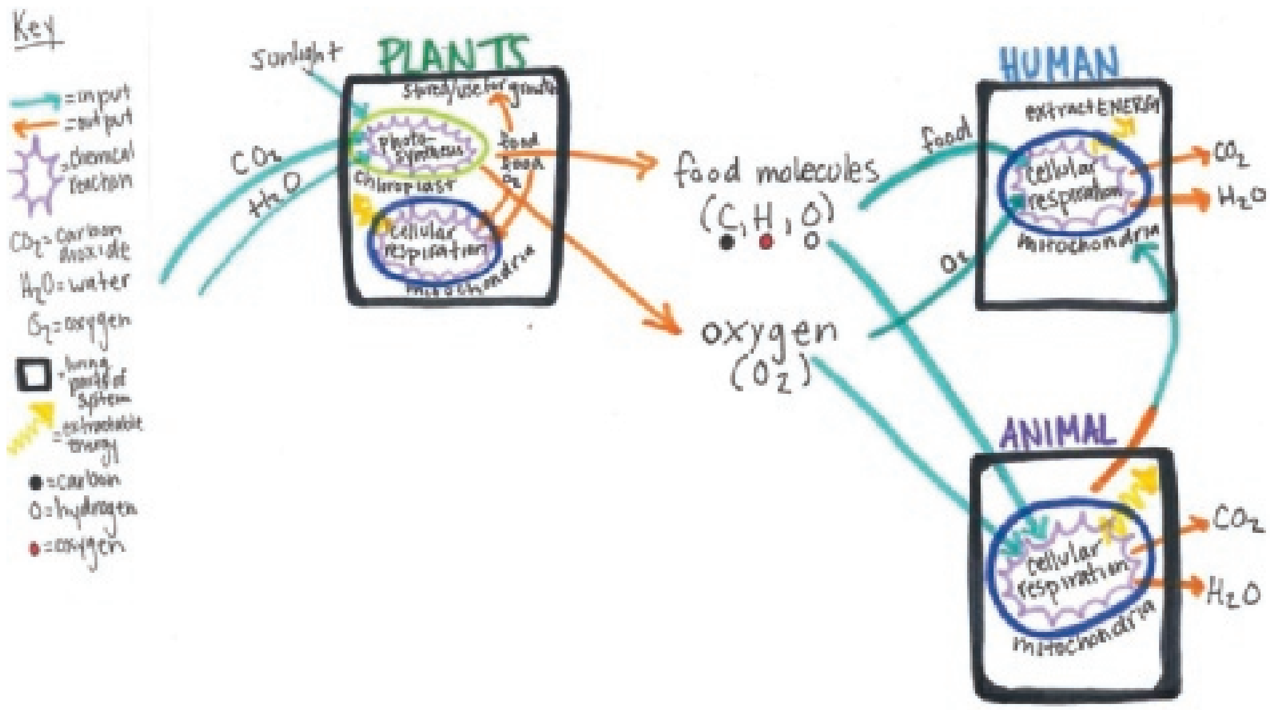
Materials: optional: final model from the Inside our Bodies Unit

Motivate students to remember back to what they figured out about what animals do with the food molecules they get from eating plants. As a class, reflect on what students know about what animals do with the food they eat (**slide S**). The purpose here is to have students remember that in the Unit 7.3: *How do things inside our bodies work together to make us feel the way we do?*, (Inside our Bodies Unit), they figured out what the human body does with the food it eats *and* that humans are animals. In addition, they figured out animal bodies do the same thing that human bodies do with the food they eat.

Suggested prompts	Sample student responses
What happens to the food molecules that animals take in from plants, other animals, or both?	*Humans could eat them, and they become part of us.*
What do animals do with food molecules? How do they use them?	*to grow* *for energy* *They also do cellular respiration.*
Are humans animals?	*Yes, we are animals.*
Do humans and animals do the same thing with food molecules?	*Yes! We figured this out in the Inside our Bodies Unit. Animals and humans use food for growth and energy.*

Add to representation in science notebooks to include what animals do with food. Students will have just revisited what happens at a cellular scale in plants and animals in Lesson 11 and they already have developed a component of a model in their notebook to represent what happens at the cellular level in plants and humans. Now we are adding on a component to capture what happens in animals. This should be reviewed from the Inside our Bodies Unit.

Project slide T. Have students return to their plant representations from Lessons 10 and 11 and use the blank right-hand page of their notebooks to develop a representation that summarizes: (1) where other animals (besides humans) get their food molecules from and, (2) what animals do with those food molecules. Use colored pencils or markers. Draw a class representation on chart paper to keep up in the classroom. An example:



Additional Guidance

If you have already done the Inside our Bodies Unit, you can have students bring out their models showing M'Kenna and a healthy person's digestion or bring out the class consensus model. One addition from Lesson 11 that students should discuss is that cellular respiration takes place within mitochondria in cells.

11. Update our Progress Tracker. 12 MIN

Materials: science notebook, colored markers, chart paper

Convene students in a Scientists Circle to update their Progress Trackers. Present **slide U**. Have students add the lesson question to their Progress Trackers and the source of evidence shown below. Have students propose ideas to add to the Progress Tracker, based on claims they can make to answer the question.

- You can start with claims about where the foods in the "not sure" category come from. The main claim they will add is that these foods—and consequently all foods—come from animals or plants.
- Then have students discuss where foods from animals come from and what animals do with those foods. Ask students to summarize the key ideas from the food labels, reference, and model to explain what humans do with food molecules.

Once the class has come to consensus on statements, or claims, proposed, record them on a class poster. Emphasize that these ideas that are being recorded are big science ideas we have figured out together. As the statements are recorded on the class poster, students should also record them in their Progress Trackers under "What we have figured out".

Question	Source of Evidence
Where does the rest of our food come from?	• "Not sure" food ingredients lists • Nutrition facts for animal foods • Information about cow and chicken diets • Model to explain what people do with food molecules (from the Inside our Bodies Unit or other prior unit)
What we figured out in words and pictures	
• Everything we eat contains matter that came from either plants or animals. • Most animals, including humans, eat plants, other animals that once ate plants, or both. • Most animals, including humans, use food molecules they eat to build up larger molecules for growth, to get energy by burning glucose through cellular respiration, or to store for use later. (Some students may wish to capture pieces of this as a picture. If they suggest this, then propose they include the page number that the two page model of the plant, animal and human cell is located on in their notebook, as opposed to redrawing it here.)	

12. Navigation

5 MIN

Materials: None

Turn and Talk about plant parts we don't use or eat. Project **slide V.** Say, *Wow we have figured out a lot about where our food comes from and that all our food can be traced back to plants! But, do we eat or use all parts of the plants? What do you think happens to the parts of the plants we don't use?*

Suggested prompts	Sample student responses
Do we eat or use all parts of plants?	*No, I throw away the peels of fruits, like bananas or oranges.* *No, there are leaves or roots or seeds of plants I don't eat.*
What do you think happens to the parts of the plants we don't use?	*It goes in the garbage. Then the garbage truck takes it away.* *It goes in a compost bin and disappears.*

ADDITIONAL LESSON 12 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

Throughout the lesson, students must integrate information from a range of sources to come to conclusions about where food molecules come from, ultimately concluding that all foods, natural and synthetic, some from plants.

CCSS.ELA-LITERACY.RST.6-8.9 is addressed as students integrate information from video, texts, data tables, and other media to come to these conclusions.

In the jigsaw activity, students address **CCSS.ELA-LITERACY.RST.6-8.1** by reading a text, synthesizing the information, and reporting it out to their peers to answer specific questions.

SCIENCE LITERACY: READING COLLECTION 4

Producers and Consumers

1 **Plants Need Oxygen, Too**
2 **Sugar Storage Strategies of Plants**
3 **Seasonal Primary Productivity**
4 **Tasting the Other Kingdoms**
5 **Producers and Pyramids**

Literacy Objectives

- ✓ Summarize key points related to producers and consumers.
- ✓ Organize related details about producers.
- ✓ Determine the veracity of evidence supporting a claim.

Literacy Exercises

- Read varied text selections related to the topics explored in Lessons 11 and 12.
- 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 thank-you card in response to the reading.

Instructional Resources

Student Reader

Collection 4

Science Literacy Student Reader, Collection 4
"Producers and Consumers"

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 11: Why don't plants die when they can't make food?
- Lesson 12: Where does the rest of our food come from?

Standards and Dimensions

NGSS

Disciplinary Core Idea LS1.C: From Molecules to Organisms: Structures and Processes Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

PS3.D: Energy in Chemical Processes and Everyday Life Cellular respiration in plants and animals involve 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.

Science and Engineering Practices: Information; Analyzing and Interpreting Data

Crosscutting Concept: Structure and Function

CCSS

English Language Arts

RST.6-8.1: Cite specific textual evidence to support analysis of science and technical texts.

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

RST.6-8.10: By the end of grade 8, read and comprehend science/technical texts in the grades 6-8 text complexity band independently and proficiently.

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.

biomass

cellular respiration

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.

bacteria

cellulose

cell wall

chloroplast

fungi

glucose

mitochondrion

phytoplankton

primary productivity

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 Matter Cycling and Photosynthesis 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.
    - *First, you will find some serious science in a cartoon with a talking daisy plant.*
    - *Next, you'll read about plant parts that function as food storage organs—and also make tasty food for people.*

- *You'll compare maps of Earth showing how much photosynthesis is taking place on land and in the ocean in summer and in winter.*
- *Then, you'll take a quick tour of kingdoms of living things that are neither plant nor animal but are food sources for humans.*
- *Finally, you'll read what happens to matter and energy as it moves through a food chain and use this information to evaluate an ad for a food supplement.*

- 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 hand-drawn thank-you card to one or more producers in response to this reading collection. So, as you read, be on the lookout for ways that organisms that perform photosynthesis are important to you and other people.*
- 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 time of day do plants perform cellular respiration?	*all times—daytime and nighttime* *24–7*
What is the function of a taproot, such as a carrot?	*It stores sugars and starches for the plant so it can get through the winter without photosynthesis.*
What are examples of foods that are not from the plant or animal kingdoms?	*sauerkraut or kimchi bacteria*

Suggested prompts	Sample student responses
	yogurt bacteria *mushrooms* *seaweed*

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
Think about your class investigations. How could you test a daisy plant to see if it is "engaged in cellular respiration"?	*We could put the plant inside a plastic bag and use the carbon dioxide detector device.* *Or maybe we could put one daisy leaf in bromothymol blue (BTB) inside a plastic bag and look for a color change in the BTB.*
Would you say sauerkraut and kimchi, which are mostly made of cabbage, are natural foods or processed/synthetic foods? Support your claim with reasoning.	*I'd say they are processed because bacteria have to be on the cabbage to change it into sauerkraut or kimchi.*
How does a pyramid of biomass model support the idea that almost all the food that animals eat originally comes from organisms that perform photosynthesis?	*It shows that the biomass for even top carnivores, such as Atlantic cod, depend on producers for their matter.*

Exercise Page

EP 4

- 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 thank-you card addressed to one or more producer organisms.*
    - *The message on your card should explain why you, as a consumer, are grateful to organisms that carry out photosynthesis.*
    - *Your reasoning should reflect points made in two or more readings in Collection 4.*
    - *The style of your writing can be direct, personal, whimsical, or even poetic. But once you establish a style, stick with it.*
    - *The important criteria for your work are that you clearly identify ways that humans depend on and interact with producers and that your writing is appropriate for a thank-you card.*
- Answer any questions students may have relative to the reading content or the exercise expectations.

4. Facilitate discussion.

Facilitate class discussion about the reading collection and writing exercise. Students begin the reading activity with a cartoon in which everything is accurate science . . . except that a daisy plant and a mouse are doing all the talking!

Pages 34–43 **Suggested prompts**	**Sample student responses**
What is the general purpose of the first selection, "Plants Need Oxygen, Too"?	*It explains, in an amusing way, that plants and other producers carry out cellular respiration, just like animals and other consumers.*
Why do you think the author chose to write this selection as a comic strip with a talking plant?	*maybe to grab the reader's attention and make sure they corrected a common misconception*
	to make the point about plants doing both photosynthesis and cellular respiration memorable
The daisy plant mentions using glucose to make cellulose for its cell walls. If you were not sure what that meant, how could you find out?	*It sounds familiar. Didn't we learn in sixth grade that plant cells have a structure called a "cell wall" that gives the cell a certain shape?*
	We could look it up in a good online dictionary.
	We could write the word down and put the paper in the word envelope.
What is the general purpose of the second selection, "Sugar Storage Strategies of Plants"?	*It describes several structures plants use for long-term storage of sugars and starches.*
	It explains the function of plant parts that people find delicious to eat.
How does the second selection help you build knowledge on top of what you learned in the first selection?	*The first article reveals that plants use the glucose they make during photosynthesis to build molecules they need to live. The second article details where the glucose is stored until it is needed.*
What makes taproots, bulbs, tubers, rhizomes, and fruits attractive to animals?	*They taste sweet and contain the sugars and starches animals need for energy and to build body parts.*
What is the general purpose of the third article, "Seasonal Primary Productivity"?	*It compares the primary productivity of land plants in summer and winter and the primary productivity of ocean phytoplankton in summer and winter.*

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.

Online Resources

SUPPORT—Some students may need a refresher (if they studied the Cells and Systems unit in Grade 6) or introduction to cell structure and function to understand what the author means by the terms "cellulose, "cell wall," "chloroplasts," and "mitochondria." Guide students to access online videos or web pages that will describe the functions of these structures and explain if they exist only in plants, only in animals, or in both plant and animal cells.

Pages 34–43 **Suggested prompts**	**Sample student responses**
Looking at the land data, why is productivity so low in the Northern Hemisphere in January, compared to the Southern Hemisphere?	*because it is summer in the Southern Hemisphere in January, meaning that that part of Earth gets more direct light from the sun at that time of year*
Look at the Dig into Data box. What's different about the color schemes on the two sets of maps?	*On the land productivity maps, white is lowest productivity, and dark green is highest productivity. But on the ocean maps, white is the highest productivity, and dark blue and black are the lowest.*
What do you notice about phytoplankton productivity near continents?	*The water near continents seems to have high productivity.*
What is the general purpose of the fourth article, "Tasting Other Kingdoms"?	*It identifies foods humans eat that come from kingdoms other than the plant kingdom and animal kingdom.*
Based on your reading in Lesson 12 of "Where else does our food come from?" what does the author mean by saying that carrageenan is "processed"?	*that the seaweed it comes from was either chemically or physically changed*
What is the general purpose of the fifth selection, "Producers and Pyramids"?	*The first part is an article explaining how the amount of energy and matter decreases as it moves along a food chain. The second part is an advertisement for a protein powder for people who want to gain weight and build muscle.*
How is using a pyramid as the model for matter transfer in a food chain helpful?	*If you think about a real pyramid, there is less rock at each level as you go up from the base to the top. So, it makes a good model for the idea that each level of the food chain has less matter in it than the level below.*
Take a look at the Spot the BS box. Which of the claims made in the ad does not seem possible, given the general trends in how mass and energy are utilized when food is consumed?	*According to the article, only about 10 percent of the food someone eats is changed into human biomass. So, the claim in the ad that 90 percent of the product will be converted to human muscle does not seem possible.*

SUPPORT—If students have been exposed to other classification schema, they may be confused by the identification of five kingdoms in this article. Point out that biologists have proposed many models to explain the structural and evolutionary relatedness of species, using anywhere from two to eight kingdoms.

5. Check for understanding.

Evaluate and Provide Feedback

For Exercise 4, students should create a thank-you card from themselves to one or all producer organisms. The message on the inside of the card should give reasons why the writer is grateful, in a style that is appropriate for a formal card. Look for reasoning that reflects points made in at least two of the five selections in Collection 4. Possible reasoning may include:

- Plants store sugars and starches in taproots, bulbs, tubers, rhizomes, and fruit—many of which are delicious to eat and sources of nutrients and energy needed for humans to live.
- Plants take carbon dioxide out of the atmosphere and use it to make something we can eat.
- Phytoplankton in the ocean also take carbon dioxide out of the atmosphere.
- Kelp and other seaweeds also perform photosynthesis and are sources of food and other products for humans.
- Producers are the base of most food chains, which means even if humans don't eat some of them directly, they still get biomass and energy from them.

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

What happens to food that doesn't get eaten?

Previous Lesson

We obtain information from ingredients lists for common processed foods, nutrition facts, and data about animal diets. We argue that processed foods are made of matter from plants and/or animals.

This Lesson

Investigation

2 DAYS

In this lesson, we watch videos of decomposers that recycle matter and energy from dead plants and animals. We examine data (for changing inputs and outputs of the system) from bread mold (a decomposer) in the light and dark. We read about decomposers in systems around the world and revise our model to include decomposers as a living part of the system.

Next Lesson

In this lesson, we will revise our consensus model to show how the outputs of one component of the system can become the inputs for other parts. We will problematize how atoms can be continually cycled through a system as energy flows. We will make a Gotta-Have-It Checklist, which will help explain where our food comes from and where it goes next. We will explain the story of food atoms.

Building Toward NGSS

MS-LS1-6, MS-LS2-3, MS-PS1-3

What Students Will Do

Integrate scientific information about the inputs and outputs of decomposers.

Communicate information to demonstrate how matter and energy is transferred between producers, consumers, and decomposers.

What Students Will Figure Out

- The decomposers we investigated took in oxygen and food molecules and gave off carbon dioxide and water (cellular respiration).
- Decomposers recycle dead plant and animal matter and put energy back into the system.
- Decomposers use matter for food that humans (and many animals) cannot use for energy and matter.

Lesson 13 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	10 min	**NAVIGATION: WHERE DOES THE FOOD GO NEXT?** Students recall what happens to the food that comes from plants and share predictions about what happens to the food we don't eat.	A	consensus model from Lesson 12
2	12 min	**INVESTIGATE WHAT HAPPENS TO FOOD THAT DOES NOT GET EATEN** Watch videos of food that does not get eaten by animals.	B-D	Timelapse of Uneaten Pumpkin - Unit 7.4 Matter Cycling & Photosynthesis Lesson 13 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**), Timelapse of Oak Log - Unit 7.4 Matter Cycling & Photosynthesis Lesson 13 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)
3	13 min	**INVESTIGATE THE CHANGES AROUND UNEATEN FOOD** Students examine second-hand data of bread mold for the inputs and outputs in a closed system.	C	*What changes are happening around food that does not get eaten?, Data from food that did not get eaten*
4	10 min	**BUILDING UNDERSTANDINGS DISCUSSION ABOUT WHAT HAPPENED IN THE BREAD MOLD SYSTEM THAT WE CANNOT SEE** Students discuss the inputs and outputs from the bread mold investigation and what this means about the processes decomposers are doing in the dark and light.	D	*What changes are happening around food that does not get eaten?*
				End of day 1
5	2 min	**NAVIGATION**	E	
6	10 min	**OBTAIN INFORMATION ABOUT ORGANISMS THAT USE FOOD THAT DOESN'T GET EATEN** Students do a jigsaw reading about 4 organisms from around the world that use food that doesn't get eaten.	F	*Reading: Organisms that use food that doesn't get eaten, Obtaining and Communicating Information from Scientific Text Checklist*

Part	Duration	Summary	Slide	Materials
7	13 min	**COMMUNICATE INFORMATION ABOUT THE ROLE OF THESE ORGANISMS** Students communicate information about the role of their organisms in systems that they read about in *Obtaining and Communicating Information from Scientific Text Checklist*.	G	*Obtaining and Communicating Information from Scientific Text Checklist*
8	11 min	**REVISE OUR CONSENSUS MODEL TO INCLUDE DECOMPOSERS**	H	consensus model from Lesson 12, colored markers
9	3 min	**NAVIGATION** Students summarize what they've learned about decomposers and then consider if they can find decomposers other places in their lives. Students will document what they find in photographs or drawings.	I-J	

End of day 2

Lesson 13 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide** **Student Work Pages**	• science notebook • *What changes are happening around food that does not get eaten?* • *Data from food that did not get eaten* • *Reading: Organisms that use food that doesn't get eaten* • *Obtaining and Communicating Information from Scientific Text Checklist*		• consensus model from Lesson 12 • Timelapse of Uneaten Pumpkin - Unit 7.4 Matter Cycling & Photosynthesis Lesson 13 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) • Rotting Kebab - Time Lapse (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) • Timelapse of Oak Log - Unit 7.4 Matter Cycling & Photosynthesis Lesson 13 (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) • colored markers

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.

Online Resources

Lesson 13 • Where We Are Going and NOT Going

Where We Are Going

In the previous lesson, students figured out that all of their food–whether the source is synthetic, processed, or animal–comes from plants. In this lesson, students figure out where that food goes if it does not get eaten.

The purpose of this lesson is to provide students with data that serves as evidence that decomposers are recycling matter and energy from dead plants and animals back into the system. Decomposers (such as bacteria, fungi, and worms) are able to extract energy and take in matter from sources of food that are otherwise indigestible for plants and animals. Decomposers do not make their own food (like plants) but use sources such as dead plants, animals, or poop for their matter and energy. The decomposers investigated and studied in this lesson produce carbon dioxide and water via cellular respiration, like animals and plants. We also revise our model to represent the living (animals, plants, and decomposers) and non-living (air, water, sunlight, etc.) components.

Where We Are NOT Going

It is beyond the middle grade school grade band to follow cycling of nitrogen.

This lesson addresses the common misconception that decomposers, like fungi, are plants (that are able to make their own food) when they are actually more similar to animals because they must take in energy and matter from an outside source for food, rather than make it themselves.

This lesson does not separate decomposers into more specific categories such as detritivores or scavengers but identifies decomposers as organisms that produce carbon dioxide and water when using dead plants, dead animals, and poop for food (matter and energy) to live. This lesson does not address the types of decomposers that do anaerobic respiration. Not all decomposers do cellular respiration; however, the ones the students investigate do cellular respiration, producing carbon dioxide and water by taking in oxygen and matter that they are able to use for food.

In the next lesson students will connect that decomposers allow for carbon to be recycled from the dead plants and animals and put back into the air as carbon dioxide. That carbon dioxide is then available for plants as an input for photosynthesis.

LEARNING PLAN FOR LESSON 13

1. Navigation: Where does the food go next?

10 MIN

Materials: science notebook, consensus model from Lesson 12

Connect back to what we figured out from the last lesson. Project **slide A.** Remind students that last time we revised our model to show where the rest of our breakfast food came from. But we were left wondering what happens to food that does not get eaten.

Cue students to look back at their Progress Tracker from Lesson 12. Ask students to turn and talk* about the following questions:

- What did we figure out about where our food comes from?
- Where do you think that food goes if it doesn't get eaten?
- Where does food go next?

Share out ideas with the whole class.

Suggested prompts	Sample student responses
We figured out where all of our food comes from, but where does it go next?	*to the garbage dump* *Maybe something else eats it.* *into the earth*
Can anyone give me examples of plants (or animals) where we do not eat the whole plant?	*banana peels, pumpkins, parts of animals, fish bones, grape stems*
What happens to the matter and energy in those living things when we don't eat them?	*Maybe it goes into the ground.* *Maybe it disappears.* *It just builds up at the garbage dump.* *Maybe it goes in something else.*

Say, *Let's take a few minutes to watch some time lapse videos of what happens to food that does not get eaten.*

*** Attending to Equity**
Before students engage in whole-class discussions, it can be helpful to first provide them with the opportunity to work with others (either in pairs, triads, or small groups), focusing on ideas related to their reasoning. These smaller group structures can be especially helpful for your emerging multilingual students, as they give students a chance to engage in rich sensemaking with their peers, and also offers them the space to use their linguistic and nonlinguistic resources to express their ideas (and learn from other students' uses of these resources too).

2. Investigate what happens to food that does not get eaten.

12 MIN

Materials: science notebook, Timelapse of Uneaten Pumpkin - Unit 7.4 Matter Cycling & Photosynthesis Lesson 13, Rotting Kebab - Time Lapse, Timelapse of Oak Log - Unit 7.4 Matter Cycling & Photosynthesis Lesson 13 (See the **Online Resources Guide** for a link to these items. **www.coreknowledge.org/cksci-online-resources**)

Make a Notice and Wonder chart. Display **slide B.** Have students set up a "What happens to food that does not get eaten?" Notice and Wonder chart to record their observations and questions from watching examples of what happens to food that does not get eaten by animals.

Watch videos about what happens to plants and animals when they don't get eaten. Play each video and give students time to record in their Notice and Wonder chart after each video. (See the **Online Resources Guide** for a link to these items. **www.coreknowledge.org/cksci-online-resources**)

Create a whole-class Notice and Wonder poster.

Suggested prompts	Sample student responses	Follow-up questions
What did you notice when you watched the videos of the food that doesn't get eaten?	*The food got smaller. It looked like it disappeared.* *Fuzzy stuff appeared on the food.* *It looked like a liquid appeared on the bottoms.* *It looked like the soil was moving!*	*What do you mean the pumpkin disappeared?*
What did you wonder when you watched the videos of the food that doesn't get eaten?	*I wonder where the food was actually going.* *I wonder what that stuff was that appeared in the video that didn't look like it was there before.* *It looks like something is growing. What is that? Is it a plant? Or an animal?*	*When you say "I wonder where the food is actually going" is this because you think there must be something happening that we cannot see?* *Where do you think it's going? Is there something happening that we can't see?*
So in the past, how did we try to figure out what was going on with plants? What substances did we measure (such as in Lessons 4, 10, and 11)?	*We measured carbon dioxide, humidity (water), oxygen, and light.*	*What is happening when these changes are occurring to food that was not eaten? Let's look at some similar data for one of these organisms.*

3. Investigate the changes around uneaten food.

13 MIN

Materials: science notebook, *What changes are happening around food that does not get eaten?, Data from food that did not get eaten*

Examine data for old bread in the light and in the dark. Display **slide C.** Distribute *What changes are happening around food that does not get eaten?* and *Data from food that did not get eaten*. Tell students to work with their groups to fill out the data table on *What changes are happening around food that does not get eaten?*. Once they have filled this out have them work in their group to answer the making sense questions.

*** Supporting Students in Engaging in Obtaining, Evaluating, and Communicating Information**
Scientists communicate their findings to others by writing

Have students tape *What changes are happening around food that does not get eaten?* into their notebooks.

Say, *I was able to get some data of bread that did not get eaten from another classroom. Let's examine what happened to the bread and the gases around it over 7 days.**

articles for publication in scientific journals. Scientific journals typically do not include any visual media (photos, videos, etc.) of experimental setup, so a skill that scientists develop is the ability to obtain information and recreate experiments based solely on concisely written experimental procedures. In *Data from food that did not get eaten*, students will read about the experimental setup and data collection for the bread mold experiment, as well as discuss how they would conduct a similar experiment.

Assessment Opportunity

Students should notice that the bread mold growth is similar in the light and the dark. Students should describe that carbon dioxide and water are increasing and oxygen is decreasing, which is similar to data for plants in the dark and animals.

If students struggle to integrate information from the bread mold images and graphs into what they have already figured out about systems, ask them about similar investigations from Lessons 4, 10, and 11 where they examined data for other systems.

Alternate Activity

If time permits, your students can do this investigation, first-hand, in the classroom using BTB (like in Lessons 7 and 11) or the carbon dioxide/relative humidity detector (like they used in Lessons 4 and 10). It takes 7 days for the bread mold to grow, so you would have to start this during an earlier lesson.

Additional Guidance

The data for the changes in water levels in *Data from food that did not get eaten* is reported as percent relative humidity (% RH). These data were collected using the same carbon dioxide/relative humidity detector used in Lessons 4 and 10, so students should know that % RH is a measure of the relative amount of water in the air.

4. Building Understandings Discussion About What Happened in the Bread Mold System That We Cannot See

10 MIN

Materials: science notebook, *What changes are happening around food that does not get eaten?*

Gather students in a Scientists Circle with their science notebooks. Display **slide D.** Have students bring their science notebooks and find a good spot where the whole class can see each other. On their walk over, tell students to think about one thing they noticed in the old bread investigation that they could share as a class.*

*** Attending to Equity**
This is a great opportunity to pick a student to trace an equity map of the discussion, following each student who speaks with a line on the equity map to the next person. Make sure to have the chosen student start by writing the names of each student around the circle so they are ready to start mapping as soon as the discussion begins.

Facilitate a Building Understandings Discussion about what must be happening in the system with decomposers.

Key Ideas

Purpose of this discussion: Identify the inputs and outputs of bread mold in the light and dark using evidence produced from visual observations of bread and measuring the gases in a closed system around bread. This leads us to add a new type of organism (decomposers) into the system with animals and plants.

Listen for these ideas:

- Bread mold grew in the light and the dark.
- Carbon dioxide and water increased in the light and the dark.
- Oxygen decreased in the light and the dark.
- Carbon dioxide and water must be outputs for bread mold.
- Oxygen must be an input for bread mold.
- Bread mold is more likely doing cellular respiration than photosynthesis because of its inputs and outputs.

Suggested prompts	Sample student responses	Follow-up questions
What did we notice happened to the bread in the light?	*It got moldy!*	*Can you describe how the bread changed from day 1 to day 7?*
What did we notice happened to the bread in the dark?	*It also got moldy!*	*Do I hear you saying the bread got a similar amount of mold growth in both the dark and the light?*
How does what we observed happen with our eyes compared to what we measured with the gases we could not see?	*We saw that the similar amounts of mold grew on the bread left in the light and the dark.* *For both breads, carbon dioxide went up, water went up, and oxygen went down.*	*What does it mean for carbon dioxide or water to go up? And for oxygen to go down?*
What do you think could be going on in these organisms to cause the carbon dioxide and water to go up, and oxygen to go down in both the dark and the light?	*chemical reactions* *cellular respiration*	*What is our evidence that chemical reactions (or series of) like cellular respiration are happening?*
What other inputs besides oxygen do we think these organisms are using to do cellular respiration?	*The old bread is like food for these organisms!*	*How could we know if that was true?*
What else would we want to know about these organisms to figure out what is going on inside of them?	*Does this happen with more than just bread mold?* *Are these organisms made of cells?* *What else can these organisms use for food besides bread?*	*Great ideas! How about we come back next class and we can look at some examples of other organisms around the world?*

Assessment Opportunity

Students should say that bread mold is doing cellular respiration because the inputs are food and oxygen and the outputs are carbon dioxide and water, like we saw with animals or plants, specifically, in the dark. If students struggle to connect what they have previously figured out about the inputs and outputs of cellular respiration and photosynthesis, ask them to reexamine the class consensus model or the incremental model in their notebook and tell you the inputs and outputs they notice for plants and animals.

End of day 1

5. Navigation

2 MIN

Materials: None

Turn and talk about what we figured out about bread mold in the last class. Display **slide E.**

Suggested prompts	Sample student responses
What did we figure out about bread mold in the last class?	*Bread mold produced carbon dioxide and water.* *Bread mold took in matter from old bread and oxygen.*
What are we wondering about these types of organisms?	*Where can these organisms live?* *Where did these organisms come from?* *What other types of organisms like this are there?* *Do these types of organisms break down other things beside the food we saw in the video?* *What is going on inside this organisms that produces water and carbon dioxide?*

Say, *We have been examining data collected in a lab with the bread inside of a bag, which is an example of a closed system with individual components sealed inside of a bag. Like in the Bath Bombs Unit where we conducted an investigation inside a closed baggie, what would happen if we open the bag where the bread mold was growing? We would see some of the components of the system interact with other systems (or parts of systems) outside the bag.*

*In order to answer some of our questions, let's take a few minutes to read about some organisms that use food that is not eaten by plants and animals (like the bread mold) that live in different (open) systems from around the world. As you read, think about what other components of the system such as plants, animals, or others are present.**

* Supporting Students in Developing and Using Systems and System Models

Systems and System Models is a focal crosscutting concept in 4 of the 6 6th grade Units and in Unit 7.3: *How do things inside our bodies make use feel the way we do?* (Inside our Bodies Unit) immediately before this unit so students can build off of their understanding in this lesson. In *Inside our Bodies* we figured out about how the digestive system was one big system with lots of subsystems, similar to how students are making sense of the different organisms as living components of this system that cycle their inputs and outputs between one another. Students should also remember from Unit 7.1: *How can we make something new that was not there before?* (Bath Bombs Unit) that they did investigations in closed systems (a baggie) and open systems. Use this to help motivate talking about the food web model being created as a system with inputs and outputs.

6. Obtain information about organisms that use food that doesn't get eaten. 10 MIN

Materials: science notebook, *Reading: Organisms that use food that doesn't get eaten*, *Obtaining and Communicating Information from Scientific Text Checklist*

Individually read about *Organisms that use food that doesn't get eaten.* Display **slide F**. Assign students one of the 4 organisms to read about in ***Reading: Organisms that use food that doesn't get eaten***. Give students 7 minutes to read, marking up their copy of ***Reading: Organisms that use food that doesn't get eaten,*** filling out the Obtaining Scientific Information Checklist on *Obtaining and Communicating Information from Scientific Text Checklist*.

Additional Guidance

Have students find a partner who read the same reading. Give students 3 minutes to come together and share their Obtaining Scientific Information Checklist from *Obtaining and Communicating Information from Scientific Text Checklist*. Have students add ideas from their partners to obtain and integrate more information from the ***Organisms that use food that doesn't get eaten*** reading.

*** Attending to Equity**
Each of the four readings is designed for students of different reading capabilities to access. If a student struggles with reading complex text, assign them the Dung Beetle reading, which relies more on images. If a student is looking for a challenge, assign them *Bacillis Subtilis,* which relies more heavily on text.

7. Communicate information about the role of these organisms. 13 MIN

Materials: science notebook, *Obtaining and Communicating Information from Scientific Text Checklist*

Prepare to communicate about the organism you researched. Display **slide G.** Give partners, 7 minutes to fill out the Communicating in Science checklist on *Obtaining and Communicating Information from Scientific Text Checklist* for their organism.

Explain how to conduct an oral gallery walk. Tell students there will be three rounds where they get to share about their organism with one other person. During the first round the group that researched *Bacillis* will meet with Beetle, and Worm will meet with Fungi. In the second round, *Bacillis* will meet with Worm, and Beetle will meet with Fungi. In the third round, *Bacillis* will meet with Fungi, and Beetle will meet with Worm.

Round	Pairs of Organisms	
1	*Bacillis* and Beetle	Worm and Fungi
2	*Bacillis* and Worm	Beetle and Fungi
3	*Bacillis* and Fungi	Beetle and Worm

Conduct an oral gallery walk. Students will have 1 minute to share about their decomposer and then switch and the other partner will share about their decomposer. After the oral gallery walk, students will have orally communicated and listened to scientific information about all 4 organisms.

8. Revise our Consensus Model to include decomposers.

11 MIN

Materials: consensus model from Lesson 12, colored markers

Gather in a Scientists Circle around the consensus model from Lesson 12 for a Consensus Discussion. Display **slide H.** Have students bring their science notebooks.*

Key Ideas

Purpose of this discussion: To establish the role of decomposers in a system and add them to the system model we are incrementally building.

Listen for these ideas:

- Decomposers use dead plants and animals for energy and matter.
- Decomposers also take in oxygen.
- Decomposer produce carbon dioxide and water.
- Decomposers (that we researched) do chemical reactions like cellular respiration to extract energy from their food.
- Animals are called consumers because they have to eat other animals or plants for food.
- Plants are called producers because they produce their own food through photosynthesis.

Suggested prompt	Sample student responses
What patterns can we agree on about these 4 organisms, the organisms in the videos, and the bread mold?	*We noticed they all take apart plants and animals that did not get eaten.* *We noticed they all take in oxygen and some type of food and output carbon dioxide and water.* *It is like they take waste (like old food and poop) and eat what other animals can't!* *We noticed that while the organisms look very different they do the similar process that we think is cellular respiration.*

Say, *Scientists call these organisms that are able to use food that does not get eaten for energy and matter* decomposers.

Co-construct how to add *decomposers* to the class consensus model. *Say, Let's take what we have figured out and add it to the consensus model we have been building as a class and in your notebooks.**

Additional Guidance

When co-constructing this model, it is important to note that we think cellular respiration is happening in the decomposers we investigated, because we saw that oxygen decreased and carbon dioxide and water increased in the bread mold, which is similar to animals and the net production when plants are in the dark. We also read about four

*** Strategies for This Consensus Discussion**

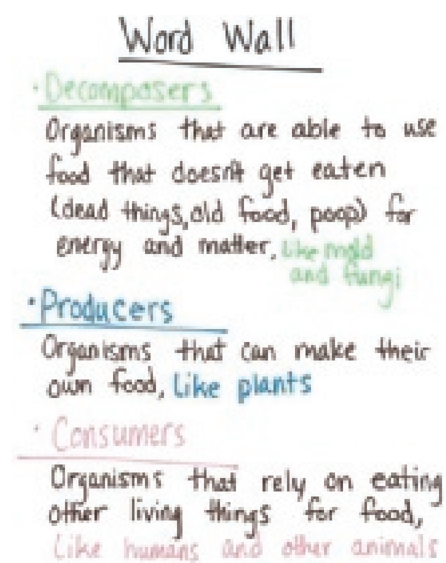
To encourage students to build upon one another's ideas and come to points of agreement, prompt students to say things like, *We agree with that idea but want to add to it*, or *Our group has a different way of thinking about it and so we drew it this way.* Ask questions of students (and encourage students to ask them of each other) such as: Where do we have agreement? Do we feel like we know the role these organisms are playing in the system? How does energy and matter relate to that idea?

*** Attending to Equity**

When new scientific words, like *decomposers*, are introduced, it can be helpful for emergent multilingual students to see a other decomposers that do cellular respiration to extract energy from their food, so we know it is an important process for them too. While all decomposers may not do cellular respiration (because they do anaerobic respiration or other processes in environments without oxygen), all of the ones we investigated do.

Suggested prompts	Sample student responses	Follow-up questions
Can someone remind me of some of the types of decomposers we read about?	*Bacteria, fungi, worms, beetles!*	*Great! How about we add a "living things" box for decomposers to our model?*
What were some of the other related components in the system with the decomposers?	*Plants (which could become dead plants), animals (which could become dead animals), humans, carbon dioxide, water, oxygen, etc.*	*So if we were to label our model as a model system, were there any interactions between those components of the system you mentioned?*
What inputs and outputs should we show for decomposers in our revised model of the system?	*There should be arrows going from dead plants and animals into the decomposers along with oxygen and arrows coming out of the decomposers for carbon dioxide and water.*	*What chemical reactions are going on in the decomposers we investigated and read about?* *Where are those reactions taking place?*
We just added decomposers to our models. Let's think about what would happen if there were no decomposers in the system? Why do we think decomposers are so important in the systems where they live?	*There would be a lot of dead plants and animals from all the food we don't eat!* *There would be more oxygen for plants and animals to do cellular respiration.*	*So how is the role of decomposers different than that of plants or of animals in the system?*
How do decomposers compare to plants and animals in relation to how they get their energy and matter?	*Plants absorb energy from the sun along with carbon dioxide and water to make their own food.* *Animals have to eat a plant or another animal to make food.* *Decomposers, plants, and animals, are all living.*	*Do I hear you saying that while plants, animals, and decomposers all require an input of food to live, the source of their food is different?*
And we are calling plants, animals, and decomposers living things, what about the inputs they need to survive? Are they all living too?	*No, plants need carbon dioxide and water and light to do photosynthesis. These aren't alive.* *Animals and decomposers need oxygen to survive and it is not alive.*	

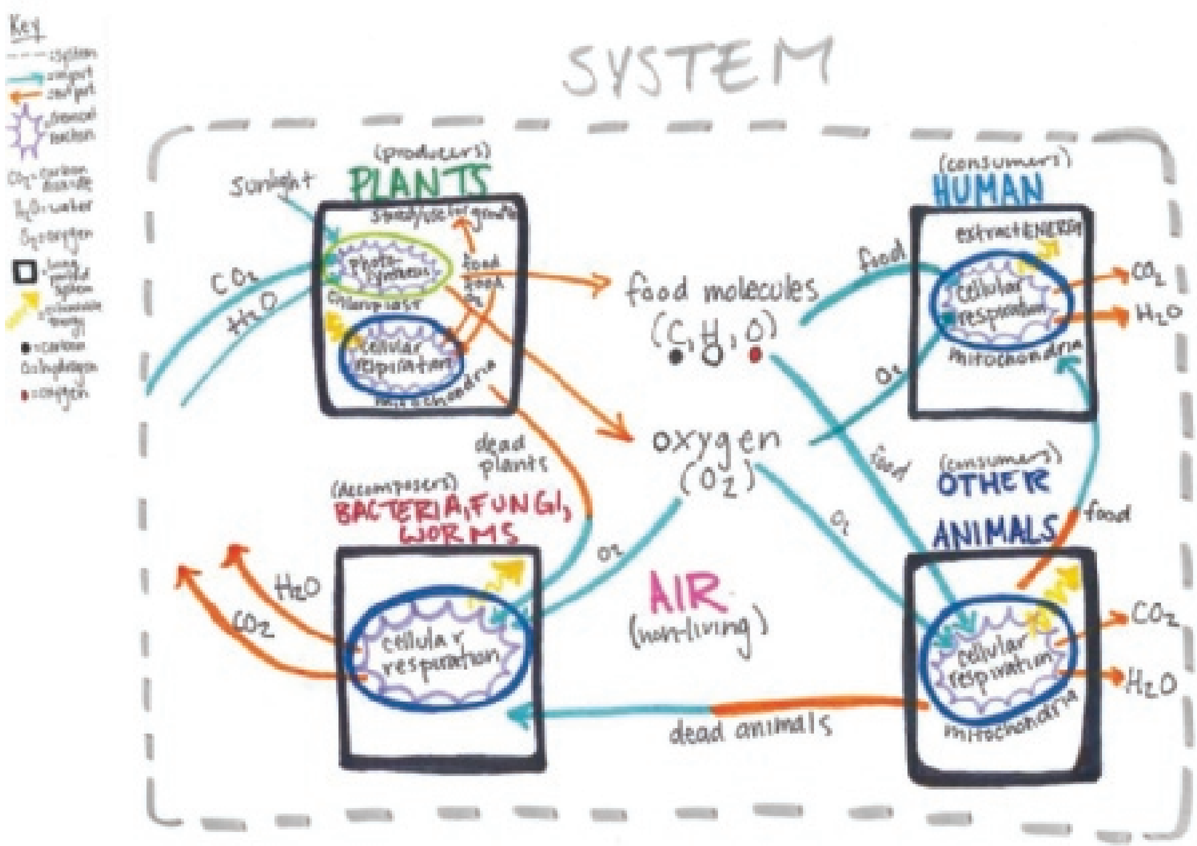
reference to those words added to a word wall. Add these words to the word wall as they emerge in the discussion, rather than before. Add the word *decomposers*, then later add *producers* and *consumers* to the word wall.



Suggested prompt	Sample student response	Follow-up question
In our model we have labeled plants, humans, animals and decomposers as living, and now we are saying that some of the inputs and outputs from these living components are not alive. How could we revise our model to capture this idea that the living things in our model need matter and energy from things that are not alive in order to survive?	*Maybe we could label it as something like "not living" … or "non-living".*	*What inputs and outputs in our model would we want to label as "not living"?*

Say, *Scientists call organisms, like plants, that make their own food* producers. *They call organisms that rely on eating other animals or plants for food* consumers. *Let's add these ideas to our word wall and then to our model.*

On the next page is one possible representation of the co-constructed model:



9. Navigation

3 MIN

Materials: None

Turn and talk. Display **slide I**. Ask students to turn and talk about this question: *How does what we just figured out help us explain what happens to the leaves of the maple tree when they fall to the ground or the maple tree after it dies?* Listen for ideas about how we are trying to explain that some decomposers must take molecules from the tree and give off carbon dioxide.

Explain the Home Learning. Display **slide J.**

Home Learning Opportunity

Home learning assignment: Look for evidence of decomposers in our lives. Instruct students to use what they have figured out from the oral gallery walk to look for evidence of decomposers outside of the classroom. If possible, ask students to photograph or take short videos of places in their lives where they noticed decomposers, and bring the photographs video clips, or drawings of the decomposers in to share with the class. Ask the group for suggestions of where to look. Listen for ideas such as rotten or fermented food, on the ground, in dead trees, etc.

End class by saying, *We have learned a lot about where we can find decomposers in systems and what process they are doing. The maple tree and the decomposers that use its dead leaves for food is just one example. Let's try to find more examples in our lives and communities of decomposers in systems. As you leave today, share with your elbow partner at least one place outside of class that you plan to look for decomposers and take or draw pictures. We want to see that decomposers cycle matter and energy in other places so let's take some time next lesson to look at some of your examples.**

*** Attending to Equity**
This is an example of self-documentation, an instructional routine that can be used to help students see how the focal science ideas they have learned about relate to everyday phenomena in their lives. This routine can be a powerful way to support students in forging connections between their identity outside of the classroom and the science ideas they engage with inside of the classroom.

ADDITIONAL LESSON 13 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

This lesson addresses **CCSS.ELA-LITERACY.RST.6-8.7** and **CCSS.ELA-LITERACY.RST.6-8.9** as students must integrate information from a variety of sources to build their understanding of the role and function of decomposers in matter cycling. With each video, reading, and examination of images from experiments, students compare the information and build on their initial ideas.

LESSON 14

Where does food come from, and where does it go next?

Previous Lesson

We watched videos of decomposers that recycle matter and energy from dead plants and animals. We examined data from bread mold (a decomposer) in the light and dark and read about decomposers in systems around the world. We revised our model to include decomposers as a living part of the system.

This Lesson

Putting Pieces Together

2 DAYS

In this lesson, we revise our consensus model to show how the outputs of one component of the system can become the inputs for other parts. We problematize how atoms can be continually cycled through a system as energy flows. We make a Gotta-Have-It Checklist, which helps explain where our food comes from and where it goes next. We explain the story of food atoms.

Next Lesson

We will revisit the Driving Question Board and discuss all of our questions that we have now 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-LS1-6, MS-LS2-3, MS-PS1-3

What Students Will Do

Construct an explanation to describe the cycling of atoms (matter) into and out of organisms within a system, and respectfully provide and receive feedback on respective explanations with a partner.

What Students Will Figure Out

- The outputs of living things become the inputs of other living things and part of the nonliving components of the system.
- Atoms are continuously recycled between living (producers, consumers, and decomposers) and non-living (air and water) components in our world.

Lesson 14 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	10 min	**NAVIGATION: UPDATE OUR PROGRESS TRACKERS** Highlight key ideas we learned from the previous day.	A	
2	10 min	**SHARE HOME LEARNING** Share photographs and drawings of decomposers from student communities.	B	photographs/drawings of decomposers in our communities
3	15 min	**UPDATE OUR WHOLE-CLASS CONSENSUS MODEL**	C	colored markers
4	10 min	**PROBLEMATIZE HOW ATOMS IN DECOMPOSERS COULD BECOME PART OF US**	D-E	
				End of day 1
5	5 min	**UPDATE OUR PROGRESS TRACKERS**	F	
6	20 min	**CREATE A GOTTA-HAVE-IT CHECKLIST FOR LESSONS 9-14** Students work in pairs to review their artifacts from Lessons 9 to 14 and then as a class decide on what ideas should be included in our final assessment model to answer the lesson question.	G	*Lesson 14 Gotta-Have-It Checklist*
7	10 min	**EXPLAIN THE STORY OF A FOOD ATOM** Students use their models and Gotta-Have-It Checklists to tell the story of a food.	H	*Lesson 14 Gotta-Have-It Checklist*, *Story of a Food Atom*
8	5 min	**PROVIDE AND RECEIVE FEEDBACK** Provide and receive feedback about *Story of a Food Atom* with a partner.	I	*Story of a Food Atom*, Optional *Peer Feedback Guidelines*
9	5 min	**RESPOND TO FEEDBACK** Use feedback to make any revisions to their *Story of a Food Atom*.	J	*Story of a Food Atom*, *Self-Assessment*
				End of day 2
		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: *Connected Lives*

Lesson 14 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide** **Student Work Pages**	• science notebook • photographs/drawings of decomposers in our communities • *Lesson 14 Gotta-Have-It Checklist* • *Story of a Food Atom* • Optional *Peer Feedback Guidelines* • *Self-Assessment*		• colored markers

Materials preparation (30 minutes)

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

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

Online Resources

Lesson 14 • Where We Are Going and NOT Going

Where We Are Going

In previous lessons, students individually modeled the inputs and outputs of producers, consumers, and decomposers in a system and saw that the food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat those animals that eat plants.

In this lesson, students connect that the outputs of each living thing can become the inputs of other living things at each level in the system. Concurrently, students are able to trace the cycling of matter from one organism to the next and into the nonliving parts of the system. They will figure out that atoms that make up our food are continuously recycled between living and nonliving things. Students will need to recall previous knowledge that all matter (and thus atoms) in our world is conserved and cannot be created or destroyed. This is especially important when making sense of the recycling of atoms into and out of the nonliving and living parts of the system. In the next lesson, students will add in the flow of energy between components of the system.

Where We Are NOT Going

Systems are used to make sense of the cycling of atoms through living and nonliving things. Though the system model students are developing represents a small ecosystem model, we do not label it as such here. The next unit, Unit 7.5: *Ecosystem Dynamics (Palm Oil Unit)*, goes into depth about what an ecosystem is and students will investigate the interactions between organisms within an ecosystem beyond how inputs of matter and energy of one organism can come from an output of another organism. This unit does not identify different types of ecosystems or effects on or causes of changes in populations. In the unit that follows this one, the *Palm Oil Unit*, students will dive into what effects and/or causes changes to ecosystems.

LEARNING PLAN FOR LESSON 14

1. Navigation: Update our Progress Trackers. 10 MIN

Materials: science notebook

Recap where you left off at the end of the previous class. Display **slide A.** Remind students about their work from the day before looking at videos, data, and readings about the inputs and outputs of decomposers (and how they get their matter and energy).

Individually update the Progress Tracker.

Say, *Wow! In our last lesson, we figured out a lot about a new component in our system, decomposers. Let's take a few minutes to capture in your Progress Trackers what we figured out in our last lesson.*

In their notebooks, students should draw a 3-box Progress Tracker using what the class came to consensus on in the previous lesson. First, have students write down the question they have been trying to answer, *What happens to food that does not get eaten?* Ask students what evidence they have been working with to answer this question.

Give students an opportunity to generate a list of ideas they have figured out now. Students may refer to the page number in their notebooks for the incremental model that the class has been developing rather than developing a new model just for their Progress Trackers.

Below is one suggested representation.

Question	Source of Evidence
What happens to food that does not get eaten?	• Videos and images of decomposers • Graphs of the inputs and outputs for bread mold • *Data from food that did not get eaten*
What we figured out in words and pictures	
• Decomposers we investigated use oxygen and food molecules as inputs and give off carbon dioxide and water from doing cellular respiration. • Decomposers recycle dead plant and animal matter and energy back into the system. • Decomposers use matter for food that humans (and many animals) cannot use for energy and matter.	

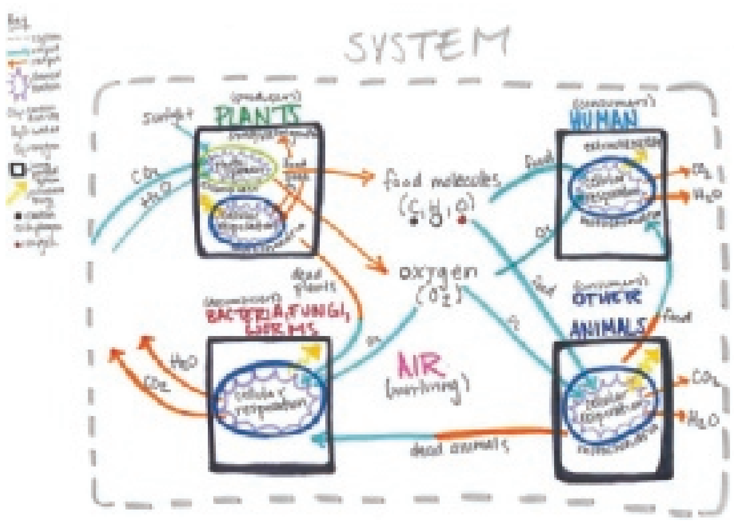
2. Share home learning. 10 MIN

Materials: science notebook, photographs/drawings of decomposers in our communities

Share what evidence of decomposers students observed in their lives. Display **slide B.** Have students share what they discovered in their home learning experience. If you asked students to take photographs, consider collecting photographs digitally before class and making a slideshow. Ask students to describe what they found as each of their slides come up. If you ask students to print photos or they brought in drawings, have them post them on chart paper at the front of the room. As students come up and post their photos, they should explain what they took a photo of and why they'd label it as a decomposer.*

Suggested prompts	Sample student responses
What evidence of decomposers did you find at home or in your community?	*We saw mold on bread, mold on fruit, mushrooms growing on logs, worms in a worm bin, leaves that were breaking down, etc.*
When you picture where you found the decomposer at home, what was the environment around it like?	*The moldy bread was on the counter.* *The moldy fruit was in the refrigerator.* *There were fruit flies flying around a tomato on the counter at home.* *I found worms in the garden when I was digging.* *I saw leaves where we took a walk on the trail that were weird colors, like whitish mold maybe?*
In the environment where you found your decomposer, what else did you notice besides your decomposer? Were there any producers or consumers in the environment the decomposer was found in?	*We noticed that there were also plants, dampness, animals, lots of sun, or no sun.* *The bread came from producers. I was a consumer of the bread (if it wasn't moldy!).* *Worms are confusing. Maybe they are both consumers and decomposers?*

Say, *Open your notebook to the two pages where we are creating a model of the plant, the animal, the human, and the decomposer. Let's take a closer look at the inputs and outputs in our two-page model.*



*** Attending to Equity**
If you are concerned that some students will not have access to a camera or drawing materials but still want to give all students the opportunity to feel like participants, consider collecting the images anonymously and adding them to a slideshow. Afterward, ask for a couple of volunteers who want to talk more about the photo they contributed, so as not to draw attention to those students who did not.

Suggested prompts	Sample student responses
There are a lot of arrows for inputs and outputs. Some of them extend from one component to another. Find decomposers. Is there any connection from decomposers to other organisms in our model? Do any other organisms use the outputs from decomposers?	*It looks like plants use the outputs from decomposers!*
Is there anywhere on the model that you can trace where the outputs of one becomes an input for another?	*The outputs (food) of the plant are easy to trace. We have an arrow showing they make food and give off oxygen and then there is an arrow showing that is what humans and animals need so the food and oxygen become an input for us.*
Okay, so if we can trace where the outputs of plants go, let's try to figure out where in our model the inputs of plants come from.	*The inputs of the plant are carbon dioxide and water and light. We give off carbon dioxide and water, so maybe our outputs become the plant's inputs?*

3. Update our whole-class Consensus Model.

15 MIN

Materials: science notebook, colored markers

Gather in the Scientists Circle to update the consensus model. Display **slide C.**

Say, *Let's return to the model we are creating in our notebooks and see if we can capture on paper how these different components of the larger system interact in terms of energy and matter. Let's zoom into our model and try to figure out where plants get the carbon dioxide they need to make food. Can we connect plants to any other components in our model?*

Key Ideas

Purpose of this discussion: Students will revisit the model that they have been adding to the last few lessons. Up until this point, we have only been concerned with keeping track of the inputs and outputs of plants, animals, humans, and decomposers. And, although there is a connection between food as an output of plants and an input for animals and humans, this has not been made explicit to students. By the end of this discussion, students should realize that the inputs of one component comes from the outputs of another component. Such as the output of carbon dioxide from humans potentially becomes the input for a plant.

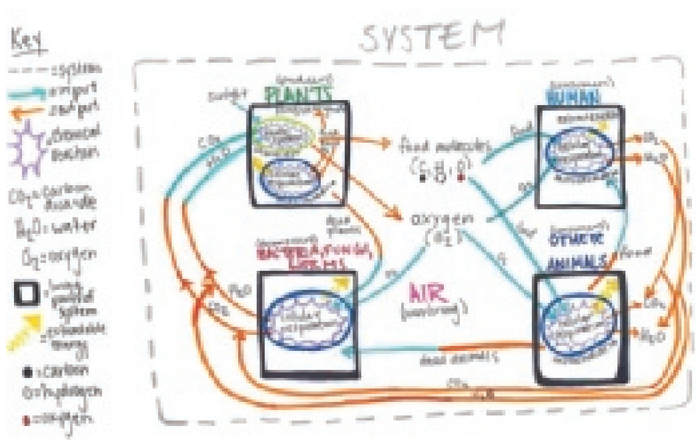
Listen for these ideas:

- The outputs of plants, food, and oxygen, are inputs humans and other animals need.
- The outputs of animals, humans, decomposers, and plants (when not doing photosynthesis) are all the same: carbon dioxide and water. These are the inputs that plants need.
- The outputs of animals, plants, and decomposers can become the inputs for plants.
- It is like a big circle where inputs are becoming outputs that then become inputs again!

Suggested prompts	Sample student responses	Follow-up questions
Looking at the models you have created in your notebooks, where do you think plants get carbon dioxide and water they need to be able to do photosynthesis and make food?	*Humans breathe out carbon dioxide and water, so they might get those from us.*	*Where else might they get these inputs needed to make food?*
So if our outputs of carbon dioxide and water are inputs for the plant, then how could we represent that on our model?	*We could draw an arrow from the output of carbon dioxide from humans all the way around and over to become an input for the plant.*	*Could we do the same thing for water then?*
What about the outputs from animals and decomposers? Where might they be used?	*Since they are the same outputs from humans and the same inputs needed by the plants, maybe they also go to the plants.*	*How should we represent this on our model?*
What are some things you notice about your model now that we have added in the arrows?	*It is like a big circle! Things that come out of some components go into other components.* *It is kind of like the outputs are recycled to become inputs for other things.*	

Tell students to make sure they are updating their models to include arrows showing that the outputs from animals, humans, and decomposers are inputs for plants. At this point, student models should have loops of arrows to show where molecules of matter are coming from and going to between the different living components using matter from nonliving components.

An example of what the model could look like is included here:



Suggested prompts	Sample student responses
Let's take a moment and reflect on this model we have created. We started our unit by looking at plants, so let's start there. Would a plant be able to make food molecules if there were no decomposers?	*Yes, possibly because they could get what they need from humans and animals.*
Okay, what if there were no plants in our system? Would humans be able to get the food they need for energy and growth?	*Yes, possibly because there are still animals and some of our foods come from animals.*
What did we figure out animals need for energy and growth?	*Plants. So plants are a pretty important piece of this system.*

Say, *Now we have a model that represents how different living things in our system depend on each other for the inputs they need to survive. Our model shows how the matter and energy cycle, or move, between producers, consumers, and decomposers within one big system. You may have investigated similar models, called food webs or food cycles, in earlier grades.*

Additional Guidance

The food web in this unit is built incrementally over several lessons as students gather evidence for the roles of producers, consumers, and decomposers as matter cycles and energy flows through the living and nonliving parts of the system. This focus on the inputs and outputs, both living and nonliving, in this nontraditional, simplistic food web looks slightly different than traditional food webs students may have developed in the past due to the focus on where our food comes from and where it goes next through a system thinking model. Additionally, and this will be built more in the next unit, *Palm Oil*, food webs often show more than one path that matter and energy can take through the various organisms. Since students will be explaining *Story of a Food Atom* they will have the chance to demonstrate multiple paths for cycling atoms in the system.

4. Problematize how atoms in decomposers could become part of us.

10 MIN

Materials: science notebook

Problematize how an atom found in the food for a decomposer could become part of food for a human.

Say, *Okay, let's pause and reflect on our model that we have been revising. It looks like there are all kinds of different paths that matter can move between organisms and the surroundings and back again. It's almost like everything is connected because we have so many arrows showing connections! That makes me wonder—is* everything *connected? Could a part of a molecule—like one specific atom from inside a decomposer—become part of us? Like make up* our *body? Let's use an example to think about this. What is a food we can't eat but decomposers can? Let's brainstorm a list.*

Either on chart paper or a white board, record students' ideas for foods decomposers can eat but we can't. Some examples students might say include: leaves, wood, orange peels, rotten food, etc.

Display slide D. Say, *Up until now we have been trying to figure out where whole food molecules come from and go next. Our new question now is, could one of the* ***atoms*** *in one of these examples of foods we can't eat and decomposers can, end up back* *in the foods we can eat? Take a moment to talk to a partner about these questions: Could something in what that breakfast mold ate that we looked at in our last lesson end up inside us? Could one of the exact same atoms from this mold get inside you?*

Have a few students share their ideas.

Say, *It sounds like we need some more time to dig into this further. Where does the matter go after it is in decomposers? You are going to work with a partner using the two-page system model in your notebooks to see if you can answer this question.*

Work with a partner to track an atom from inputs of decomposers to inputs of humans. Project **slide E.** Tell students that they will work with a partner to see if they can trace an atom from a food for a decomposer to food for humans. They should choose an atom that is an input for decomposers and trace where that atom could potentially go throughout the model. An example could be: if a pair chooses to follow a carbon atom that comes from a piece of food a decomposer eats, then they should trace this carbon into the decomposer where it goes through cellular respiration. After this the carbon atom could become part of the carbon dioxide that the decomposer releases. Then the carbon atom could go into a plant as part of carbon dioxide where, through photosynthesis, it becomes part of the food the plant makes that we eat. As partners work together, listen in to different groups' conversations to get and provide support through questions and prompts to use the system models in their notebooks as needed.

Have some pairs share what they found. They should be able to trace the atom they chose from food for a decomposer to food for us.

Suggested prompts	Sample student responses
Were you able to follow an atom from food for a decomposer to food for an animal?	*Yes!*
Can some of you share your findings? What atom did you follow?	*My partner and I followed an oxygen atom from food for a decomposer. We were able to trace it in the carbon dioxide or water that a plant takes in to do photosynthesis. Then the oxygen atom left the plant either as oxygen in air or in food molecules. So it could take different paths, but could potentially end up in the food we eat.* *My partner and I traced a carbon atom from food a decomposer can eat. We were able to trace it to the carbon dioxide the decomposer releases. Then the carbon could be an input for the plant to do photosynthesis and make food molecules. These food molecules we can eat so the carbon atom could end up in us.* *My partner and I traced a hydrogen atom from food a decomposer can eat. This hydrogen atom was released from the decomposer as part of water vapor. This water vapor the plant can take in to do photosynthesis and make food. We can eat the food the plant makes, so the hydrogen atom that was in the food of the decomposer could end up in us!*

Suggested prompts	Sample student responses
Wow! So an atom that went into a decomposer can eventually end up in us! This is a really big cycle! What are some conclusions you can make about the importance of decomposers so plants can get what they need to make food in systems?	*It seems like if there weren't any decomposers, then there would be a lot of rotten food and poop around. The decomposers are important because they use this for energy and then they put carbon dioxide and water back into the system, which helps plants make food!*
What are some conclusions about the importance of plants (producers) in this system?	*Plants are very important! We eat plants, other animals each plants, and even decomposers eat dead plants! Without plants, a lot of living things wouldn't get what they need to survive.*
What are some conclusions about the importance of animals and humans (consumers) in this system?	*Humans and other animals use plants for food to get energy to live and grow and then put carbon dioxide and water back into the system, which helps plants be able to make more food!*
Tomorrow we will use what we have figured out to update our Progress Trackers!	

End of day 1

5. Update our Progress Trackers. 5 MIN

Materials: science notebook

Update Progress Trackers in science notebooks. Project **slide F.** Tell students to turn to their Progress Tracker sections in their notebooks, make another row in the two-column table, and record the question, *What happens to the outputs of decomposers after they take in food that does not get eaten in the system?* Students individually record what they have figured out about this so far. Below are some sample ideas students may include.

Question	What I figured out in words/pictures
Where does our food come from, and where does it go next?	• Food comes from plants. Even the food that comes from animals can be traced back to plants because they eat plants. • Food that isn't or can't be eaten by animals and humans is eaten by decomposers. • Decomposers break down the foods we can't eat and recycle the atoms back into the system. • The outputs of living things become the inputs of other living things and part of the nonliving components of the system. • Atoms are continuously moved between living and nonliving things. • Atoms are continuously recycled. Nothing is really new. The atoms that make up an organism (or any living or nonliving thing) have been a part of something else before.

6. Create a Gotta-Have-It Checklist for Lessons 9–14. 20 MIN

Materials: science notebook, *Lesson 14 Gotta-Have-It Checklist*

Take stock of all of the ideas we have added to our models in Lessons 9-14. Display **slide G**

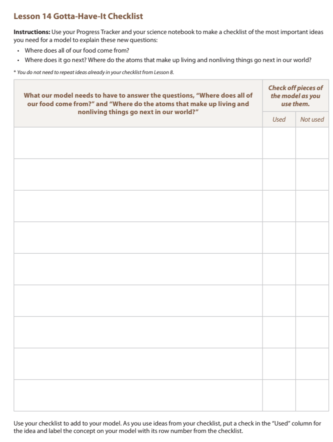
Say, *Let's pause and take stock of all of the amazing ideas we have figured out so far. We did a lot of investigating and sensemaking in Lessons 9-14, so let's start by adding to our Gotta-Have-It Checklist with Lesson 9 until today.*

Preview the Gotta-Have-It Checklist. Explain to students, *You will create a Gotta-Have-It Checklist for everything we have figured out since we last made a checklist in Lesson 8 when we figured out where plants are getting food from. We will decide which ideas from our Progress Trackers and investigations are most important for explaining where food comes from* ***and*** *where it goes next. What have you figured out about how food is made in plants? What have you figured out about what happens to food that is not eaten? What have you figured out about what happens to food that we eat? Think about how all these different pieces of matter move through the system model we created as you choose what to add to your Gotta-Have-It Checklist. You will use this checklist with the Story of a Food Atom. First, consult the Progress Trackers in your notebooks to determine what is most important for explaining where food comes from and where it goes next.**

Additional Guidance

Although a Gotta-Have-It Checklist is often built before doing a final class model, in this case we have just added some more ideas to the class model so we are going to use the Gotta-Have-It Checklist as a way to make sure all of our ideas are represented in the final class model. Then students will be able to use the Gotta-Have-It Checklist on their final unit assessment.

Create the Gotta-Have-It Checklist with a partner. Pass out a copy of *Lesson 14 Gotta-Have-It Checklist* to each student. This will be taped or glued into students' science notebooks when complete. Remind students how to build the checklist. Students will complete only the left column. They should leave the right column blank for now.



Lesson 14 Gotta-Have-It Checklist

Instructions: Use your Progress Tracker and your science notebook to make a checklist of the most important ideas you need for a model to explain these new questions:

- Where does all of our food come from?
- Where does it go next? Where do the atoms that make up living and nonliving things go next in our world?

** You do not need to repeat ideas already in your checklist from Lesson 8.*

What our model needs to have to answer the questions, "Where does all of our food come from?" and "Where do the atoms that make up living and nonliving things go next in our world?"	*Check off pieces of the model as you use them.*	
	Used	*Not used*

Use your checklist to add to your model. As you use ideas from your checklist, put a check in the "Used" column for the idea and label the concept on your model with its row number from the checklist.

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Have students work with a partner to develop their checklists from important science findings recorded in their Progress Trackers that would help them answer, *Where does food come from, and where does it go next?* Students should record the ideas they agree would help them answer this question on the checklist. They do not need to record all of the ideas from previous lessons–only the ones they want to include to answer the lesson question. Students should spend up to 5 minutes working with their partners.

Remind students of classroom norms, as necessary. Emphasize the importance of having a safe space where students can share their ideas and push one another's thinking.

Facilitate a discussion to share ideas about what to include in the Gotta-Have-It Checklist. Spend up to 15 minutes to allow students to share what they included on their checklists. Do not let this discussion take too long or it will take away from students' time to tell the story of food in the next activity section. Ask students to briefly mention an idea they

* Supporting Students in Engaging in Developing and Using Models

An alternative to doing the Gotta-Have-It Checklist in partners is to construct the checklist together as a class with a public representation of the ideas the class agrees should be part of the consensus model. If you make a modification to the current activity, keep in mind the following important components to make this activity a productive one:

- The process should be collaborative and involve students arguing from evidence for their ideas.
- There should be a public record, or artifact, of the ideas students agree to include in their models.

included on the checklist and why it's important. As you build the checklist as a class, have students add anything they are missing to their individual copy of *Lesson 14 Gotta-Have-It Checklist*, so they can use it on *Story of a Food Atom*. If time permits, you can also ask which ideas they did not include and why those ideas are less important. The example student responses below are not a comprehensive list of all the ideas. See *Key: Lesson 14 Gotta-Have-It Checklist* for an example.

Key Ideas

Purpose of discussion: Gather all of the things we have figured out in our Progress Trackers and class consensus models to create a Gotta-Have-It Checklist.

Listen for these ideas:

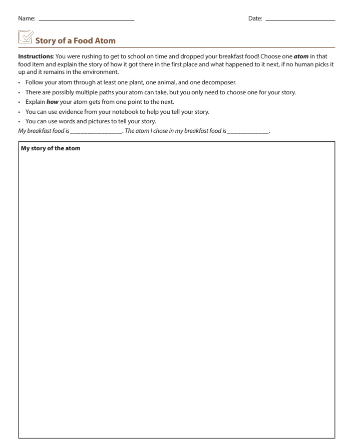
- When plants are not doing photosynthesis, they take in oxygen and give off carbon dioxide and water above the surface (Lesson 10).
- Plants use their stored food molecules in cellular respiration for energy just as animals do (Lessons 10 and 11).
- Sugar that is made from photosynthesis can be stored and is also used for plant growth (Lesson 11).
- All the food we eat, even the food from animals, can be traced back to being from plants at some point (Lesson 12).
- Foods that are processed and have been changed physically or chemically (synthetic), can be traced back to plants at some point (Lesson 12).
- Decomposers recycle matter and energy from dead plants and animals back into the system (Lesson 13).
- Atoms are continuously moving between living (biotic) and nonliving (abiotic) things (Lesson 14).
- Atoms are continuously recycled. Nothing is really new. The atoms that make up something new (or any living or nonliving thing) had been a part of something else before (Lesson 14).

7. Explain the story of a food atom.

10 MIN

Materials: science notebook, *Lesson 14 Gotta-Have-It Checklist*, *Story of a Food Atom*

Explain the story of a food atom. Display **slide H**. Students will take one of their original breakfast foods from Lesson 1 and use ideas from *Lesson 14 Gotta-Have-It Checklist* and the model they developed over the last few lessons to write the story of what happens to that food in a system on *Story of a Food Atom*. To help support students in giving each other feedback use the *Reference: Peer Feedback Guidelines*.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MATTER CYCLING AND PHOTOSYNTHESIS | 348

Story of a Food Atom

Instructions: You were rushing to get to school on time and dropped your breakfast food! Choose one ***atom*** in that food item and explain the story of how it got there in the first place and what happened to it next, if no human picks it up and it remains in the environment.

- Follow your atom through at least one plant, one animal, and one decomposer.
- There are possibly multiple paths your atom can take, but you only need to choose one for your story.
- Explain ***how*** your atom gets from one point to the next.
- You can use evidence from your notebook to help you tell your story.
- You can use words and pictures to tell your story.

My breakfast food is ______. The atom I chose in my breakfast food is ______.

My story of the atom

TEACHER RESOURCES

Read students the prompt on *Story of a Food Atom*: *You were rushing to get to school on time and dropped your breakfast food! Choose one atom in that food item and explain the story of how it got there in the first place and what happened to it next, if no human picks it up and it remains in the environment where it was dropped. Follow your atom through at least one plant, one animal, and one decomposer. Note: There are multiple paths your atom can take.*

Tell students that this is their chance to put all the pieces they have figured out together about where our food comes from and where it goes next. They should use all the resources at their disposal such as evidence from their notebooks, their Gotta-Have-It Checklists, the two-page system model and their Progress Trackers. After they finish, they will receive guided feedback from a peer on how to improve their explanation prior to submitting.

See *Key: Story of a Food Atom* for an example *Story of a Food Atom*.

Additional Guidance

This is an opportunity for students to put together all the pieces they have figured out about where our food comes from and where it goes at an atomic level. Students are encouraged to use their resources (science notebooks, Gotta-Have-It Checklists, Progress Trackers, and two-page models) to help them write their stories about an atom from a breakfast food. In addition, they have the freedom to choose how they want to represent their tracing of an atom from a breakfast food through the system model. They could write a story starting with "once upon a time", write in bullet points, or write out as steps. Once finished, they will exchange with a partner to provide and receive feedback about how to make their story stronger. Though this is a student assessment, it is set up as practice before the final transfer task in the next lesson. This scaffolded approach, where students are receiving feedback from peers and the teacher is not the sole feedback provider, will support students in taking their understanding to a deeper level prior to the final transfer task.

Assessment Opportunity

Students have been developing the system model in their notebooks over multiple lessons. This model captures how matter and energy flows throughout the system through different processes such as photosynthesis, cellular respiration, energy transfer, and recycling of atoms. At the beginning of this lesson students worked with a partner to trace an atom from food a decomposer eats through their system model to see if it could end up in the food we eat. Now using all the tools at their disposal, students are asked to explain what happens to food that is dropped on the floor and not cleaned up. If students are struggling with tracing an atom from the food we eat using the models in their notebooks and the Gotta-Have-It Checklist, remind them of what they did with their partner. Ask them if they could use the same strategy at first, and then encourage them to look over the Gotta-Have-It Checklist to see what science ideas they can add to their story.

8. Provide and receive feedback. 5 MIN

Materials: *Story of a Food Atom*, Optional *Peer Feedback Guidelines*

Students pair up and share with a partner their *Story of a Food Atom*. Show **slide I.** Pass out *Peer Feedback Guidelines* if desired. This can be taped into notebooks. Using *Peer Feedback Guidelines*, explain how students will give each other feedback. Have students get up and find a partner to share with.

Alternate Activity

Have students give and get feedback using sticky notes instead of verbal feedback. Prompts for what to write include the following:

- I wonder about ______. I noticed you ______.
- I appreciate how you ______.

- It would be clearer if you added ________.
- I see you're thinking about ________.
- Do you think you should add ________?

9. Respond to feedback.

5 MIN

Materials: *Story of a Food Atom*, *Self-Assessment*

Reflect on peer feedback. Display **slide J** for reminders about receiving feedback, also listed below. Explain, *We use peer feedback to improve our work, making it clearer, more accurate, and better supported by evidence. When you receive feedback, you should take these steps:*

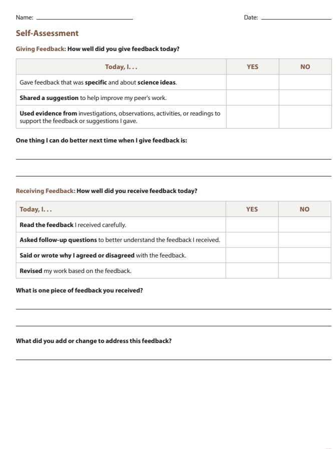
- *Review your notes about the feedback your partner provided.*
- *Decide if you agree or disagree with the feedback.*
- *Revise your work to address the feedback.*

Give students 4 minutes to make any additions or revisions to their explanation using the feedback provided.

Assessment Opportunity

At the end of this lesson or for home learning is a good opportunity for students to self-assess using *Self-Assessment*. Helping students reflect on their progress in giving and receiving feedback will help build their skills in this important area.

Say, *We've figured out so much! Tomorrow, we will revisit our Driving Question Board* (DQB) *and see what questions we can now answer.*



Name: ____________ Date: ____________

Self-Assessment

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?

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SCIENCE LITERACY: READING COLLECTION 5

Connected Lives

1 **Food Chains and Webs**

2 **Decomposition Diaries**

3 **The Life of a Carbon Atom**

4 **Debate Transcript**

Literacy Objectives

- ✓ Summarize key points related to decomposition.
- ✓ Argue a position on the issue of food waste.
- ✓ Identify a claim and list the evidence that supports it.
- ✓ Contrast pros and cons of solutions for disposing of food waste.

Literacy Exercises

- Read varied text selections related to the topics explored in Lessons 13 and 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 a well-reasoned paragraph in response to the reading.

Instructional Resources

Student Reader

Collection 5

Science Literacy Student Reader, Collection 5
"Connected Lives"

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 13: What happens to food that doesn't get eaten?
- Lesson 14: Where does food come from, and where does it go next?

Standards and Dimensions

NGSS

Disciplinary Core Idea LS2.B: Cycles of Matter and Energy Transfer in Ecosystems
Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3)

Science and Engineering Practices: Engaging in Argument from Evidence; Obtaining, Evaluating, and Communicating Information

Crosscutting Concepts: Energy and Matter; 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.

WHST.6–8.1: Write arguments focused on discipline-specific content.

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.

carbon cycle

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.

carbon footprint	**carbon sink**	**compost**
decomposition	**invertebrate**	**methane**
nutrient	**photosynthetic**	**plankton**
predator	**prey**	**scavenger**
species		

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

1. Plan ahead.

Exercise Page

EP 5

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.

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 Matter Cycling and Photosynthesis 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.
    - *First, you will read an infographic that explains how two scientific models—food chains and food webs—are used to show the transfer of matter and energy when species produce food or feed on one another.*

- ◦ *Next, you'll read a couple of journal entries from a fictitious college student who has decomposition on the mind.*
  - ◦ *While that last journal was realistic, you'll next read one that is a bit fantastic. In it, a carbon atom writes about its 350-million-year "life" moving in and out of various systems on Earth.*
  - ◦ *The collection ends with the transcript of a mock debate between two students about the best way to handle food waste from a college cafeteria.*
- 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 a well-reasoned paragraph in response to one of the readings in Collection 5. You'll choose a claim and use some of the science related to the readings to support your argument.*
- 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's the difference in function between a mulching lawn mower and a bagging lawn mower?	*A mulching mower cuts the grass, and then the clippings fall on the ground to decompose above the roots of the growing grass. A bagging mower collects the clippings in a bag so that they can be carried away to decompose somewhere else.*
Where could a carbon atom be found before or after it is inside a living thing as part of a sugar molecule?	*in the atmosphere, as part of a carbon dioxide molecule* *in the ground or air as part of a methane molecule*

Suggested prompt	Sample student responses
	as part of a clamshell
	in a chunk of coal
What are some advantages of composting food waste?	*The compost can be used by gardeners on their plants, it keeps the food out of the landfills, and it is good for the local economy.*

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 does a food chain or food web model inputs and outputs such as water and carbon dioxide?	*It doesn't. It just shows the species that food passes between.*
Do the species that decompose a dead whale in the ocean need sunlight?	*No, they can decompose food in the dark or the light.*
How would you summarize the "life" of a carbon atom?	*A carbon atom never changes, but it becomes part of many different kinds of molecules, some in living systems and others in nonliving systems.*

Exercise Page

EP 5

- Refer students to the Exercise Page 5. Provide more specific guidance about expectations for students' deliverables due at the end of the week.
  - *The expectation for this assignment is that you will write a well-reasoned paragraph in support of one of the claims about how to deal with food waste listed on the Exercise Page.*
  - *Your argument in support of the claim should show understanding of how matter moves in food webs or as a result of decomposition but can also touch upon cost or even moral factors.*
  - *Keep a formal style in your writing, and try to make your concluding sentence memorable.*
  - *The important criteria for your work are that your argument is coherent and uses scientific reasoning.*
- Explain that a well-organized paragraph begins with a topic sentence, has supporting details in a logical order, and ends with a concluding sentence.
- Answer any questions students may have relative to the reading content or the exercise expectations.

4. Facilitate discussion.

Facilitate class discussion about the reading collection and writing exercise. Students begin the reading activity by learning how food chains and food webs model feeding relationships between species.

Pages 44–52 Suggested prompts	Sample student responses
What is the general purpose of the first selection, called "Food Chains and Webs"?	*It compares and contrasts two models showing feeding relationships among living things.*
Using examples from the models, explain how one species can be both a predator and prey.	*Large crabs are predators of sea stars and small fish, but they are also prey for large fish, octopuses, and sea otters.*
What other food chains can you find in the food web model, other than the kelp → sea urchin → sea otter → orca chain?	*kelp → large crab → sea otter → orca* *kelp → sea urchin → sea star → large crab → sea otter → orca* *microscopic planktonic algae → crab → large fish → octopus → orca*
What is the general purpose of the second selection, called "Decomposition Diaries"?	*It describes two examples of how the remains of living things are decomposed, one on land and the other in the ocean.*
This article refers to nutrient cycling. Based on your work in this unit, what are some of the nutrients that decomposers likely release into the environment?	*carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur*
What kinds of organisms are probably decomposing the grass clippings left on a lawn with a mulching mower?	*bacteria, fungi, worms, and beetles*
What is the general purpose of the third article, called "The Life of a Carbon Atom"?	*It describes how a single carbon atom might move around Earth and become part of many different kinds of molecules over millions or billions of years.*
How does the third selection help you build knowledge on top of what you learned in the second selection?	*The second article reveals how mulching and scavenging make the remains of once-living things available to decomposers. The third article details what happens to the carbon atoms once decomposers release them to the environment.*
How could you turn the carbon atom's diary entry for 1967 into a food chain diagram?	*I'd draw the shrimp with an arrow pointing to a picture of a menhaden. The menhaden arrow would point to a picture of a striped bass. The striped bass arrow would point to a picture of a human. What I don't know is what the shrimp eats, so the producer is missing. Maybe it is photosynthetic plankton.*

Student Reader

Collection 5

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—Students will encounter the term *invertebrate* in the first and third selections. If it is unfamiliar, point out that the prefix *–in* means "not" or "without" and the root *vertebra* refers to the jointed bones in the spine, or backbone. Explain that there are more species of invertebrate animals than vertebrate animals, and they include corals, sea stars, sea urchins, clams, and abalones in water and worms, insects, spiders, and centipedes on land.

Online Resources

Pages 44–52 Suggested prompts	Sample student responses
How would you summarize the "life" of a carbon atom in a few words?	*millions of years, moving from air to rock, to water, to living things, and back again* *joining with and unjoining from other atoms, making different kinds of molecules, but never leaving Earth*
What is the general purpose of the fourth article, called "Debate Transcript: How to Handle Food Waste"?	*It uses a debate format to try to persuade the reader to consider two different ways to handle cafeteria food waste.*
How did the author organize the text to make it clear how the debate worked?	*The problem was introduced at the beginning. After that, there are headings for each section of the debate.*
Whose argument was most convincing to you and why?	*I think Kyle seemed more convincing, especially when he explained that trees are better carbon sinks than are hogs, because trees live much longer.*

CHALLENGE—In the debate transcript, Kyle refers to the "carbon footprint" of the meat industry. Explain to students that a carbon footprint represents the total amount of greenhouse gases that are generated by certain actions. Interested students can use online calculators to find their own family's carbon footprint but will need information, such as the costs of utilities, from their parents. Alternately, they can explore manipulating the calculators to understand what variables affect their carbon footprint.

5. Check for understanding.

Evaluate and Provide Feedback

For Exercise 5, students should, from a provided topic sentence that they select, write a well-constructed paragraph to argue support for a proposition. Look for evidence that students use scientific reasoning, showing understanding that humans are parts of food webs and that matter is recycled in the environment. Students may also raise other compelling reasonings, such as financial and health costs. A sample paragraph is shown below in response to the third topic sentence choice.

> *Getting students to reduce their food waste is better than sending off loads of waste to be processed. College students should be more aware of how much food they need to stay healthy and resist taking more food on their trays than they need. I've heard about something called the "freshman 15"—when new college students often gain weight in their first year of college. Maybe this is related to the university's policy of allowing students to take all they can eat. Instead, they should learn more about their personal energy and food needs and take only what they need to eat. If the cafeteria puts out too much food some days, they might deliver the leftovers to a food pantry where humans who do not get enough matter and energy to live could eat it. In conclusion, getting students to only take what they need is better for their heath and will cost less for the university.*

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

EXTEND—If students wish to dig deeper into the issue of managing food waste, direct them to reputable online resources where they can learn more. They can begin with the U.S. Environmental Protection Agency's web pages called "Sustainable Management of Food," where they will find data-collection tools and other resources. Invite students to take action to support solutions that spark their passion. Actions may include making posters for their school cafeteria, writing letters to editors, or making presentations to school managers and governance.

LESSON 15

Where does food come from, and where does it go next?

Previous Lesson

In this lesson, we revised our consensus model to show how the outputs of one component of the system can become the inputs for other parts. We problematized how atoms can be continually cycled through a system as energy flows. We made a Gotta-Have-It Checklist, which helped explain where our food comes from and where it goes next. We explained the story of food atoms.

This Lesson

Putting Pieces Together

2 DAYS

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.

Next Lesson

There is no next lesson.

Building Toward NGSS

MS-LS1-6, MS-LS2-3, MS-PS1-3

What Students Will Do

Develop and revise a model to describe the cycling of matter and flow of energy among living and nonliving parts of a system.

Construct an explanation based on evidence for the necessary role of photosynthesis in the cycling of matter and flow of energy in a system into and out of organisms.

Obtain information from multiple sources to describe that synthetic materials come from the matter and energy in natural resources and impact society.

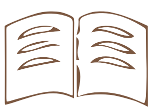
What Students Will Figure Out

- We can answer many of our Driving Question Board questions!

Lesson 15 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	10 min	**EVALUATE OUR DQB QUESTIONS** In pairs, students evaluate our list of questions for ones they think we have made progress on. Then students place sticky dots on the questions they think we have made progress on and move into their Scientists Circle.	A-B	*Reviewing Our Driving Question Board*, 10 sticky dots
2	25 min	**REVISIT THE DRIVING QUESTION BOARD (DQB)** Revisit the DQB with the whole class and take stock of all the questions we've now answered.	C	
3	5 min	**ADD TO OUR PROGRESS TRACKERS** Allow time for students to update their 2-column Progress Trackers.	D	Progress Tracker
4	10 min	**PREPARE FOR FINAL ASSESSMENT: THE IMPORTANCE OF WHALES**	E	
				End of day 1
5	37 min	**DEMONSTRATE UNDERSTANDING ON AN ASSESSMENT TASK** Students individually demonstrate understanding on an assessment to explain the phenomenon of a whale fall, marine surface ecosystem, and synthetic materials that come from algae.	F	*Reviewing Our Driving Question Board, Whale Fall Task (End of Unit Assessment)*
6	8 min	**QUICK WRITE: REFLECT ON OUR EXPERIENCES** Students discuss what was challenging and rewarding about this unit.	G	
				End of day 2

Lesson 15 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• science notebook • *Reviewing Our Driving Question Board* • 10 sticky dots • Progress Tracker • *Reviewing Our Driving Question Board Whale Fall Task (End of Unit Assessment)*		

Materials preparation (30 minutes)

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

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

Test the video and make sure the sound is functional. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Type up or take a high-resolution photograph of all the questions on the DQB *or* type them into *Reviewing Our Driving Question Board*.

Display all previous classroom consensus models around the room.

Make sure the DQB is displayed and space is available for the class to gather in a Scientists Circle.

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 various parts of an ecosystem (LS2.B). This lesson also highlights the importance of decomposers for recycling matter back into the environment (LS2.B) and necessity for algae (plants) to use the energy from light to make sugars (food). This lesson provides an opportunity for students to demonstrate their facility with obtaining, evaluating, and communicating information about synthetic materials coming from plants.

Where We Are NOT Going

Students do not need to understand populations or interactions in ecosystems. The populations and interactions components of DCI LS2.B and LS2.A will be in the OpenSciEd Unit 7.5: *How does changing an ecosystem affect what lives there?* (Palm Oil) immediately following this unit.

LEARNING PLAN FOR LESSON 15

1. Evaluate our DQB questions.

10 MIN

Materials: science notebook, *Reviewing Our Driving Question Board*, 10 sticky dots

Have students work in pairs to evaluate what questions the class has answered from the DQB. Display **slide A**. Provide students with *Reviewing Our Driving Question Board*, which you created to contain all of the student questions from the DQB, and have students tape it into their science notebooks. Have students work with a partner to mark questions 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 on the class DQB with sticky dots the questions that they think we have made progress on.*

Then have students move into their Scientists Circle.

*** Attending to Equity**
Revisiting the DQB 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 the Driving Questions Board (DQB).

25 MIN

Materials: science notebook

Look for patterns using the sticky dots. In the Scientists Circle, focus on the questions that have the most number of sticky dots.

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

Assessment Opportunity

While students are answering questions from the DQB, this is an excellent formative assessment opportunity used 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.

Alternate Activity

Another option is to have students work on answering their own questions they posed either individually or in pairs. This could be done similarly to what they did in Lesson 9 where they attached the question to a sheet of paper and answered in words and/or pictures. A focus on those questions that we have not answered but feel we could now (or partially could) with the ideas we have developed can help students feel like they made progress on their own questions.

*** Supporting Students in Engaging in Asking Questions and Defining Problems**
Revisiting the DQB at the end of the unit helps students see the progress they have made toward answering questions that are important to them at the onset of the unit. Students were tasked with asking questions "that require sufficient and appropriate evidence to answer." Through the investigations in the unit and individual and whole-group sensemaking, they can now answer many of the questions. This final visit to the DQB also allows students to see how their hard work toward a shared learning goal helps them figure out the phenomenon

Additionally, some teachers start a Wonder board, where questions that have not yet been answered but students are still interested in pursuing are housed. These questions are available for students to pursue independently or as time allows.

and can also explain a lot of other phenomena in the world.

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 DQB and working together to answer questions, new ideas or insights may have surfaced for individual students. Have the students update their 2-column Progress Trackers with any additional ideas they think are important.

4. Prepare for final assessment: The Importance of Whales. 10 MIN

Materials: science notebook

Explain the historic importance of whales. Display **slide E.**

Tell students, *OK. Are you ready to apply what we've figured out in a new context? Let's go for it! I have a really interesting thing to share with you. Before I do, I want to share some background knowledge with you so you have more context. In 1982, the International Whaling Commission placed a moratorium on global whaling, or hunting of whales. Many people initially wondered why it was such a big deal to protect these animals that most people rarely see.*

Say, *This video shows an underwater science expedition that accidentally came across the dead remains and bones of a whale, also called a whale fall, while looking for something else. They recorded the video we are about to see. You can hear them what they were saying when they found it and got super excited.*

Their ship is pulling a deep-sea video camera with a light on it (there is no light that far down in the ocean) and they even ask the ship to turn around and go back to see more of the whale fall! Let's take a few minutes (before we watch) to think about what is different about this system compared to the other systems we have been working with.

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

Key Ideas

Make sure students notice that there are not any plants in this system. Ask them what this would mean for the system. Students will likely mention that there is probably no natural light and very little oxygen.

Additional Guidance

You may need to tell students there can be molecules of oxygen and carbon dioxide dissolved in seawater. This is not something addressed by this assessment nor is it something essential to this unit. Rather, it is part of the transfer task to an aquatic ecosystem.

Create a whole class Notice and Wonder chart. In a whole-class, debrief of the video, create a Notice and Wonder chart (or one in notebooks) from the video. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**).

Ask students, *What is interesting? What were people really excited about? Did you see/hear how the scientists were really looking to see if the bone-eating worms were there? Why do you think they were looking for them? What organisms did we see? What did we notice about the remains of the whale?*

Say, *Tomorrow we will use what we have noticed in this video as a phenomenon on Lesson 14 Gotta-Have-It Checklist*.

End of day 1

5. Demonstrate understanding on an assessment task.

37 MIN

Materials: science notebook, *Reviewing Our Driving Question Board, Whale Fall Task (End of Unit Assessment)*

Prepare for *Whale Fall Task (End of Unit Assessment)*. Display **slide F.** As students enter ask them to locate their *Reviewing Our Driving Question Board* from the previous class.

Administer *Whale Fall Task (End of Unit Assessment)* to students to work on individually. This will take students most of a class period to complete.

Assessment Opportunity

If your students are struggling or you think they will need support in creating the model, consider letting them use their Gotta-Have-It Checklists for this assessment task. See *Key: Lesson 14 Gotta-Have-It Checklist* for an example, but it is best to use the list that your students generated in previous lessons.

Additional Guidance

Note that the bone-eating snot worms *(Osedax sp.)* have a mutualistic relationship with bacteria that live inside of them to aid in digestion of fats and proteins in the bones. These kinds of relationships will be investigated in greater depth in *Unit 7.5: Ecosystems Dynamics* (Palm Oil). Since this is already a transfer task to an aquatic system, students are not asked to show the mutualistic relationship in their models at this time.

The second part of the assessment is intended to assess student progress on SEP 8 and creation of synthetic materials, therefore it has readings.

You can choose not to do this question, chose to do it on a different day, or choose to do it as a jigsaw.

Callout: Point students who are ready for challenge to the biofuel reading (and can do additional online research).

For students who struggle with reading, you can have them listen to you read the article.*

*** Attending to Equity**
This assessment encourages students to demonstrate their understanding of key skills and concepts from the unit so far through multiple different modalities, including writing to explain and drawing models. Some students may benefit from using multiple modalities to show their thinking for any or all of the questions on this assessment. You may consider allowing some students to present their answers verbally with you or another student acting as a scribe to record their thinking on paper. Other students may benefit from using gestures rather than images to describe parts of their models. Some students might also benefit from using manipulatives to represent parts of the model and to support a written or verbal explanation of what's happening in each part of the model. In each case, encouraging students to use multiple modalities to show their thinking creates a clear, accessible, equitable pathway for all students to demonstrate proficiency.

6. Quick Write: Reflect on Our Experiences

8 MIN

Materials: science notebook

Celebrate the class's accomplishments. Say, *I can't believe how far we have come since we first wondered about where plants got their food molecules. We should be very proud of what we have accomplished.*

Have students reflect on their experiences with the unit. Project **slide G**. They should begin on their own by answering the questions in their science notebooks. Then bring students together for a whole-class discussion.

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

Additional Guidance

This unit asks students to do sensemaking 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.

ADDITIONAL LESSON 15 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

In the *Whale Fall Task (End of Unit Assessment)* students read an infographic and other short texts to obtain information about a variety of synthetic materials that originate from plants. Students must cite evidence from the texts they read to answer questions about synthetic materials, which addresses **CCSS.ELALITERACY.RST.6-8.1**.

Teacher Resources

Table of Contents

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 Handout Driving Question Board	**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. Specifically, look for students' initial understandings of modeling, asking questions, systems and systems models, and matter and energy. **Developing and Using Models; Systems and System Modeling** **When to check for understanding:** At the end of day 2, collect student *How Plants Get Food Initial Model* to use their initial models as a three-dimensional pre-assessment. **What to look/listen for**: Accept all initial models, but here are some components you may find: • Inputs (and possibly outputs) to the plant *or* • A source of food molecules for the plant • Food molecules inside the the plant • Different parts of the plant (used for getting food molecules or parts of food molecules) **What to do:** As a pre-assessment, student models might not have all elements identified above. Use students' initial models to highlight the range and diversity of ideas the class as a whole has when building the initial whole-class consensus model to explain where the plant's food molecules might be coming from. If student initial models are not showing food molecules inside the plant or any inputs to the plant ask them about what they noticed in the food labels and how those food molecules came to be inside the plant. Also, ask students if there are any additional parts of the system that we noticed when watching the video of the maple syrup being tapped. **Asking Questions; Matter and Energy** **When to check for understanding:** At the end of day 2 students will record questions as an exit ticket. These questions will be refined at the beginning of day 3 and then posted to the Driving Question Board (DQB). **What to look/listen for**: Look for the kinds of questions students are asking. Are they all about one aspect of the maple syrup (plant food) phenomenon? Are their questions only focused on energy? Or matter? Are there parts of the cycle of matter or flow of energy with no questions?

When	Assessment and Scoring Guidance	Purpose of Assessment
		What to do: When students are sharing their questions with their partners, ask students which part of phenomenon their question comes from and if there are any other parts of the phenomenon they are curious about. As students ask and post their questions, have them reflect on any parts of the matter cycle or energy flow that have few or no questions posted on the DQB. Prompt students to generate more questions in this space so that each important part so that each part of the cycle has some questions that we can investigate to help figure out how energy and matter flow are part of this process.
Lesson 4	L4 Student Assessment: Comparing and Critiquing Arguments about Water in Plants L4 Key: Student Assessment	**Formative Assessment** In Lesson 4 students complete a formative assessment focused on argumentation and the core ideas and using data collected in their investigations. There are multiple places in this lesson to monitor student thinking and learning across the DCIs, SEP, and CCC (systems and systems models). **Engaging in Argument from Evidence; Systems and System Models** **When to check for understanding:** (1) During the Building Understandings Discussion on day 1. (2) During students' work on the assessment *Comparing and Critiquing Arguments about Water in Plants*. (3) During the Consensus Discussion on day 2. **What to look/listen for:** • Students cite data their class collected and secondary data showing a decrease in carbon dioxide levels as evidence that carbon dioxide is going into plant leaves. • Students cite data their class collected and secondary data showing an increase in water levels as evidence that water is coming out of plant leaves. • Students cite secondary data showing an increase in oxygen levels as evidence that oxygen is coming out of plant leaves. • Students cite the need to refill the hydroponic plant food solution as evidence that water and hydroponic plant food are going into the plant through the roots. • Students may note that all of these data were collected with light present. • Students may make connections to the Unit 7.3: *How do things inside our bodies work together to make us feel the way we do? (Inside our Bodies Unit)* in terms of breathing (cellular respiration). • Students may make connections to the Inside our Bodies Unit and 7.1: *How can we make something new that was not there before? (Bath Bombs Unit)* in terms of chemical reactions as a means of rearranging the components of molecules.

When	Assessment and Scoring Guidance	Purpose of Assessment
		• Students may think that the water does not change in the plant because it is only there to carry in the hydroponic plant food molecules. • Students may have the misconception that molecules cannot be destroyed so therefore water passes through unchanged. **What to do:** The skill of using data from an investigation as evidence when supporting a claim is one that can be challenging for many students. If students are not using actual evidence from the investigation in this lesson such as the levels of water changing over time, then it could be helpful to summarize this data in bullet points that the students can then use in sentence form on their assessment. Two examples are below: • The amount of water in the closed bag with spinach went up after the light was shined on it for a little time. • The amount of water and hydroponic plant food in the hydroponic setup decreased over time and needed to be refilled.
Lesson 8	L8 Student Assessment: Individual Midpoint Assessment L8 Key: Individual Midpoint Assessment	**Formative + Summative** This lesson offers students an opportunity to use their ideas to explain an adjacent phenomenon. We call this formative + summative because it offers a midpoint grading opportunity but should also be used to gain insight into student understanding and to inform subsequent instruction. **Developing and Using Models; Energy and Matter** **When to check for understanding:** (1) During the whole-class consensus model. (2) During the *Individual Midpoint Assessment* students will create individual models. **What to look/listen for:** 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 making the following claims: • Plants have sugar and other food molecules in them (Lesson 1). • Plants don't take in any "whole" food molecules (Lesson 2). • Plants take in *parts* of food molecules from below the surface (water and hydroponic plant food) (Lesson 3) and from above the surface (carbon dioxide) (Lesson 4). • Plants also give off outputs (oxygen and water) (Lesson 4). • There are structures on the surface of leaves through which gases can enter and exit (Lesson 5). • There are also structures in plant cells called chloroplasts that move around in response to sunlight (Lesson 5). • Plants must do a chemical reaction or a series of chemical reactions in the chloroplasts to rearrange the molecules in water and carbon dioxide in order to make glucose and oxygen (Lesson 6). • Plants must need sunlight to use as energy to make glucose (Lesson 7). • There are both matter and energy inputs and outputs (Lesson 7).

When	Assessment and Scoring Guidance	Purpose of Assessment
		What to do: If students are missing some of these claims during the consensus model discussion ask students to refer to their Progress Trackers for each lesson and to add those ideas to their *Lesson 8: Gotta-Have-It Checklist*. **Arguing from Evidence; Systems and System Modeling** **When to check for understanding:** During the *Individual Midpoint Assessment*. **What to look/listen for:** Look for students to identify that the plants give off oxygen for the scientist to breathe in and glucose for the scientist to eat, which provides calories. The scientist is breathing out carbon dioxide, which would accumulate to high levels but the plants take in the carbon dioxide and water that the scientist breathes out. **What to do:** If students struggle to argue for how the scientist can survive, ask them to look back at the inputs and outputs for the plant in their Progress Trackers.
Lesson 11	L11 Student Assessment: Maple Tree through the Seasons Explanation L11 Key 1: Annotations for *How do plant (and animal) cells use food?* L11 Key 2: Maple Tree through the Seasons Explanation	**Formative** In Lesson 11 there is an assessment opportunity to monitor students' progress on the DCIs, constructing explanations, and energy and matter as they write an explanation of how trees or saplings that do not have leaves can survive. **Constructing Explanations; Energy and Matter** **When to check for understanding:** At the end of day 3 collect *Maple Tree through the Seasons Explanation* to see if students are putting together pieces of what they've figured out about photosynthesis and cellular respiration in plants during various seasons. **What to look/listen for:** Students can identify the following: • The maple tree is doing photosynthesis and producing sugars when it has green leaves and sunlight available. • The maple tree converts excess sugars and stores them as food molecules. It extracts energy via cellular respiration from stored food molecules when it is unable to produce sugars via photosynthesis. This is how it gets its energy when its leaves fall off. • The maple tree is always doing cellular respiration and using sugars to get its energy, but when it has green leaves, it can use sugars from photosynthesis. • The maple tree and a maple tree seed use stored food molecules like fats, proteins, and starches by breaking them down and reassembling them into new parts of plant cells (e.g., cellulose) via chemical reactions. Since the tree has these food molecules stored and the tree created a supply of food molecules for the seed, they each can make new cells (matter) even when they can't make new sugars through photosynthesis.

When	Assessment and Scoring Guidance	Purpose of Assessment
		What to do: If students are struggling, ask them to think about the matter inputs and outputs of both photosynthesis and cellular respiration, carbon dioxide, water, and sugar/food molecules. Thinking about the composition of food molecules (carbons, hydrogens, and oxygens, mostly) and the maple tree tapping may also help them recognize that trees are storing those molecules for the tree's benefit (not just so we can eat them). It may be helpful to pull small groups of struggling students together and have them revisit their Progress Trackers (specifically rows for Lessons 9–11). If students still struggle with completing the assessment, it may be beneficial to allow students to redo *Maple Tree through the Seasons Explanation* after individual support from the teacher.
Lesson 13	Use the Obtaining and Communicating checklist	**Formative** In Lesson 13, there is a focus on obtaining, evaluating, and communicating information using DCIs and systems and system models. Use this formative assessment opportunity to give students feedback and support their growth in communicating science ideas. **Obtaining, Evaluating, and Communicating Information; Energy and Matter** **When it happens:** (1) During the Oral Gallery Walk on day 2. (2) When revising the consensus model toward the end of day 2. **What to look/listen for:** (1) Students communicating about where the organism they researched gets energy and matter. (2) Students sharing that decomposers play an important role in recycling matter and energy the system because of their input of dead plants and animals. **What to do:** (1) If students struggle to identify the source of energy and matter for their organism, refer them back to the images and text on their fact sheet and to use the communicating information checklist they developed with their partner (of the same organism) on *Obtaining and Communicating Information from Scientific Text Checklist*. (2) If students struggle to describe that without decomposers the energy and matter within the system would be stuck in massive piles of dead plants and animals, ask them what would happen if there were no decomposers or specifically ask them where decomposers get their inputs.
Lesson 14	L14 Student Assessment: Story of a Food Atom L14 Key: Story of a Food Atom	**Formative** This is an opportunity for students to put together all the pieces they have figured out about where our food comes from and where it goes at an atomic level. Students are encouraged to use their resources (science notebook, Gotta-Have-It Checklist, Progress Tracker, and two-page model) to help them write their story of an atom from a breakfast food. In addition, they have the freedom to choose how they want to represent their tracing of an atom from a breakfast food through the system model. They could write a story starting "with once upon a time," write in bullet points, or write out as steps. Once finished, they will exchange with a partner to provide and receive feedback about how to make their story stronger. Though this is a student assessment, it is set up as practice before the final transfer task in the next lesson. This scaffolded approach, where students are receiving feedback from peers and the teacher is not the sole feedback provider, will support students in taking their understanding to a deeper level prior to the final transfer task.

When	Assessment and Scoring Guidance	Purpose of Assessment
		Constructing Explanations; Systems and System Models **When to check for understanding:** In students' *Story of a Food Atom*. **What to look/listen for:** • A carbon (or oxygen or hydrogen) atom from a breakfast food could be used by a decomposer to do cellular respiration. • This same carbon (or oxygen or hydrogen) atom could be used by a plant to do photosynthesis to make food. • This same carbon (or oxygen or hydrogen) atom could then be used by an animal to do cellular respiration for energy. • This same carbon (or oxygen or hydrogen) atom could then be used again by a decomposer to do cellular respiration. **What to do:** If students struggle with where to start when using a whole breakfast food that could be made from multiple ingredients, encourage them to look back at the nutrition labels from *Nutrition Labels: What is in food?* or the food labels analyzed in Lesson 12 and choose just one ingredient. They may also need a reminder of what food molecules are in these ingredients from *Food Molecule Cards* and then one atom from the food molecule in that ingredient to follow.
Lesson 15	L15 Student Assessment: Whale Fall Task (End of Unit Assessment) L15 Key: Whale Fall Task (End of Unit Assessment)	**Summative** 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 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 include 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.
After each lesson	Lesson Performance Expectation Assessment Guidance	**Formative Assessment** Use this document to see which parts of lessons or student activity sheets can be used as embedded formative assessments.

When	Assessment and Scoring Guidance	Purpose of Assessment
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	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 an initial model to describe the inputs of the system where plants get food molecules (matter). Ask questions that arise from careful observation of food-related phenomena that the class can investigate to explain how plants get matter and energy to make food molecules.	**Developing and Using Models; Systems and System Modeling** **When to check for understanding:** At the end of day 2, collect student *How Plants Get Food Initial Model* to use their initial models as a three-dimensional pre-assessment. **What to look/listen for**: Accept all initial models, but here are some components you may find: inputs (and possibly outputs) to the plant *or* a source of food molecules for the plant, food molecules inside the the plant, or different parts of the plant (used for getting food molecules or parts of food molecules). **What to do:** As a pre-assessment student models might not have all elements identified above. Use students' initial models to highlight the range and diversity of ideas the class as a whole has when building the initial whole-class consensus model to explain where the plant's food molecules might be coming from. If student initial models are not showing food molecules inside the plant or any inputs to the plant ask them about what they noticed in the food labels and how those food molecules came to be inside the plant. Also, ask students if there are any additional parts of the system that we noticed when watching the video of the maple syrup being tapped. **Asking Questions; Matter and Energy** **When to check for understanding:** At the end of day 2 students will record questions as an exit ticket. These questions will be refined at the beginning of day 3 and then posted to the DQB. **What to look/listen for**: Look for the kinds of questions students are asking. Are they all about one aspect of the maple syrup (plant food) phenomenon? Are their questions only focused on energy? Or matter? Are there parts of the cycle of matter or flow of energy with no questions? **What to do:** When students are sharing their questions with their partners, ask students which part of phenomenon their question comes from and if there are any other parts of the phenomenon they are curious about. As students ask and post their questions, have them reflect on any parts of the matter cycle or energy flow that have few or no questions posted on the DQB. Prompt students to generate more questions in this space so that each important part so that each part of the cycle has some questions that we can investigate to help figure out how energy and matter flow are part of this process.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 2	Plan and carry out an investigation collaboratively by identifying controls to produce data as evidence to determine whether hydroponic plant food contains food molecules as inputs. Engage in argument from evidence to support or refute possible inputs of where plants get their food molecules from, such as hydroponic plant food or soil.	**Planning and Carrying Out Investigations; Systems and System Models, Patterns** **When to check for understanding:** On *Which food molecules are in the hydroponic plant food?* students identify the control, independent and dependent variables for an investigation and collect data from the investigation. **What to look/listen for:** Students can identify what food molecule they are testing for using the indicator their group is assigned, what food molecule they are testing for in the hydroponic food solution, and how they know if that food molecule is present. Students can follow an investigation plan and collect accurate data as evidence. **What to do:** If students are using the incorrect food indicator for their control food sample, ask the students what food molecule they are testing for and whether the food sample they have should show positive with the indicator. Refer students to the questions on **slide N** as a way to guide them through what they should be testing for. **Engaging in Argument; Systems and System Models** **When to check for understanding:** (1) The making sense questions in Part 5 of *Which food molecules are in the hydroponic plant food?* students argue using evidence from the investigation. (2) At the end of the lesson students fill out a progress tracker to answer the question, "Were any of the below the surface inputs sources of food molecules?" (3) At the end of the lesson, students answer two questions on a notecard as an exit ticket. **What to look/listen for:** (1) In the making sense questions, look for answers similar to the following: #1 - Students should argue that food molecules are not found in hydroponic plant food. They should use evidence to support this statement such as (the example is for carbohydrates but this would work for any of the indicators): When the food indicator for carbohydrates was added to the hydroponic plant food, the color of the indicator did not change. #2 - Students should argue that the hydroponic plant food can not be the source of the food molecules we find in plants. The evidence they could use to support this argument could be something similar to: Since the food indicator for carbohydrates didn't change color when the hydroponic plant food was added to it, there are not any carbohydrate molecules in the hydroponic plant food. So the plant food can't be the source of the food molecules. (2) For the progress tracker, listen for ideas such as: There is not any soil in the hydroponic system. When the hydroponic plant food was tested with food indicators, there were not any of the food molecules. Plain water does not contain food molecules. None of the inputs we looked at that are below the surface contain food molecules. (3) For the exit ticket, look for students to say they think we should investigate things above the surface that could be inputs, like air or sunlight. Students might also say they think parts of food molecules might come from the inputs below the surface. They might question why plant food has different things in it than food for us.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 3	Construct an explanation by applying scientific reasoning to show why data found in images and charts show patterns that parts of inputs could be the source of food molecules in a plant.	**What to do:** (1) The first two questions in the "Making sense of your data" section of *Which food molecules are in the hydroponic plant food?* can provide evidence of students' ability to argue with evidence. They should be able to argue that there are no food molecules found in the hydroponic plant food solution using evidence from the investigation. If students argue they found evidence of food molecules in the hydroponic plant food solution sample they tested, it might be helpful to talk through with them how they conducted their investigation and ask them for the data they collected (no color change or a color change when the food indicator was added to the solution). (2) When the class is explaining what they have figured out so far and the evidence they have to support this for their Progress Tracker, some students might suggest that pieces of the food molecules might be in the inputs we looked at even if whole food molecules are not found in the inputs. This is great thinking, but push back briefly here to focus on what we have figured out and then suggest it sounds like we still have more to investigate. (3) If students claim they have no idea where plants could be getting food molecules from now that we removed all our candidates, suggest they think about other parts of the plant that might come in contact with other potential inputs and remind them we only looked at what the plant interacts with below the surface. What about above the surface? **Constructing Explanations; Patterns** **When to check for understanding:** Throughout the lesson students will be looking to see patterns between food molecules and the matter that makes up candidate sources of food molecules like air, light, hydroponic plant food, and water. At the end of the lesson, students will construct an explanation to explain these patterns on the exit ticket. **What to look/listen for:** • Air, water, hydroponic plant food, and light do not contain any whole food molecules. • The air composition chart shows that air contains carbon dioxide (carbon and oxygen) and oxygen molecules that are parts of each food molecule's structure. • Water has hydrogen and oxygen atoms. • Hydroponic plant food has nitrogen and sulfur, which are atoms found in proteins and amino acids. • We have confirmed in Lesson 2 investigations that water and hydroponic plant food go into the plant but have yet to confirm that air enters the plant. **What to do:** If your students struggle with identifying why the question needs to be revised to include parts instead of just (whole) food molecules have your students revisit the *Day 1 Dialysis Tube Investigation Instructions* reference. Cue students to look for similarities in the atoms present in air and food molecules. You can also cue them to look back at their Progress Trackers from Lesson 2 to confirm that soil is not needed for plants to grow and that hydroponic plant food and water do go into the plant as it gets bigger. Then they can revisit the nutrition labels for plant food and water to see what parts of food molecules are found in the ingredients.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 4	Engage in argument from evidence by comparing and critiquing claims that plants take in (input) water through their roots and give off (output) water through their leaves. Analyze and interpret data and graphs to identify patterns to show that plants are taking in (inputs) carbon dioxide and releasing water and oxygen (outputs).	**Engaging in Argument from Evidence; Systems and System Models** **When to check for understanding:** (1) During the Building Understandings Discussion on day 1. (2) During student's work on the assessment *Comparing and Critiquing Arguments about Water in Plants*. (3) During the Consensus Discussion on day 2. **What to look/listen for:** Students cite data their class collected and secondary data showing a decrease in carbon dioxide levels as evidence that carbon dioxide is going into plant leaves. Students cite data their class collected and secondary data showing an increase in water levels as evidence that water is coming out of plant leaves. Students cite secondary data showing an increase in oxygen levels as evidence that oxygen is coming out of plant leaves. Students cite the need to refill the hydroponic plant food solution as evidence that water and hydroponic plant food are going into the plant through the roots. Students may note that all of these data were collected with light present. Students may make connections to the Inside our Bodies Unit in terms of breathing (cellular respiration). Students may make connections to the Inside our Bodies Unit and Bath Bombs Unit in terms of chemical reactions as a means of rearranging the components of molecules. Students may think that the water does not change in the plant because it is only there to carry in the hydroponic plant food molecules. Students may have the misconception that molecules cannot be destroyed so therefore water passes through unchanged. **What to do:** The skill of using data from an investigation as evidence when supporting a claim is one that can be challenging for many students. If students are not using actual evidence from the investigation in this lesson such as the levels of water changing over time, then it could be helpful to summarize this data in bullet points that the students can then use in sentence form on their assessment. Two examples: (1) The amount of water in the closed bag with spinach went up after the light was shined on it for a little time. (2) The amount of water and hydroponic plant food in the hydroponic setup decreased over time and need to be refilled. **Analyzing and Interpreting Data; Patterns; Systems and System Models** **When to check for understanding:** (1) When student pairs are responding to the "Making sense of our results" questions in the *Investigating Above the Surface Inputs* handout. (2) During the Building Understandings Discussion on day 1. (3) When students are using the I^2 strategy to analyze and interpret secondhand data on day 2.

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		What to look/listen for: Students use the correct units to discuss changes over time (e.g., Carbon dioxide drops from 839 ppm to 832 ppm in 30 seconds). Students can identify that carbon dioxide levels steadily and significantly decrease over 10 minutes. Students can identify that humidity levels steadily and significantly increase over 10 minutes. Students can identify that although the data for oxygen is very noisy, oxygen levels steadily and significantly increase over 10 minutes. Although students may notice minor fluctuations in tabular light data but in looking at the graph they will conclude that the light level does not significantly change over 10 minutes. Students interpret the decrease in carbon dioxide level as evidence that carbon dioxide is going into the leaves. Students interpret the increase in water and oxygen levels as evidence that these substances are being released from the leaves. **What to do:** As students discuss their "What I see" (WIS) and "What it means" (WIM) comments, circulate among them to listen for the ideas listed above. Although the I^2 strategy scaffolds data analysis and interpretation, they may still struggle. Some suggestions to support students: Remind students to simply state what they observe for WIS. Encourage them to draw arrows and write comments on the graphs to help them connect their ideas to the graphical representations.Remind them to read the labels on the *x*- and *y*-axes. Ask guiding questions to help them identify patterns, such as *What do you notice about the amount of ___ in the air at an early time compared to a later time?* Ask them to look at one graph at a time. Breaking the information down into smaller chunks will make it easier for them to work with. If students are still struggling to identify patterns in the data, consider modeling the I^2 strategy for the whole class using one of the graphs.
Lesson 5	Obtain information from scientific texts to describe how chloroplasts (microscopic leaf structures) respond to light (an external stimulus).	**Obtaining, Evaluating, and Communicating Information; Structure and Function** **When it happens:** During the *Plant Cells* reading while answering questions with a partner and during the whole class Building Understandings discussion that follows. **What to look/listen for:** • Plant and animal cells look similar, but chloroplasts only exist in plant cells. • Plant cells must also be alive. • Students cite evidence from the reading that chloroplasts want a certain amount of light—not too much, not too little. • Chloroplasts must be using sunlight somehow. **What to do:** You can cue students to think back to Unit 7.3: *How do things inside our bodies work together to make us feel the way we do?* (Inside our Bodies Unit) if they are not remembering structures and functions in the animal cell. If students are not seeing a connection between the chloroplasts and light and/or energy, consider rewatching the video. Students will be able to see that light is present in the video and must be important somehow.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 6	Plan and carry out an investigation to support a claim about how the inputs to a plant are related to what the plant cell can produce from chemical reactions in the chloroplasts (outputs). Engage in argument from evidence about what plants need to make food molecules using evidence from the computer simulation and scientific reasoning to support an explanation for why decreasing the amount of water, carbon dioxide, light, or chloroplasts (cause) in a plant cell decreases the amount of sugar and oxygen it produces (effect).	**Planning and Carrying Out Investigations; Systems and System Models** **When to check for understanding:** (1) At the end of day 1 collect Planning and Carrying out Investigations before students carry out their investigation. (2) At the end of the lesson students will add to their Progress TTracker stating a claim about how changing an input for a plant cell affects the amount of food the plant makes. **What to look/listen for:** (1) Students can identify what independent variable they are changing and should only be changing one variable at a time. Students can predict how changing an independent variable (input) will affect the dependent variable (output - food). Students will be able to follow an investigation plan. Students can collect accurate data as evidence. (2) Students can agree or disagree with another student's claim using evidence from their own investigation. Students can build off each other's ideas to articulate how the results from each other's investigations relate. For example: 1. *When I changed the number of chloroplasts from 3 to 2, the amount of sugar the plant made decreased from 7 to 8.* 2. *When the amounts of inputs were decreased, the amount of sugar the plant can make decreases too.* 3. *When an input is decreased to 0, the plant makes no sugar.* **What to do:** (1) Ask the students what input they are changing to see how it affects the outputs (food made). Refer students to *Simulation Procedures* part A, and/or B for the directions to follow as they run the simulation. (2) When students are sharing their claims in their small group, if they are struggling with the relationship of how increasing or decreasing the inputs into the plant system affects the outputs, ask them to explain in their own words what they saw happen in the simulation when they changed variables. Once they do this, encourage them to explain the relationship using words such as, "When ___________ increased/decreased, ___________ increased/decreased," or "If there was more ___________, then the plant made more _________." **Engaging in Argument from Evidence; Cause and Effect** **When to check for understanding:** (1) Before consensus discussion students fill in the Progress Tracker individually with a claim to answer the question *How are all these things interacting together in this part of the plant?* **What to look/listen for:** • Students claims include one or more of the following: ◦ Carbon dioxide, water, and light interact to make food in a plant. ◦ The more carbon dioxide, water, and light a plant gets, the more food it can make.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
		What to do: If students struggle with making a claim based on their evidence from the simulation, encourage them to summarize the data in a statement initially. Then ask students to use this summary to generalize this relationship. One example might be: • Student sample summary: When I increased the amount of carbon dioxide from 100 to 150, the amount of sugar that was made in the plant increased from 8 to 9. • Student sample generalization: If a plant gets more carbon dioxide, it was make more sugar.
Lesson 7	Obtain, evaluate, and communicate information to show the relationships among matter and energy between the inputs and outputs for the process by which plants use energy from light to make sugars from carbon dioxide and water (photosynthesis). Engage in argument from evidence and scientific reasoning to support the claim that plants use sunlight for energy to convert carbon dioxide and water into sugar that provides a form of energy the body can use.	**Obtaining, Evaluating, and Communicating Information; Systems and System Models** **When to check for understanding:** (1) On *How do scientists measure energy in food?* students read text and view food labels that show how calories are a measure of energy that the body uses. (2) At the end of the lesson, students will add to their Progress Trackers after the Building Understandings Discussion. **What to look/listen for:** (1) On material *How do scientists measure energy in food?*, look for students to describe which source of information was most helpful in revising their thinking about which inputs/outputs from photosynthesis provide energy that the body can use. (2) Students should label the inputs and outputs: carbon dioxide, water, and oxygen as matter, sunlight as energy, and glucose as matter and energy in their Progress Trackers. They should explain that they know glucose provides energy because it has calories. **What to do:** (1) If students are struggling to integrate information from text, images, and what they figured out previously, guide them to focus on just one source, such as the caloric data from the food label or the explanation of calories from the text. (2) If students struggle to label both matter and energy and explain how they know which inputs and outputs are energy, matter, or both, ask them what evidence they have for whether or not each input/output can provide (this should refer them to the *Composition of Air* and *Food Molecule Cards*). **Arguing from Evidence; Energy and Matter** **When it happens:** During the Building Understandings Discussion after examining the food labels. **What to look/listen for:** During the discussion, listen for students to use evidence from *How do scientists measure energy in food?* to explain that calories are a measure of how much energy food can provide for the body and none of the inputs for plants (carbon dioxide and water) contain any calories and thus do not provide energy for the body. However, glucose, which the plant makes through chemical reactions, does have calories. So the plant must need a source of energy from somewhere. Thus, sunlight must be the input of energy to make glucose which provides energy for the body. **What to do:** If students are struggling to provide evidence for their claim, use talk moves to help them connect their ideas to how they figured them out, such as *Why do you think that? What's your evidence?* and *How did you arrive at the conclusion?*

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Lesson 8	Develop and use models based on multiple sources of evidence to show that plants use energy from light to make sugars (food) from carbon dioxide and water through the process of photosynthesis and release oxygen as an output and that energy is transferred from the sunlight to the plant through this process. Argue from evidence that carbon dioxide is an input for plants and oxygen is an output.	**Developing and Using Models; Energy and Matter** **When to check for understanding:** (1) During the whole-class consensus model. (2) During the *Individual Midpoint Assessment* students will create individual models. **What to look/listen for:** 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 making the following claims: • Plants have sugar and other food molecules in them (Lesson 1). • Plants don't take in any "whole" food molecules (Lesson 2). • Plants take in *parts* of food molecules from below the surface (water and hydroponic plant food) (Lesson 3) and from above the surface (carbon dioxide) (Lesson 4). • Plants also give off outputs (oxygen and water) (Lesson 4). • There are structures on the surface of leaves through which gases can enter and exit (Lesson 5). • There are also structures in plant cells called chloroplasts that move around in response to sunlight (Lesson 5). • Plants must do a chemical reaction or a series of chemical reactions in the chloroplasts to rearrange the molecules in water and carbon dioxide in order to make glucose and oxygen (Lesson 6). • Plants must need sunlight to use as energy to make glucose (Lesson 7). • There are both matter and energy inputs and outputs (Lesson 7). **What to do:** If students are missing some of these claims during the consensus model discussion ask students to refer to their Progress Trackers for each lesson and to add those ideas to their *Lesson 8: Gotta-Have-It Checklist*. **Arguing from Evidence; Systems and System Models** **When to check for understanding:** During the *Individual Midpoint Assessment*. **What to look/listen for:** Look for students to identify that the plants give off oxygen for the scientist to breathe in and glucose for the scientist to eat, which provides calories. The scientist is breathing out carbon dioxide, which would accumulate to high levels but the plants take in the carbon dioxide and water that the scientist breathes out. **What to do:** If students struggle to argue for how the scientist can survive, ask them to look back at the inputs and outputs for the plant in their Progress Trackers.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 9	Ask questions to refine our model of plants to show the inputs and outputs, and energy and matter flows over time to explain how food molecules can be present during times that plants do not have leaves or chloroplasts.	**Asking Questions and Defining Problems; Systems and System Models; Energy and Matter** **When to check for understanding:** (1) At the beginning of the lesson, students will gather around the DQB to identify which questions can be answered so far and will move these questions to the "Questions we have answered" section of the DQB. (2) At the end of the lesson, students will reconvene around the DQB to add additional questions around how plants make food without the structures or inputs needed. **What to look/listen for:** (1) Students to use evidence from their notebook and from developed models when answering questions they choose to take off the DQB. (2) Students to ask questions around how a plant can make food if the structures (leaves) and/or inputs (sunlight, water) are not present. Students may also ask questions around *why* plants even make food and/or if plants need food to grow. **What to do:** (1) If students choose questions from the DQB to answer but they don't have evidence and/or they can't connect back to the model developed around how plants make food, then encourage them to look back in their notebook for evidence and/or ask them if they would like to ask a peer to help support their answer with evidence. If students are choosing questions that you know there is not yet evidence for and after being prompted to look back in their notebook for evidence, remind them that the only way a question can be removed from the DQB is if there is evidence. Encourage them to leave the question on the DQB so we can continue to investigate to find evidence to help answer it. (2) If students struggle to come up with questions to add to the DQB around how plants can make food at times when there are structures missing, a few strategies you might try to help them think more about this confounding question: • Ask for a few students to share their questions as an example. • Replay the video of the tree being tapped and encourage students to make more noticings of the environment and the tree when it is tapped. • Encourage students to look back at the reading and think about how the trees are different when they are tapped compared to what we have in our model of the plant from Lesson 8.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 10	Use a model of the plant system to predict that plants do not do photosynthesis in the dark. Analyze and interpret data to identify patterns that show that in the dark, plants take in oxygen and release carbon dioxide and water. Communicate information about the relationship between energy and the cycling of carbon dioxide and oxygen (matter) in and out of plants.	**Developing and Using Models; Systems and System Models** **When to check for understanding:** At the start of the lesson, students use their consensus model to predict conditions and real-world examples of when a plant would stop making food molecules. **What to look/listen for:** Students suggest when one input to the chemical reaction is not available (e.g., no light, no water, no carbon dioxide) or the place for the reaction is not available (e.g., no leaves means no chloroplasts). **What to do:** Refer to the consensus model and ask students, *What can our model tell us about what might cause a plant to stop making food molecules?* If students only consider conditions where an input for the reaction is not available (e.g., light, water, carbon dioxide), ask them, *Where in the plant does the photosynthesis reaction happen?* **Analyzing and Interpreting Data; Patterns** **When to check for understanding:** (1) When student groups are responding to the "Making sense of our results" questions in the *Data Table for Leaves in the Dark* handout. (2) During the whole-class discussion on day 1. (3) When students are using the I^2 strategy to analyze and interpret secondhand data on day 2. **What to look/listen for:** Students use the correct units to discuss changes over time. Students identify that carbon dioxide and humidity levels increase, oxygen levels decrease, and that the light level does not significantly change. Students interpret the increase in carbon dioxide and water levels as evidence that the leaves are releasing carbon dioxide and water and the decrease in oxygen level as evidence that this substance is going into the leaves. When students compare the data collected in the light (Lesson 4) to the dark (this lesson), they notice the carbon dioxide and oxygen patterns are the opposite and the water pattern is the same. **What to do:** Students should be familiar with analyzing and interpreting data for gases in the air from Lesson 4. If groups struggle to compare the data from this lesson to Lesson 4, have them refer to Lesson 4 graphs in their science notebooks and do a side by side comparison to the Lesson 10 graphs in another student's notebook. If students wonder why plants are releasing water in both light and dark conditions, leave this as a lingering question that we really need to answer. This will be revisited in Lesson 11. **Obtaining, Evaluating, and Communicating Information; Energy and Matter** **When to check for understanding:** Students work together to plan and create a 1-minute news release to explain what is happening with photosynthesis in the dark.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
		What to look/listen for: Students discuss and respond to the "Every time …" items in *Communicating Information from Scientific Text Checklist*. Students effectively use their chosen communication medium to convey their thinking. Students explain that photosynthesis is not happening in the dark by comparing evidence obtained in the dark (this lesson) to what they have figured out about photosynthesis in prior lessons. Students reference the changes in carbon dioxide and oxygen (matter inputs and outputs) are opposite in the light and in the dark. Students note that light (energy) is an input for photosynthesis. Students state that some type of chemical reaction (other than photosynthesis) must be occurring in the dark to account for the changes in carbon dioxide and oxygen. Students wonder what role energy plays in this other chemical reaction. Students use the idea that photosynthesis transfers energy from the sun to the plant. Students notice that water is an output of plants in the light and the dark, and wonder why. **What to do:** If students are struggling to choose a communication medium, remind them of the single notecard constraint. Ask, *Which medium conveys the information in a small amount of space?* If students are struggling to explain why water is an output in the light and the dark, ask them to focus on carbon dioxide and oxygen. They will revisit water in Lesson 11. If students are struggling to identify matter and energy inputs and outputs, ask them to consult their Progress Trackers and the data table they created in this lesson to compare light (Lesson 4) and dark conditions.
Lesson 11	Plan and carry out an investigation collecting data of relative concentration of carbon dioxide changes over time in different closed systems to answer the question, *Why don't plants die when they can't do photosynthesis?* Obtain and evaluate information from scientific texts to clarify the claim that the plant system doesn't die when it can't do photosynthesis because the sugars it produced can be stored for later use in the form of starches. The stored food molecules can be used for energy via cellular respiration or for growth.	**Planning and Carrying Out Investigations; Cause and Effect** **When to check for understanding:** On *What's in the foods we eat that come from plants?* (1) when students identify their predictions about what will happen to the BTB in each bag (2) when they enter the results of the investigation. **What to look/listen for:** Students should understand the goal of the investigation is to identify the color of BTB before and after seeds are placed inside to see if plants are doing cellular respiration like humans do. Students can properly identify that BTB will change from a dark blue-green color to a yellow-brown color in the presence of CO_2, and that color change is dependent on the amount of CO_2 present. Students will collect data that will be used as evidence in their future claims about bean sprouts and cellular respiration and their explanations about why a maple tree doesn't die during the winter. Students can collect accurate data as evidence. **What to do:** If students don't remember what color BTB changes to in the presence of CO_2, perform a demonstration by exhaling through a straw in the BTB solution. Use the prediction row only as a formative assessment to see whether students think that seedlings do cellular respiration. **Obtaining, Evaluating, and Communicating Information; Systems and System Models** **When to check for understanding:** At the beginning of day 3 when they update their Progress Trackers including information they obtained from *How do plant (and animal) cells use food?*.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
	Construct an explanation by applying scientific ideas and evidence to explain: (1) why a tree that loses leaves in the winter doesn't die, (2) where it gets its energy during that time, and (3) where it gets the matter to grow new leaves and wood in the spring.	**What to look/listen for:** Students indicate that plants are always doing cellular respiration whether or not they are doing photosynthesis. Students indicate that plants can store extra sugars created by photosynthesis by converting them to other food molecules like starches and fats. Students indicate that the extra food molecules can be used later for fuel (energy) or building blocks (matter) of new plant parts. **What to do:** If students didn't obtain this information from the reading, it may be a good idea to spend more time doing another pass with the close reading strategies. If they are having trouble making connections between the BTB investigation and the reading, have pairs of students discuss how the bean seeds are able to grow into larger plants eventually and what the results of our experiment tells us about the chemical reactions they are doing. **Constructing Explanations; Energy and Matter** **When to check for understanding:** At the end of day 3 collect *Maple Tree through the Seasons Explanation* to see if students are putting together pieces of what they've figured out about photosynthesis and cellular respiration in plants during various seasons. **What to look/listen for:** Students can identify the following: The maple tree is doing photosynthesis and producing sugars when it has green leaves and sunlight available. The maple tree converts excess sugars and stores them as food molecules. It extracts energy via cellular respiration from stored food molecules when it is unable to produce sugars via photosynthesis. This is how it gets its energy when its leaves fall off. The maple tree is always doing cellular respiration and using sugars to get its energy, but when it has green leaves, it can use sugars from photosynthesis. The maple tree and a maple tree seed use stored food molecules like fats, proteins, and starches by breaking them down and reassembling them into new parts of plant cells (e.g., cellulose) via chemical reactions. Since the tree has these food molecules stored, and the tree created a supply of food molecules for the seed, they each can make new cells (matter) even when they can't make new sugars through photosynthesis. **What to do:** If students are struggling, ask them to think about the matter inputs and outputs of both photosynthesis and cellular respiration, carbon dioxide, water, sugar/food molecules. Thinking about the composition of food molecules (carbons, hydrogens, and oxygens, mostly) and the maple tree tapping may also help them recognize that trees are storing those molecules for the tree's benefit (not just so we can eat them!). It may be helpful to pull small groups of struggling students together and have them revisit their Progress Trackers (specifically rows for Lessons 9–11). If students still struggle with completing the assessment, it may be beneficial to allow students to redo *Maple Tree through the Seasons Explanation* after individual support from the teacher.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 12	Obtain information from text and a video to determine that the processed foods we eat contain matter (atoms) that came from plants; use this information to communicate and synthesize related information presented to peers. Engage in argument from evidence (readings about where different sweeteners come from) that all the food we eat contains matter that ultimately came from plants.	**Obtaining, Evaluating, and Communicating Information; Energy and Matter** **When to check for understanding:** (1) As students read about a different sweetener with their small group. (2) In partners, students read about chicken or cow diets. **What to look/listen for:** (1) Students should include evidence from the article to support a claim as to whether the sweetener is natural or synthetic. Students should identify natural sweeteners as ones that are made by plants or animals and eaten in their original form. They should identify synthetic sweeteners as those created through chemical processing, where the molecules of the natural food change through a chemical reaction to form a new molecule (e.g. sucralose aka Splenda). Students should realize that some sweeteners have undergone physical processing where the food molecule is still the same but the form of the food is different (e.g. sugar). (2) Students should argue that even when we eat food that comes from animals, we can trace these foods back to plants because the diet of animals comes from plants. **What to do:** (1) If students are struggling to decipher between natural and synthetic foods in order to make a claim about the sweetener they read about, encourage them to think about whether the sweetener molecules have been changed in any way after being taken from the plant. They may need to re-read their article to find evidence for this. (2) Drawing a diagram or image of a food that comes from an animal and then adding in the plant food that the animal eats, can help students who struggle to see the link to plants as a food source even when we are eating food from an animal. **Engaging in Argument from Evidence; Energy and Matter** **When to check for understanding:** When students report out in groups to the whole class about the sweetener their small group read about. **What to look/listen for:** Students should clearly communicate their argument with their small group about whether their sweetener is a natural or synthetic food. Then they should include the evidence from the article that supports this argument and why they have identified their sweetener as natural or synthetic. **What to do:** If students struggle to include evidence from the article they read, then suggest they re-read the article to find evidence to support their claim about the type of food the sweetener is. If students argue their sweetener is both natural and synthetic, suggest they re-read their article and come to one conclusion based on evidence from the article.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 13	Integrate scientific information about the inputs and outputs of decomposers. Communicate information to demonstrate how matter and energy is transferred between producers, consumers, and decomposers.	**Obtaining, Evaluating, and Communicating Information; Systems and System Models** **When to check for understanding:** On *What changes are happening around food that does not get eaten?* at the end of day 1 and during the Building Understandings Discussion at the end of day 1. **What to look/listen for:** • Students should notice that the bread mold growth is similar in the light and the dark. • Students should describe that carbon dioxide and water are increasing and oxygen is decreasing, which is similar to data for plants in the dark and animals. • Students should say that bread mold is doing cellular respiration because the inputs are food and oxygen and the outputs are carbon dioxide and water, like we saw with animals or plants, specifically, in the dark. **What to do:** (1) If students struggle to integrate information from the bread mold images and graphs into what they have already figured out about systems, ask them about similar investigations from Lessons 4, 10, and 11 where they examined data for other systems. (2) If students struggle to connect what they have previously figured out about the inputs and outputs of cellular respiration and photosynthesis, ask them to reexamine the class consensus model or the incremental model in their notebook and tell you the inputs and outputs they notice for plants and animals. **Obtaining, Evaluating, and Communicating Information; Energy and Matter** **When to check for understanding:** (1) During the Oral Gallery Walk on day 2. (2) When revising the consensus model toward the end of day 2. **What to look/listen for:** (1) Students communicating about where the organism they researched gets energy and matter. (2) Students sharing that decomposers play an important role in recycling matter and energy in the system because of their input of dead plants and animals. **What to do:** (1) If students struggle to identify the source of energy and matter for their organism, refer them back to the images and text on their fact sheets and have them use the communicating information checklist (of the same organism) they developed with their partner on *Obtaining and Communicating Information from Scientific Text Checklist*. (2) If students struggle to describe that without decomposers the energy and matter within the system would be stuck in massive piles of dead plants and animals, ask them what would happen if there were no decomposers or specifically ask them where decomposers get their inputs.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 14	Construct an explanation to describe the cycling of atoms (matter) into and out of organisms within a system, and respectfully provide and receive feedback on respective explanations with a partner.	**Developing and Using a Model; Matter and Energy** **When to check for understanding:** During our class model revision. **What to look/listen for:** • The atoms that make up carbon dioxide enter the plant and then leave as food molecules and oxygen. • The food molecules can be used by the plant for cellular respiration and then water and carbon dioxide are produced. • The atoms that make up water enter the plant and then leave as food molecules and oxygen. **What to do:** If students struggle to follow the flow of energy or cycling of matter, ask them to trace the carbons that enter the plant all the way from exiting the plant as food and then on a path through other components in the system using the arrows to get back to the plant. **Constructing Explanations; Systems and System Models** **When to check for understanding:** In students' *Story of a Food Atom*. **What to look/listen for:** • A carbon (or oxygen or hydrogen) atom from a breakfast food could be used by a decomposer to do cellular respiration. • This same carbon (or oxygen or hydrogen) atom could be used by a plant to do photosynthesis to make food. • This same carbon (or oxygen or hydrogen) atom could then be used by an animal to do cellular respiration for energy. • This same carbon (or oxygen or hydrogen) atom could then be used again by a decomposer to do cellular respiration. **What to do:** If students struggle with where to start when using a whole breakfast food that could be made from multiple ingredients, encourage them to look back at the nutrition labels from *Nutrition Labels: What is in food?* or the food labels analyzed in Lesson 12 and choose just one ingredient. They may also need a reminder of what food molecules are in these ingredients from *Food Molecule Cards* and then one atom from the food molecule in that ingredient to follow.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 15	Develop and revise a model to describe the cycling of matter and flow of energy among living and nonliving parts of a system. Construct an explanation based on evidence for the necessary role of photosynthesis in the cycling of matter and flow of energy in a system into and out of organisms. Obtain information from multiple sources to describe that synthetic materials come from the matter and energy in natural resources and impact society.	This is a putting-the-pieces-together lesson. It includes a summative final assessment. *Key: Whale Fall Task (End of Unit Assessment)* provides a scoring guide specific to this assessment. While students are answering questions from the Driving Question Board (DQB) at the end of day 1, this is an excellent formative assessment opportunity to address partial understandings and see if any pieces need to be revisited before taking the summative assessment. **Developing and Using Models; Matter and Energy** **When to check for understanding:** On question 1 of *Whale Fall Task (End of Unit Assessment)*. **What to look/listen for:** • See *Key: Whale Fall Task (End of Unit Assessment)* for question 1. **What to do:** If students struggle to follow the flow of energy and cycle of matter in the whale fall system, ask them where the worms are getting energy and matter to stay alive and what they would produce in the process and refer students back to *Lesson 14 Gotta-Have-It Checklist*. **Constructing Explanations and Designing Solutions; Energy and Matter** **When to check for understanding:** While completing *Whale Fall Task (End of Unit Assessment)* question 2. **What to look/listen for:** • There are no plants and light in the system so there is nothing to do photosynthesis. Thus the carbon dioxide will accumulate and oxygen will run out. • The food source for the worms will eventually run out. **What to do:** If students struggle to see that there is not a complete circle to cycle the outputs from animals (such as the worms) into a plant ask them to follow the path of carbon atoms in their model. **Obtaining, Evaluating, and Communicating Information; Energy and Matter** **When to check for understanding:** While completing *Whale Fall Task (End of Unit Assessment)* part 3. **What to look/listen for:** • The matter in the food, medicine, or fuel came from algae. **What to do:** If students struggle to obtain information from the infographic and text about where the matter came from to make these synthetic materials remind them to mark up the text by circling key words and underlining main ideas.

LESSON 2: TEACHER REFERENCE

Details of the Hydroponic Plant System

Contents in the hydroponic planting box	
reservoir tray	top-off bottle with cap
top plate lid (8 holes)	8 net cups
8 clone collars	6 drain plugs
grow light	Grow More hydroponic nutrients
root wraps (NOT USED)	

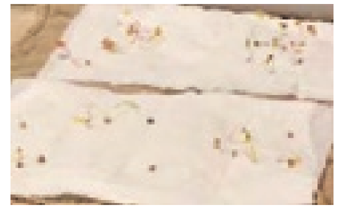
1. The seeds that you will be planting in your hydroponic kit need to be germinated for 5–7 days prior.

2. Take 9–12 seeds from each of the packets (radishes and spinach) and place them in a wet paper towel.

3. Next fold the paper towel over so the seeds are covered within the closed, wet paper towel.

4. Lastly place the wet paper towel inside of a wet cloth towel and place this in a bin that has a very thin layer of water in it at the bottom to keep the towel moist. This will help to keep them from drying out.

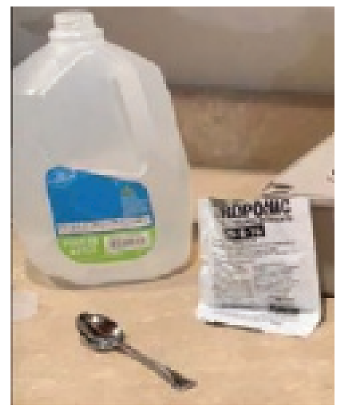
5. After about 5 days, your seeds will have grown some roots and leaves and will be ready to put into your hydroponic kit.



Setting Up the Hydroponic Kit

6. Insert 6 drain plugs into the 6 drains on the side of the reservoir tray.

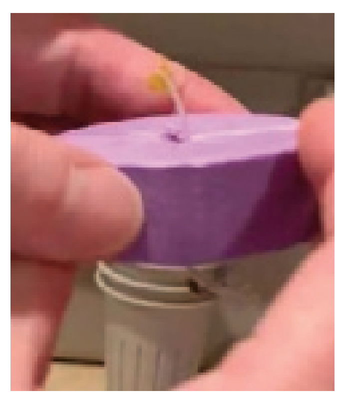
7. Combine 1 teaspoon plant nutrients with 1 gallon distilled water.



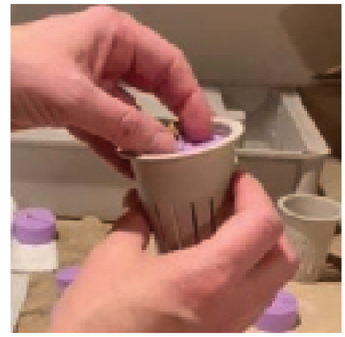
8. Pour the nutrient solution into the reservoir tray.

9. Place the lid with the 8 holes on top of the reservoir tray. Be sure the side with the cylinder tube at the bottom is on the open side of the tray.

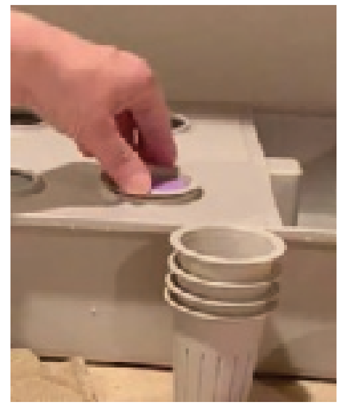
10. One at a time, place a seedling inside a foam clone collar. The roots should be extending out the bottom and the leaves should be extended out the top.



11. Place foam clone collar with the sprout into a net cup and push the collar down toward the bottom of the cup so the roots are close to the bottom of the cup. This will ensure the roots will reach the water in the reservoir.



12. Place the net cup into one of the 8 slots in the lid of the hydroponic kit.



13. Follow steps 10–12 for the remaining net cups.

14. Using a second bottle of distilled water, fill the top off bottle and secure the lid. Then turn this upside down on the side of the reservoir where the cylinder plug is located. You should hear the water begin to slowly flow and then stop. This will slowly release water and bubbles as needed.

15. Place the hydroponic system box under the grow light.

16. When the plants grow bigger, increase the concentration of plant food to 1 tablespoon per gallon of water.

Tips for teachers on the CO_2/RH detector experiment

Here are a few important tips to keep in mind while you conduct the CO_2/RH detector experiments:

1. Prior to placing the detector in the 1 gallon bag, be sure to open the bag to get some air in it. Be careful not to breathe into the bag as that may introduce additional CO_2.
2. Before taking the average baseline reading (without the leaves in the bag), let the detector stabilize in the sealed bag for 5 minutes.
3. You can use the ziplock, tape, chip clips or binder clips to seal the bag.
4. You will need ~40 square inches of leaf surface. It is recommended that you place the leaves on a piece of cardboard, cardstock, or aluminum foil that can quickly and easily be placed in the bag. When it is time to put the leaves in the bag, quickly open the bag and slide the tray with the spinach leaves inside. Seal ASAP once the leaves are inside the bag.
5. Damaged leaves tend to do more cellular respiration than photosynthesis so be gentle! Choose spinach leaves that do not appear to be damaged and lay relatively flat.
6. In order to have photosynthesis be the dominant process, the leaves in the bag need to be under bright light. Six to eight inches is a good starting distance between the leaves and the light. Adjust the distance between the light and the leaves to achieve a 50 ppm drop in CO_2 level within 5 minutes.
7. If you use one of the plants grown in your hydroponic system, it is not necessary to place the roots in water during the experiment.

Comparing and Critiquing Arguments about Water in Plants

Another class received similar data in their investigation and found that it appears water enters plants through the roots and exits through the leaves when light shines on it. Below are three students' claims to answer the question "what happens to the water inside the plant?"

Student A: The same water molecules that come into the plant through the roots go out of the plant through the leaves. They just flow through the plant without changing.

Student B: The water molecules that go into the plant are used to make food molecules, and other chemical reactions in the plant form water molecules that come out of the leaves.

Student C: Some of the water molecules are used by the plant to make food molecules while some of the water molecules pass straight through the plant unchanged.

They have collected the same evidence as our class. Using your Progress Tracker and the *Making sense of our results* section of *Investigating Above the Surface Inputs* as sources of evidence, provide written feedback to each student. How does the evidence you have in your notebook support (or refute) these claims?

Key: Lesson 4 - Student Assessment

This document provides a sample student response to the Lesson 4 assessment in an unstructured form. At this point in the unit, students do not have any evidence about what happens to water inside the plant. In this assessment, we are really looking to see if students can cite evidence and reasoning for water as both an input and output; this is common to all three claims.

Student A: The same water molecules that come into the plant through the roots go out of the plant through the leaves. They just flow through the plant without changing.

Potential response to student A:

The evidence that supports your claim is that water and plant food go into plant roots because those are the parts of the plant that hang down into the mix of water and plant food in the hydroponic setup and our teacher told us that as the plants grew, more water and plant food had to be added to the setup. Water is matter and it can't disappear so it must be going into the plants. If plant leaves are placed in a closed bag with a detector, the water level in the air increases. Matter, like water, can't be created, so it must be coming out of the plant leaves. Since water is matter and matter can't be created or destroyed, it makes sense to say water enters through the roots and goes out of the leaves. The water that goes into the roots is a liquid and the water that comes out of the leaves is a gas so maybe something like boiling is happening in the leaves.

Student B: The water molecules that go into the plant are used to make food molecules, and other chemical reactions in the plant form water molecules that come out of the leaves.

Potential response to student B:

The evidence that supports your claim is that water and plant food go into plant roots because those are the parts of the plant that hang down into the mix of water and plant food in the hydroponic setup and our teacher told us that as the plants grew, more water and plant food had to be added to the setup. Water is matter and it can't disappear so it must be going into the plants. If plant leaves are placed in a closed bag with a detector, the water level in the air increases. Matter, like water, can't be created, so it must be coming out of the plant leaves. Water contains some parts (H, O) that are also in the different kinds of food molecules, so it makes sense that those parts are rearranged to make food molecules in a chemical reaction happening inside the plant. If that plant can do chemical reactions to make food molecules maybe it can do other types of chemical reactions that make water, like cellular respiration in our bodies during metabolism.

Student C: Some of the water molecules are used by the plant to make food molecules while some of the water molecules pass straight through the plant unchanged.

Potential response to student C:

The evidence that supports your claim is that water and plant food go into plant roots because those are the parts of the plant that hang down into the mix of water and plant food in the hydroponic setup and our teacher told us that as the plants grew, more water and plant food had to be added to the setup. Water is matter and it can't disappear so it must be going into the plants. If plant leaves are placed in a closed bag with a detector, the water level in the air increases. Matter, like water, can't be created, so it must be coming out of the plant leaves. Water contains some parts (H, O) that are also in the different kinds of food molecules so it makes sense that those parts are rearranged to make food molecules in a chemical reaction happening inside the plant. If that plant can do chemical reactions to make food molecules maybe it can do other types of chemical reactions that make water, like cellular respiration in our bodies during metabolism. During metabolism, some molecules in food pass through the body so maybe something like this happens with some of the water in plants.

Name: ______________________ Date: ________________

LESSON 8: RUBRIC

Rubric for Modeling

Use this rubric to provide feedback to students as they explain the components and interactions involved when a plant gets its food molecules.

Components The model clearly represents or describes the system components and must include the following information:	**Category** Missing	 Developing	 Mastered	**Feedback**
• the **non-living aspects of the system** including air molecules and water				
• the **living aspects of the system** including the leaves with chloroplasts				
• the **structures on the leaves** that allow gases to enter and exit				
• the **outputs of the system** including oxygen and water				
• an identified **energy source in the system**				
Interactions between components The model clearly represents or describes the following information:	**Category** Missing	 Developing	 Mastered	**Feedback**
• The plants take in molecules through the leaves and the roots (not whole food molecules) *(structure)*.				
• The system has inputs and outputs that are clearly identified *(systems)*.				
• The inputs interact in the chloroplasts *(systems)*.				
• The molecules rearrange (any representation of this is acceptable). Specifically, plants do a chemical reaction or a series of chemical reactions in the chloroplasts to rearrange the molecules in water and carbon dioxide in order to make glucose and oxygen *(matter & energy)*.				
• The energy to do the chemical reactions comes from the sun *(matter & energy)*.				

Name: ______________________ Date: ______________

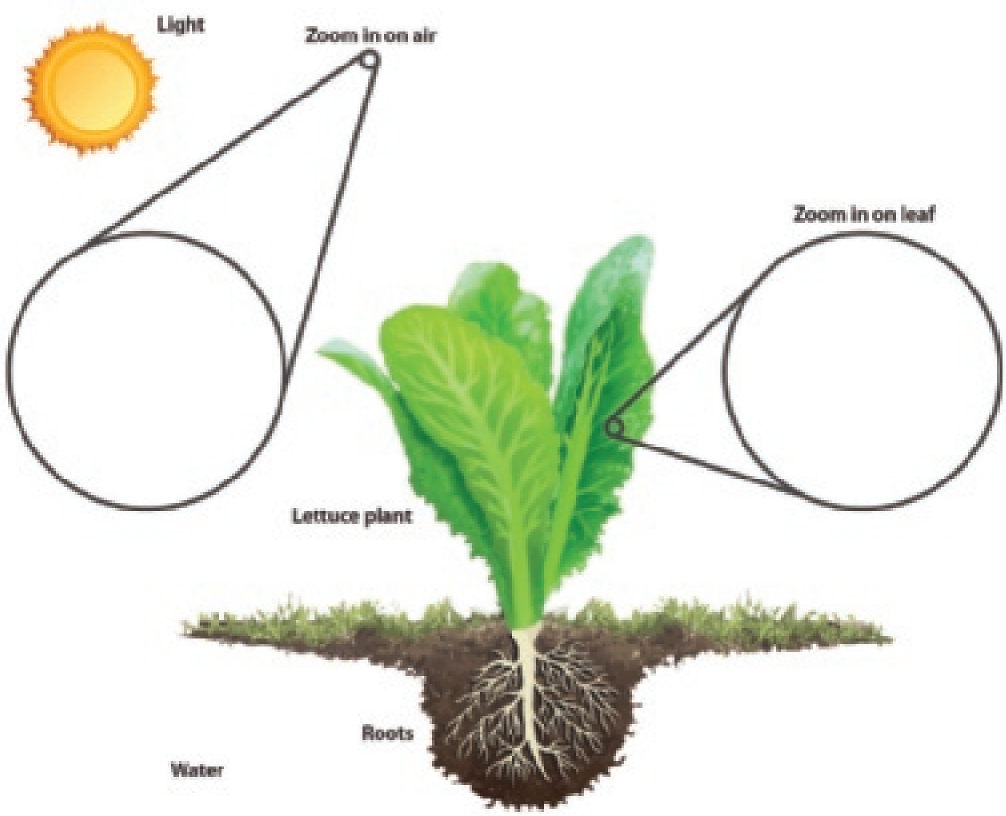
Individual Midpoint Assessment

Part 1: Revising Initial Models

How did the lettuce get the food molecules that we then eat?

Lettuce grows in the ground and we eat its leaves. Thinking about the initial model you drew in Lesson 1, we have collected a lot more evidence about where plants get their food molecules. Answer the following questions to develop a revised model to explain how plants get food molecules.

1. Use your Gotta-Have-It Checklist and complete the model below to explain how lettuce gets its food molecules. Using words add the components and interactions you need to explain what is going on.
   - Make sure to include things we can't see with our own eyes but we know are there.
   - Add in other zoom-ins if you need them.
   - If needed, add a key to explain your representations.



2. The plant itself is a system with inputs and outputs. Using your model:

   A. Label the sources of matter and energy in your model.

   B. In the space below, construct a scientific explanation for how it is possible that the inputs into the plant can enter into the plant and produce different outputs from the plant.

In your explanation, include how matter moves and energy flows in the plant system.

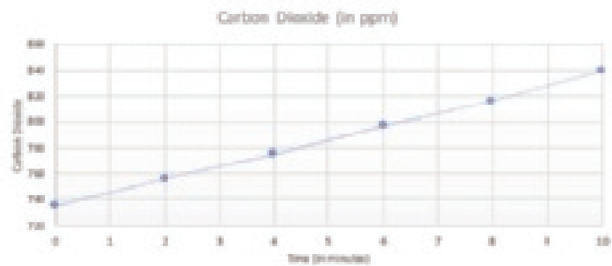
Part 2: Argue from Evidence: A New Scenario

This is an actual headline from a newspaper: **Living in a box: Scientist to spend 48 hours in an airtight container with 160 plants to keep him alive.**

The scientist survived! And he set up an experiment where he collected data before and during the time he was spending the 48 hours in the container. Throughout the study, the scientist kept the lights on and measured carbon dioxide, oxygen, and humidity (water in the air). Here we will look at three sets of data from this experiment.

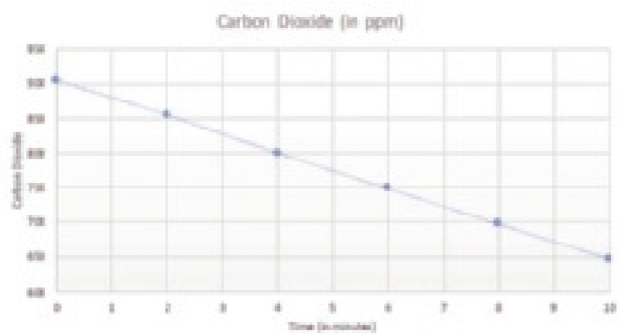
A. Before: The scientist in an empty container for 10 minutes without plants. Remember, we know from the *Inside our Bodies Unit* that animals and therefore, humans, breathe in oxygen and breathe out CO_2.

Time (in minutes)	Carbon Dioxide (in ppm)	Oxygen (in ppm)	Humidity (%)
0	735	200,200	100
2	756	200,100	93
4	775	200,000	82
6	797	199,900	72
8	816	199,700	64
10	839	199,500	56



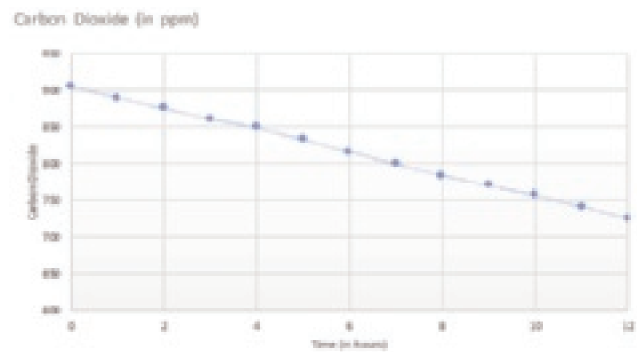
B. The plants in the container for 10 minutes before the scientist entered.

Time (in minutes)	Carbon Dioxide (in ppm)	Oxygen (in ppm)	Humidity (%)
0	905	199,600	55
2	855	199,800	63
4	800	200,000	74
6	749	200,100	82
8	698	200,200	94
10	647	200,300	100



C. Plants and the scientist in the container for 12 hours with the lights on and at the same intensity.

Time (in hours)	Carbon Dioxide (in ppm)	Oxygen (in ppm)	Humidity (%)
0	905	199,600	55
1	890	199,700	63
2	876	199,800	70
3	861	199,900	72
4	849	200,000	75
5	833	200,100	76
6	816	200,200	78
7	799	200,300	76
8	784	200,400	78
9	770	200,500	75
10	756	200,600	72
11	741	200,700	76
12	735	200,800	79



Use the prompts below to construct an argument that answers the question: Why was the scientist able to survive in an airtight (closed) space with plants? Keep in mind that he brought with him all the food and water he needed and did not eat any of the plants.

3a. Write a claim:

____

____

____

3b. Justify your claim by using evidence from the graphs above. Use words and phrases to state your reasoning why that evidence you have about the movement of carbon in the system supports your claim.

____

____

____

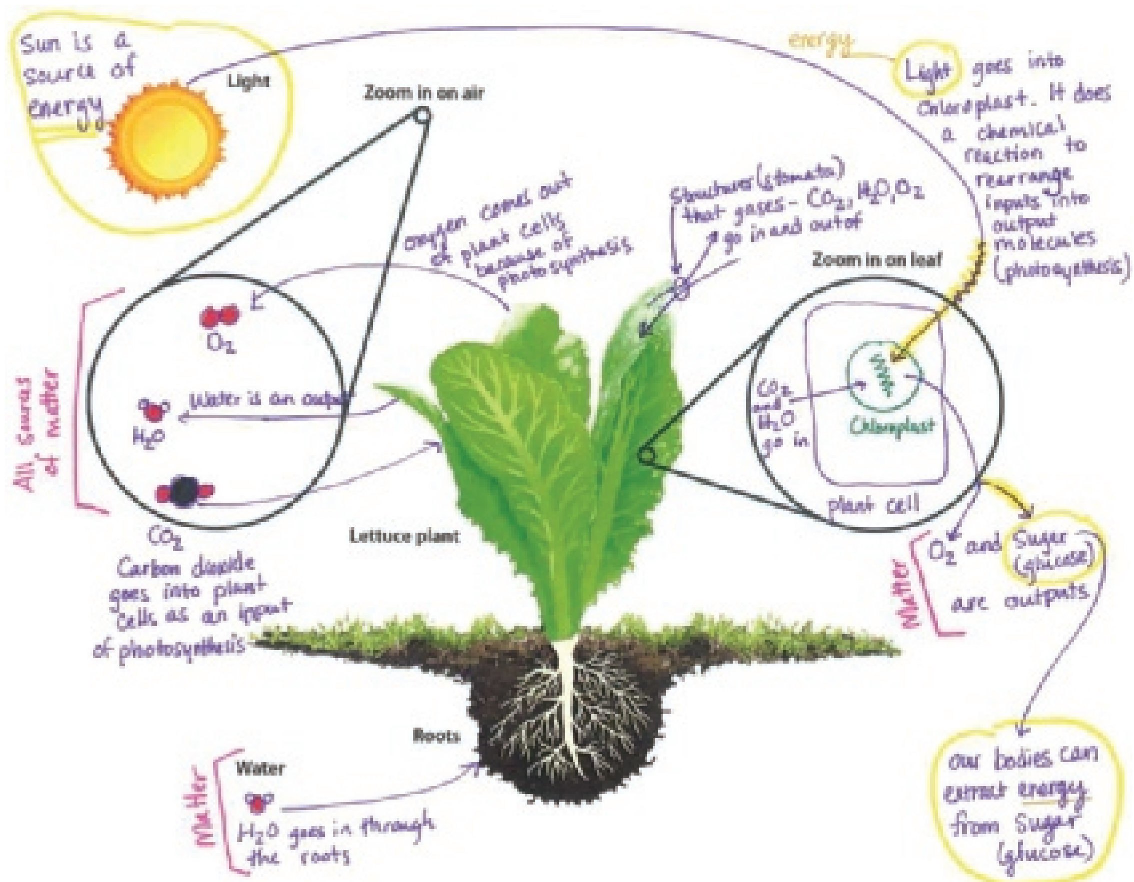
Key: Individual Midpoint Assessment

Part 1: Revising Initial Models

How did the lettuce get the food molecules that we then eat?

Lettuce grows in the ground and we eat its leaves. Thinking about the initial model you drew in Lesson 1, we have collected a lot more evidence about where plants get their food molecules. Answer the following questions to develop a revised model to explain how plants get food molecules.

1. Use your Gotta-Have-It Checklist and complete the model below to explain how lettuce gets its food molecules. Using words add the components and interactions you need to explain what is going on.
   - Make sure to include things we can't see with our own eyes but we know are there.
   - Add in other zoom-ins if you need them.
   - If needed, add a key to explain your representations.



Use the modeling rubric to assess student responses to question 1.

2. The plant itself is a system with inputs and outputs. Using your model:

   A. Label the sources of matter and energy in your model.

   B. In the space below, construct a scientific explanation for how it is possible that the inputs into the plant can enter into the plant and produce different outputs from the plant

In your explanation, include how matter moves and energy flows in the plant system.

+ Labels energy source: the sun

+ Labels matter sources: the air, the water

Explanation includes:

+ Plants (via chloroplasts) transfer energy from the sun/light and use the energy for photosynthesis/chemical reactions.

+ Plants take in molecules they need from the air and from water below the surface.

+ Plants take the energy and matter (inputs) and through photosynthesis/chemical reaction in the chloroplasts, they use the energy and matter to make sugars and water (different kinds of matter).

+ Plants also release oxygen in this process.

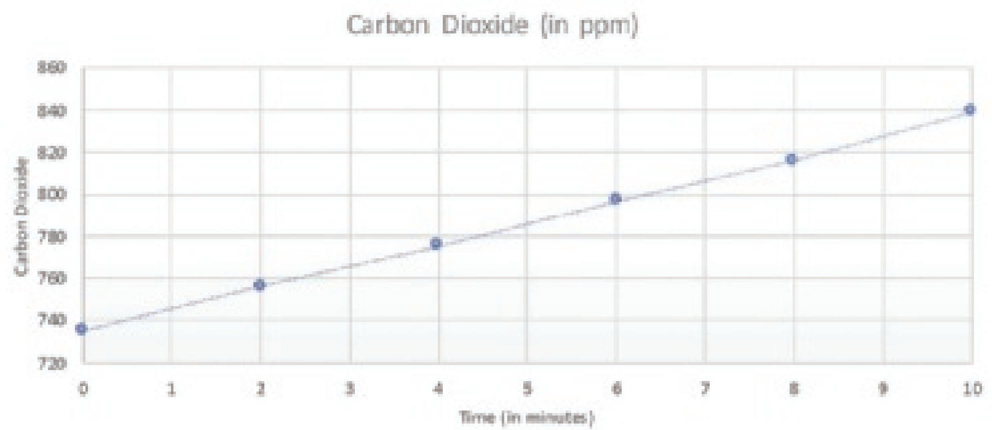
Part 2: A New Scenario

This is an actual headline from a newspaper: **Living in a box: Scientist to spend 48 hours in an airtight container with 160 plants to keep him alive.**

The scientist survived! And he set up an experiment where he collected data before and during the time he was spending the 48 hours in the container. Throughout the study, the scientist kept the lights on and measured carbon dioxide, oxygen, and humidity (water in the air). Here we will look at three sets of data from this experiment.

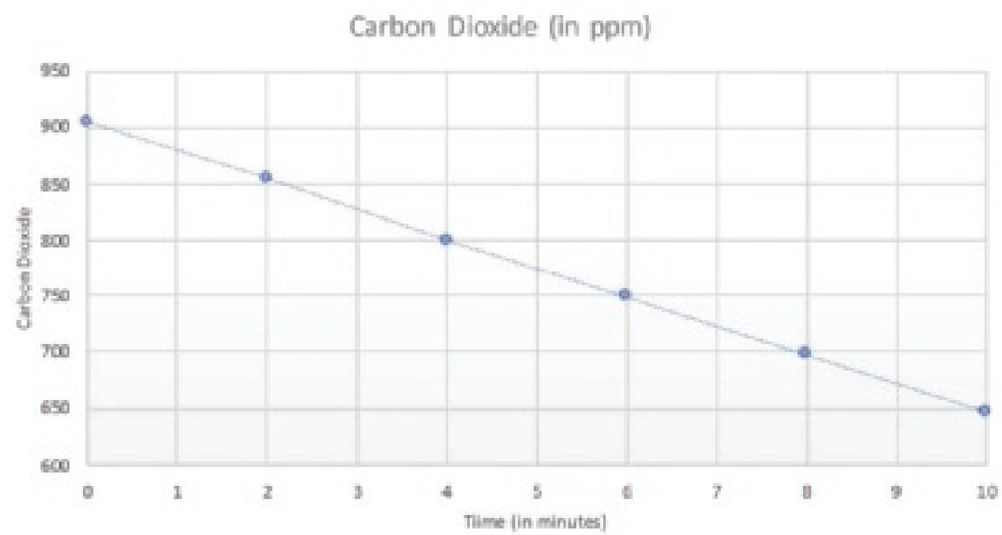
A. Before: The scientist in an empty container for 10 minutes without plants. Remember, we know from the *Inside our Bodies* unit that animals and therefore, humans, breathe in oxygen and breathe out CO_2.

Time (in minutes)	Carbon Dioxide (in ppm)	Oxygen (in ppm)	Humidity (%)
0	735	200,200	100
2	756	200,100	93
4	775	200,000	82
6	797	199,900	72
8	816	199,700	64
10	839	199,500	56



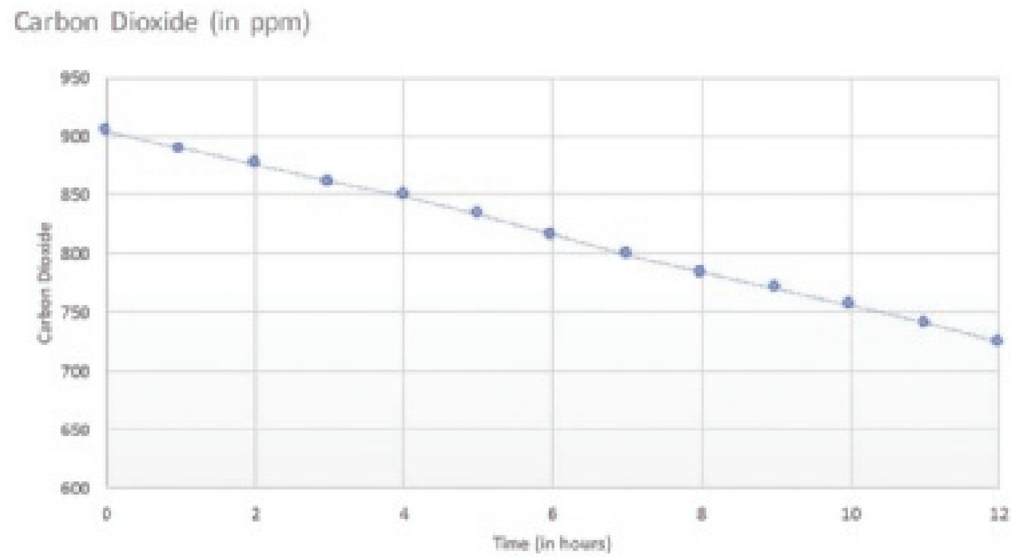
B. The plants in the container for 10 minutes before the scientist entered.

Time (in minutes)	Carbon Dioxide (in ppm)	Oxygen (in ppm)	Humidity (%)
0	905	199,600	55
2	855	199,800	63
4	800	200,000	74
6	749	200,100	82
8	698	200,200	94
10	647	200,300	100



C. Plants and the scientist in the container for 12 hours with the lights on and at the same intensity.

Time (in minutes)	Carbon Dioxide (in ppm)	Oxygen (in ppm)	Humidity (%)
0	905	199,600	55
1	890	199,700	63
2	876	199,800	70
3	861	199,900	72
4	849	200,000	75
5	833	200,100	76
6	816	200,200	78
7	799	200,300	76
8	784	200,400	78
9	770	200,500	75
10	756	200,600	72
11	741	200,700	76
12	725	200,800	79



Use the prompts below to construct an argument that answers the question: Why was the scientist able to survive in an airtight (closed) space with plants? Keep in mind that he brought with him all the food and water he needed and did not eat any of the plants.

3a. Write a claim:

The scientist can survive because the plant takes in the carbon dioxide he breathes out.

3b. Justify your claim by using evidence from the graphs above. Use words and phrases to state your reasoning why that evidence you have about the movement of carbon in the system supports your claim.

When the scientist was in the container without the plants the carbon dioxide went up from 735 to 809 ppm. When the plants were put in the container the carbon dioxide went down from 905 to 727 ppm. The oxygen in the container went down with just the scientist from 200,200 to 199,500 ppm. This means that the carbon dioxide was an output for the scientist and an input for the plant. When the plants were put in the container with the scientist the oxygen went up from 199,600 to 200,300 ppm. This means that the oxygen was an output for the plant and an input for the scientist.

Rubric: Engaging in Argument from Evidence

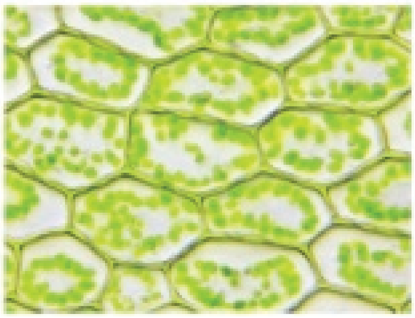
Claim	Category			Feedback
	Missing	Developing	Mastered	
• **There is a claim** that is relevant to the question, problem, or solution posed.				
Justification Clearly represents or describes the following:	**Category**			**Feedback**
	Missing	Developing	Mastered	
• Evidence or empirical data that supports 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				

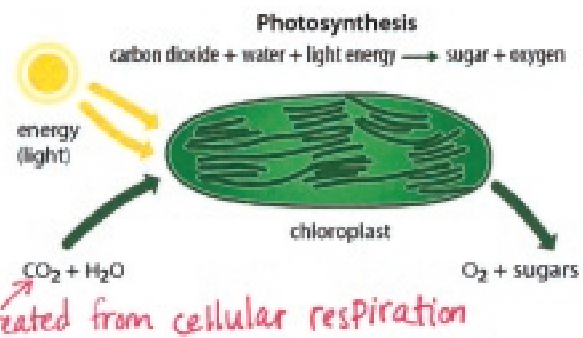
Key: Annotations for How do plant (and animal) cells use food?

How do plants use their food for fuel compared to us?

How do plant (and animal) cells use food?

When plants have light, water, carbon dioxide, and chloroplasts available, they can produce sugar and oxygen through photosynthesis. The photograph below and to the left shows chloroplasts in leaf cells. The diagram to the right represents the inputs and outputs of photosynthesis.





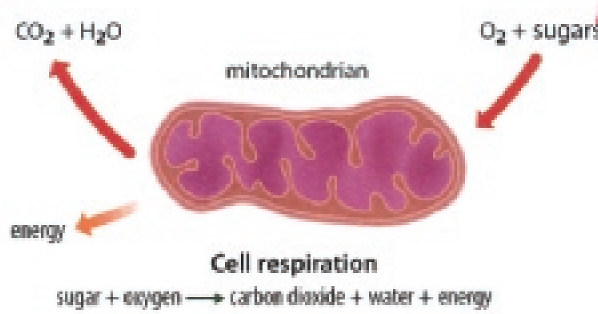
You've seen that when anyone input is missing, the plantean no longer do this process. Another process, cellular respiration, which is how the cells of our bodies use food as fuel, is something that is happening in plant cells too. It is always happening in plant cells, even at times when photosynthesis is also going on. Photosynthesis is how plant cells produce fuel. Cellular respiration is how those cells use that fuel for energy to do things.

just plants

plants AND animals

Cellular respiration happens inside specialized structures found within plant and animal cells, called **mitochondria**. Mitochondria are smaller than chloroplasts. Scientists have used electron microscopes to photograph these structures. They have found hundreds of them in each plant and animal cell. Notice the folds across the inside of each mitochondria shown i n the photograph to the left below. This feature is common to all mitochondria. The diagram to the right shows the inputs and outputs of mitochondria in cellular respiration.

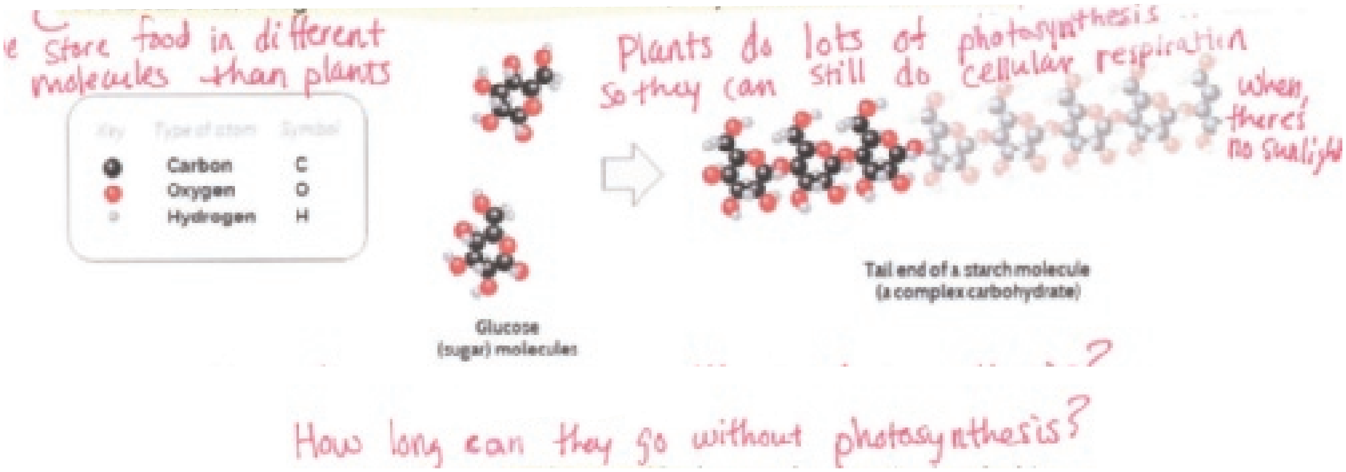
This must be what was doing the chemical reaction in the M'kenna unit



- Are there more mitochondria in cells than chloroplasts? Why?

Why don't we have chloroplasts to get (make) food?

Plant and animals cells use cellular respiration all the time to get the energy they need to function. When plants are doing photosynthesis at a faster rate than their cells use it for fuel they end up taking more carbon dioxide out of the air than they are putting back into it. When plants are producing sugar faster than they are using it, they convert extra sugar to starch and store it for later use. This is similar to how our bodies store extra food, by first converting it to a new substance through chemical reactions. Our bodies, though, store extra food as glycogen and fat molecules rather than as starch molecules. Plants typically store their extra food as starches, though in some cases, like in their seeds, they store some of it as fats too.



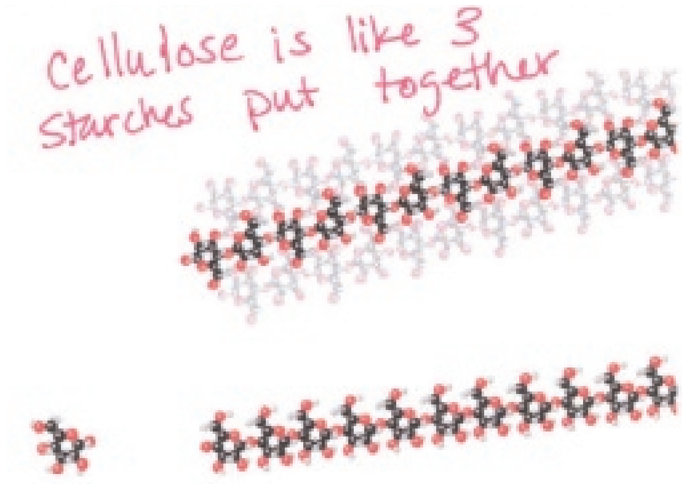
When needed for energy, plants can tap their stored food reserves by converting them back into sugar that reacts with oxygen in cellular respiration. Plants can also use those stored food molecules for building blocks to grow. When a plant grows, it does so by making more cells. To make more cells, it must first build more cell parts.

What happens when the stored food runs out?

How does the plant do that? Let's use an example of the two substances that make up most of the mass of a plant. Cellulose makes up about 33 percent of the mass of a plant. It is the main substance in cell walls. We refer to it as a type of dietary fiber. Water makes up about 50 percent of the mass of a plant. It is the main substance in cytoplasm (the liquid inside the cells).The plant doesn't need to make water to grow. It can absorb that through its roots from its environment. But it does need to make cellulose to build new cell walls.

A molecular model of cellulose is shown to the right. It shows the end of one cellulose molecule, interconnected with the ends of two other cellulose molecules.

To build cellulose molecules, plants break down stored food (e.g., starch molecules) and reassemble the atoms to make cellulose molecules through chemical reactions. Notice how similar the arrangement of atoms in cellulose molecules is to sugar and starch molecules. This is one example of how plants build one of the new molecules it needs to make new cells in order to grow.



Name: ______________________ Date: ______________________

Maple Tree through the Seasons Explanation

Instructions: Use the slide your teacher displays and your Progress Tracker to help you complete the two explanations below. Your explanation should describe how or why the phenomenon from the video is occurring, using science ideas and evidence.

1. Construct a scientific explanation with evidence that describes why the tree in the video didn't die in the winter after it lost its leaves. In your explanation, make sure to address: Where the tree gets its **matter and energy** to stay alive since it doesn't have leaves with chloroplasts that can do photosynthesis.

2. Using your model, food nutrition labels, and what we have figured out so far, construct an explanation about where a maple tree seed sprout is getting its **energy** and **matter** at the beginning of spring during the day. The sprout does not have any leaves.

LESSON 11: ANSWER KEY 2

Key: Maple Tree through the Seasons Explanation

Instructions: Use the slide your teacher displays and your Progress Tracker to help you complete the two explanations below. Each explanation should describe how or why the phenomenon from the video is occurring using science ideas and evidence.

1. Construct a scientific explanation with evidence that describes why the tree in the video didn't die in the winter after it lost its leaves. In your explanation, make sure to address where the tree gets its **matter and energy** to stay alive since it doesn't have leaves with chloroplasts that can do photosynthesis.

Explanation includes:

+ Tree stores food molecules that can be used as energy.

+ Food molecules provide energy for living things.

+ Tree did photosynthesis and made food molecules when it had leaves and sunlight was available.

+ Tree extracts energy from food molecules via cellular respiration.

+ Tree can keep extracting energy from stored food molecules, even when it doesn't have any leaves.

+ When able to do photosynthesis, tree produces a lot more glucose than is used by cellular respiration.

+ Tree made extra food molecules when doing photosynthesis and stored them.

2. Using your model food nutrition labels, and what we have figured out so far, construct an explanation about where a maple tree seed sprout is getting its **energy** and **matter** at the beginning of spring during the day. The sprout does not have any leaves.

+ Maple seed sprout uses stored food molecules that the tree produced for the seed, like the fats and proteins we saw on the sunflower seed and snap pea label.

+ Maple seed sprout does cellular respiration, like the beans in our BTB investigation, to get energy to grow.

+ Maple seed sprout does a chemical reaction to rearrange stored food molecules into new plant parts to grow.

Reference: Peer Feedback Guidelines

Teacher Instructions

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 their learning how to give and receive feedback from others. We suggest that peer review happens at least once, but preferably two times per unit. This document is designed to give you options for how to support this in your classroom. It also includes student materials to support giving and receiving feedback along with self-assessment rubrics where students can reflect on their experience with the process.

When is a good time to facilitate peer review?

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 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.

What are classroom structures I can use for peer review?

Below are three examples of ways to organize peer review in your classroom. You may choose to use all of them depending on your time or material constraints, or you may choose to always use one structure for review, so that your students get familiar with it and better at it over time.

Sticky Note Peer Review: In this protocol—shared on *Tools for Ambitious Science Teaching*—students use sticky notes to leave questions and comments on posted student work. There is time built in for students to respond to feedback. Use the self-assessment rubrics in this document at the end of the class period for students to reflect on their experience in this feedback session.

Peer Review with Unit Rubrics: Each unit and the curriculum overall, have Science and Engineering Practice (SEP) specific rubrics for teachers to assess student work. You can also use these as a way for students to assess each other's work and give feedback on how to improve. We suggest having students use the rubric to give specific feedback to each other. You can use this in a gallery walk setting or have students exchange models.

Group Review: Ask students to get into groups of four. Have students bring their individual model or explanation (or other piece of student work) to the group. Review feedback guidelines as a class, giving examples of good and bad feedback. Then, in pairs, have students provide feedback to the other two pieces of student work. They can use sticky notes or write directly on the work. Make sure to leave individual work time for students to revise their models and complete the self-assessment rubric.

Giving Feedback to Peers

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

Feedback needs to be specific and actionable

That means, it needs to be related to science ideas and include your own suggestions for improvement.

Productive examples:

- "Your model shows that the sound source changes position when it is hit. I think you should add details about how the sound source moves back and forth after it is hit."
- "You said that the drum moves when it makes sound, but the table doesn't move when it makes sound. We disagree and suggest reviewing the observation data from the laser investigation."

Nonproductive examples of feedback that do not help other students improve are:

- "I like your drawing."
- "Your poster is really pretty."
- "I agree with everything you said."

How to Give Feedback

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

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

Receiving Feedback from Peers

The purpose of feedback is to get ideas from your peers about things you might improve or change to make your work clearer, more accurate, or better supported by evidence you have collected. It also helps you to communicate your ideas more effectively to others.

When you receive feedback, you should:

- Read it carefully. Ask someone else to help you understand it, if necessary.
- Decide if you agree or disagree with the feedback and say why you agree or disagree.
- Revise your work to address the feedback.

Self-Assessment: Giving 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:

Self-Assessment: 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?

LESSON 14: ANSWER KEY 1

Key: Lesson 14 Gotta-Have-It Checklist

Instructions: Use your Progress Tracker and your science notebook to make a checklist of the most important ideas you need for a model to explain these new questions:

- Where does all of our food come from?
- Where do the atoms that make up living and nonliving things go next in our world?

**You do not need to repeat ideas already in your checklist from Lesson 8.*

What our model needs to have to answer the questions, "Where does all of our food come from?" and "Where do the atoms that make up living and nonliving things go next in our world?"	***Check off pieces of the model as you use them.***	
	Used	*Not Used*
When plants are not doing photosynthesis, they take in oxygen and give off carbon dioxide and water above the surface.		
Plants use their stored food molecules in cellular respiration for energy just as animals do.		
Sugar (glucose) that is made from photosynthesis can be stored and is also used for plant growth.		
All the food we eat, even the food from animals, can be traced back to being from plants at some point.		
Foods that are processed, and have been changed physically or chemically (synthetic), can be traced back to plants at some point.		
Decomposers recycle matter and energy from dead plants and animals back into the system.		
Atoms are continuously moving between living and nonliving things.		
Atoms are continuously recycled. Nothing is really new. The atoms that make up something new (or any living or nonliving thing) had been a part of something else before.		

Use your checklist to add to your model. As you use ideas from your checklist, put a check in the "Used" column for the idea and label the concept on your model with its row number from the checklist.

Name: ______________________ Date: ______________

Story of a Food Atom

Instructions: You were rushing to get to school on time and dropped your breakfast food! Choose one ***atom*** in that food item and explain the story of how it got there in the first place and what happened to it next, if no human picks it up and it remains in the environment.

- Follow your atom through at least one plant, one animal, and one decomposer.
- There are possibly multiple paths your atom can take, but you only need to choose one for your story.
- Explain ***how*** your atom gets from one point to the next.
- You can use evidence from your notebook to help you tell your story.
- You can use words and pictures to tell your story.

My breakfast food is ________________. The atom I chose in my breakfast food is _____________.

My story of the atom

LESSON 14: ANSWER KEY 2

Key: Story of a Food Atom

Instructions: You were rushing to get to school on time and dropped your breakfast food! Choose one ***atom*** in that food item and explain the story of how it got there in the first place and what happened to it next, if no human picks it up and it remains in the environment.

- Follow your atom through at least one plant, one animal, one decomposer, and the nonliving parts of the system.
- There are possibly multiple paths your atom can take, but you only need to choose one path for your story.
- Explain ***how*** your atom gets from one part of the system to the next.
- You can use evidence from your notebook to help you tell your story.
- You can use words and pictures to tell your story.

My breakfast food is _____________. The atom I chose in my breakfast food is ____________.

My story of the atom

Scoring Guidance

+ Names an atom (such as, carbon, hydrogen, oxygen, possibly sulfur or nitrogen from amino acids)

+ Story describes one of three viable pathways for the atom:

Animal -> Decomposer -> Plant or

Decomposer -> Plant -> Animal or

Animal -> Plant -> Decomposer and

nonliving parts of the system (such as air and/or water)

Here is what to look for in each main section of the story:

Animal

+ Eats the atom (from the breakfast food, a plant or decomposer)

+ Breaks down the food molecule by doing cellular respiration

+ releases the atom as part of carbon dioxide or water to the air

+ The atom can also stay as part of the animal's body

Decomposer

+ Breaks down the animal/plant/poop and takes in a molecule it can use for food

+ Breaks down the food molecule by doing cellular respiration

+ releases carbon dioxide (carbon or oxygen) and water (hydrogen or oxygen) to the air

+ The atom can also stay as part of the decomposer's body

Plant

+ Takes in the atom as part of carbon dioxide or water from the nonliving parts of the system (like air and water)

+ The plant uses the atom (and other atoms) to make a new food molecule and oxygen

+ The atom can also stay as part of the plant's body

Interactions between parts systems

+ Traces the atom from the output of a part of the system (living or nonliving) to the input of the next part of the system (living or nonliving)

For example, *I'm tracing oxygen and an animal breathes out carbon dioxide which goes into the air and is taken in by the plant.*

End of Unit Assessment Rubric

Use this rubric to provide feedback to students as they explain the components and interactions involved in their response to the prompt: Use a model to explain how the snot worms make it possible for the ecosystem to access all this new matter and energy in the system from the whale fall. Include inputs and outputs of each component of the system in your model.

Components The model clearly represents or describes the system components and must include the following information:	**Category**			**Feedback**
	Missing	Developing	Mastered	
• The **non-living aspects of the system** including air molecules and water				
• The **living aspects of the system** including the eelpouts, snot worms, and octopuses				
• The **outputs of the system** including CO_2				
Interactions between components The model clearly represents or describes the following information:	**Category**			**Feedback**
	Missing	Developing	Mastered	
• The system has inputs and outputs that are clearly identified *(systems).*				
• The snot worms take in oxygen and food (inputs) from the whale bones to use for cellular respiration, which allows them to extract energy to live and output CO_2 and water into the water. • Because of the snot worms, the matter and energy from the whale cycle from the whale to the snot worms to the water *(matter & energy).*				
• The whale fall contains extractable energy, which it brings with it to the seafloor and there is not a continuous energy source in the model (e.g., light, *matter & energy*).				

Name: ____________________ Date: ____________________

Whale Fall Task (End of Unit Assessment)

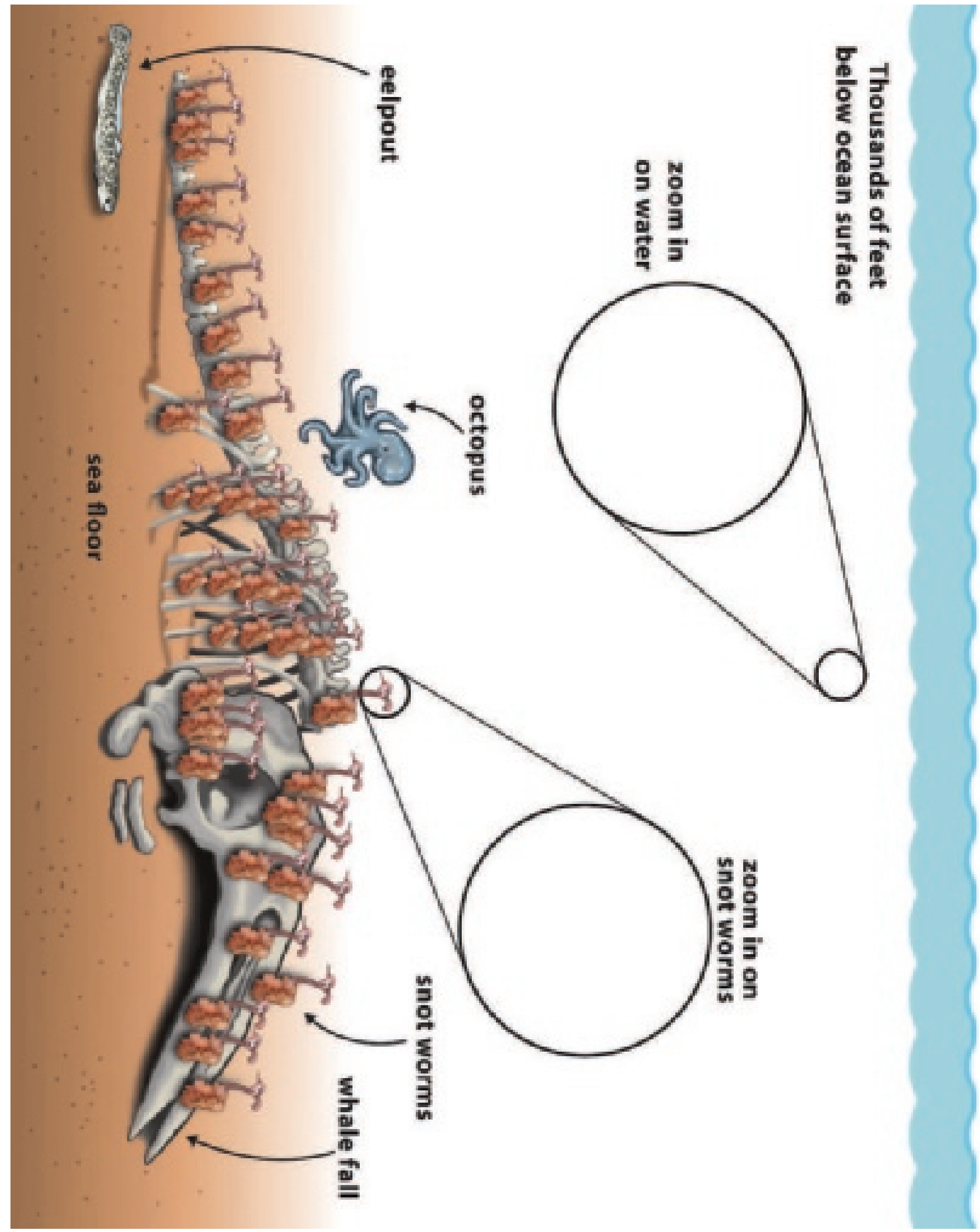
Part 1 - Whale Fall: As you saw in the video, when whales die they fall to the seafloor. This is called a *whale fall*. Before a whale fall, down on the seafloor, there are very few food sources and there is no light. A dead whale creates a whole new part of the system on the bottom of the ocean.

In the video, the whale's body is mostly bones. The octopuses and eelpouts (a type of fish) eat parts of the dead whale but not the bones. The snot worms (the brown, hairy-looking decomposers on the bones in the video) burrow into the bones to get the fats and proteins trapped inside. It can take many years for this to happen!

1. The organisms this far down in the ocean need matter and energy to survive but there is *very little* oxygen dissolved in the water and no light miles below the surface. The whale fall brings tons of matter and energy with it and that's why it's so exciting.

Use a model to explain how the snot worms make it possible for the system to access all this new matter and energy from the whale fall. Include inputs and outputs of each component of the system in your model. In the zoom-in, show what changes or processes you would expect to see happening in the water or snot worms that you couldn't see with just your eyes.

A remarkable diversity of bone-eating worms (Osedax; Siboglinidae; Annelida). BMC Biol 7, 74. CCBY 2.0.


Thousands of feet below ocean surface
zoom in on water
zoom in on snot worms
eelpout
octopus
sea floor
snot worms
whale fall

2. There is no light, no plants, and very little oxygen on the seafloor system around this whale fall. The snot worms are living animals that need oxygen and the fats and proteins from the whale bones to get the matter and energy to survive.

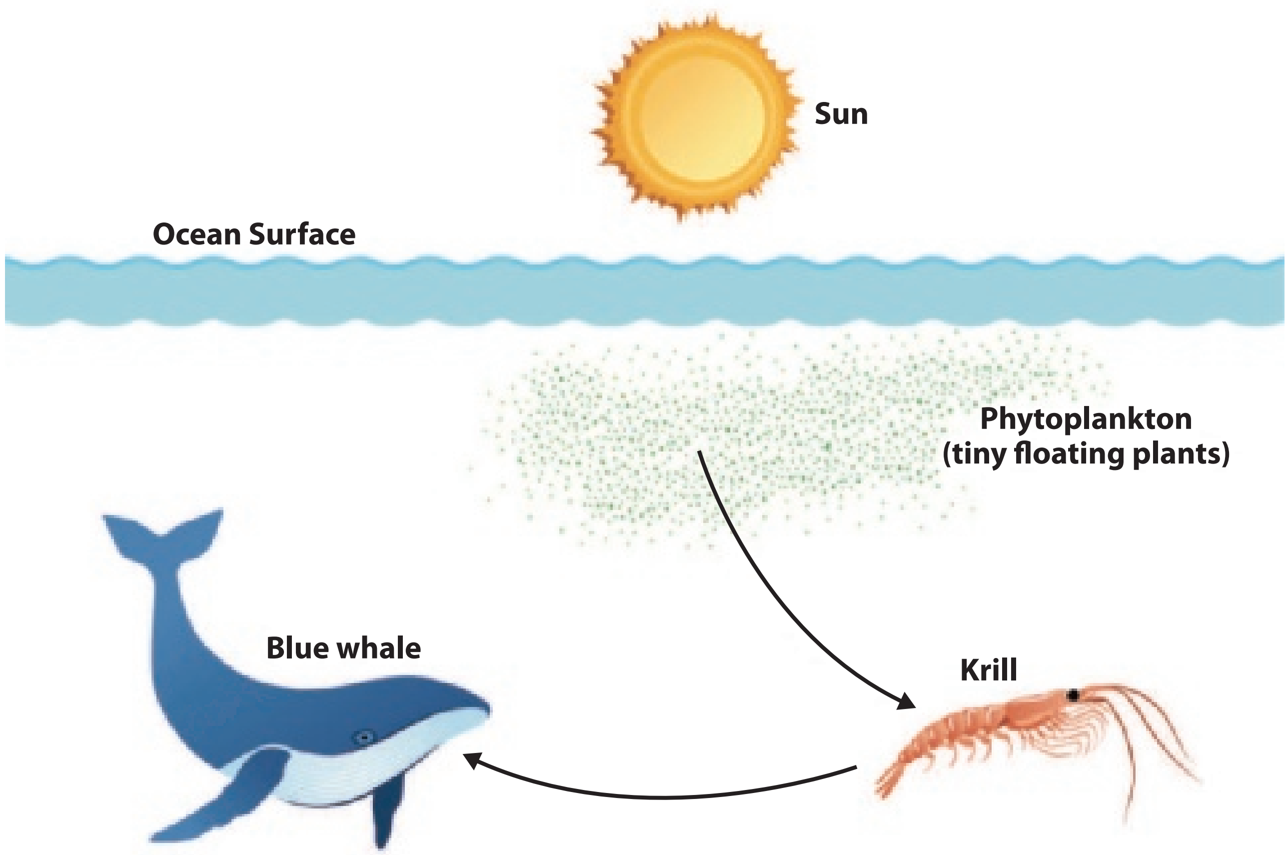
   a. Complete the table below using High(er) or Low(er) to indicate the levels of the nonliving inputs and the outputs of the system over time.

Inputs/outputs in the system	Before the whale fall	During the whale fall	After the whale fall decomposes
Oxygen	*Low*		
Available food molecules for the worms	*Low*		
Carbon dioxide	*Low*		

   B. Over time, the whale fall is completely consumed. If nothing else is added to the system, will the worms be able to live there after the whale fall is gone? Use the table above to explain your response and think about the inputs and outputs of plants, animals, and decomposers necessary for survival and what happens when plants are missing from the system.

3. During their lives, blue whales live near the surface of the ocean and only eat little tiny animals called krill. Krill only eat phytoplankton (tiny floating plants on the surface of the ocean).

   Add words and arrows to the partial food web (representation) below to explain why the whale needs to live in the part of the ocean system near the surface.



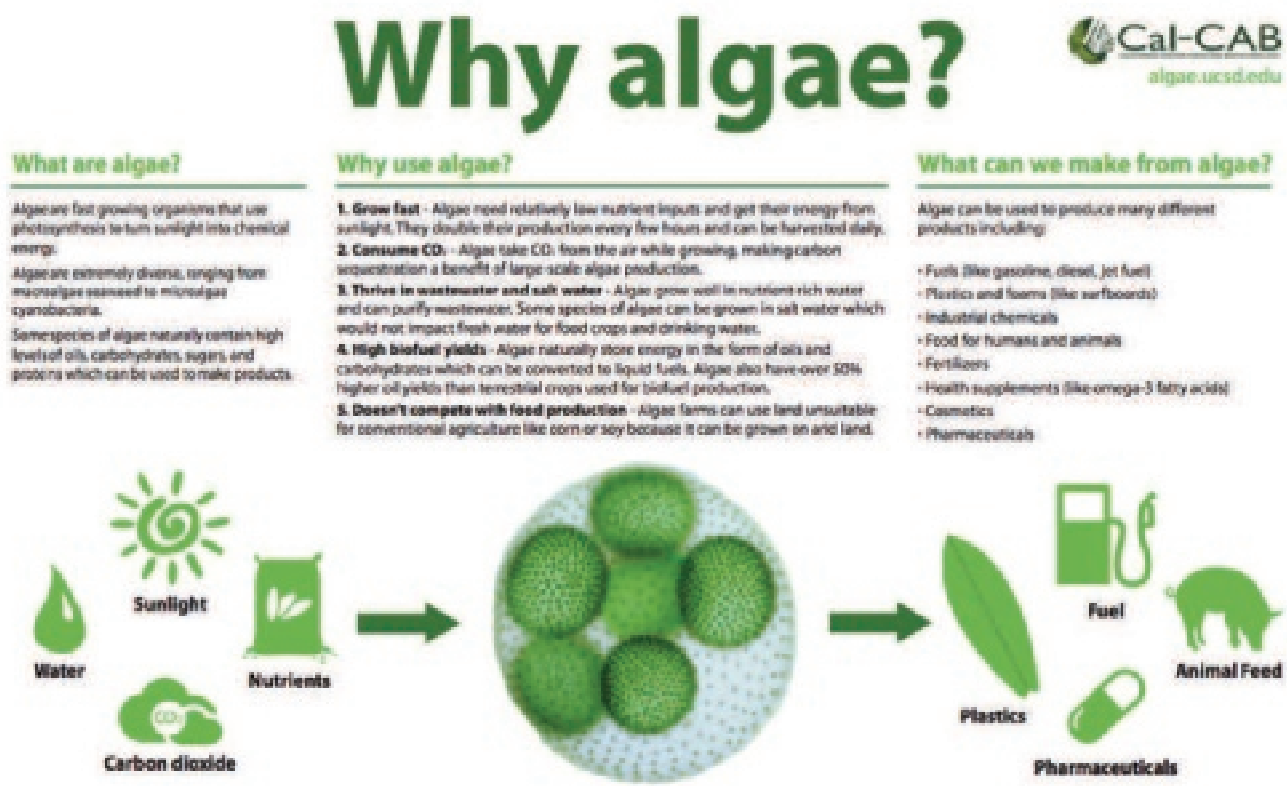
Part 2 - Phytoplankton and Synthetic Materials

The same phytoplankton that krill eat are used by humans to make new products. One type of phytoplankton is algae and there are many different species of algae—all of which are tiny plants.

In the image below (an infographic), there is some information about using algae for bio-based products and below that there is information about three different products that are being developed today.

Choose ONE of the READINGS (A, B, OR C) and use the information from the INFOGRAPHIC to answer the questions below.

Algae Infographic:



Products Made from Algae

A. Flip-flops

Scientists at the University of California San Diego are creating flip-flops made from the oil of algae plants. Scientists extract oil from algae and use it as a main ingredient in the foam used to make the flip-flops. They are called sustainable because the carbon used to make them was taken from the atmosphere, rather than oil from underground. The flip-flops are biodegradable and will break down in a compost pile.

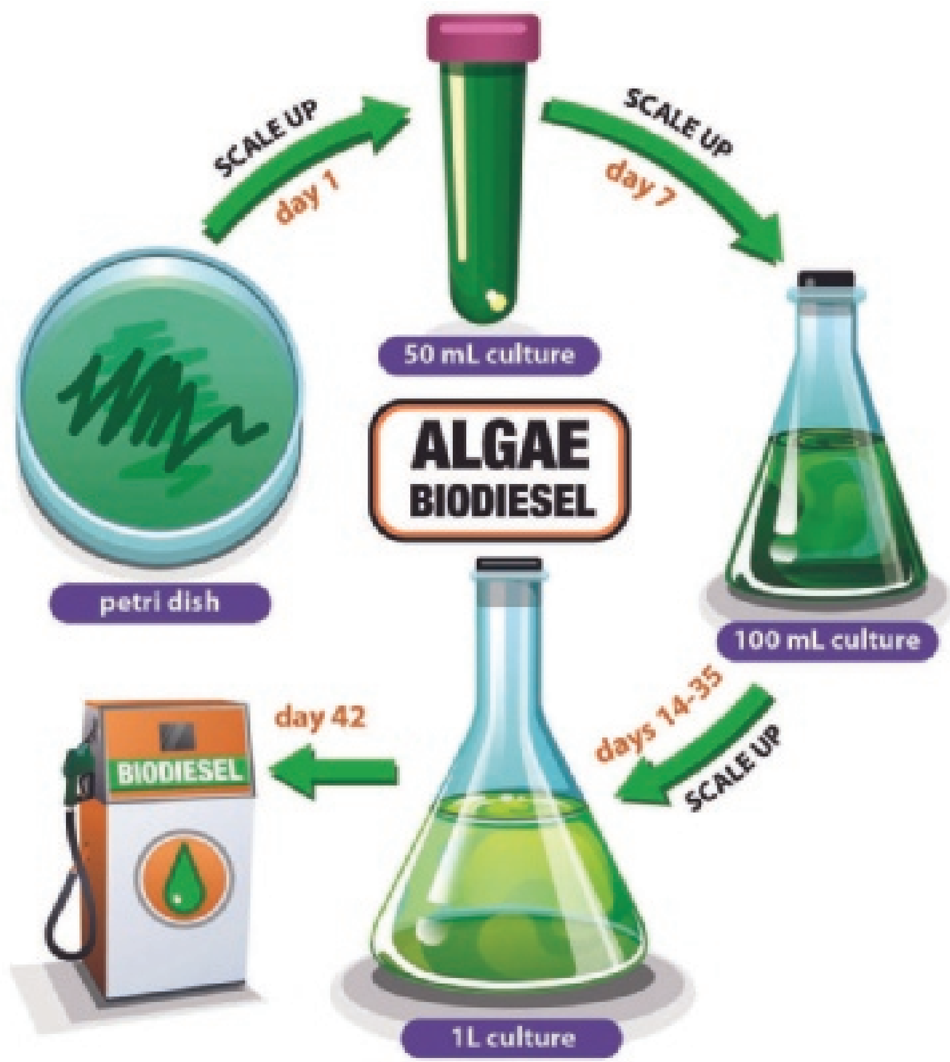
Source:

- https://www.universityofcalifornia.edu/news/guilt-free-flip-flop?utm_source=fiat-lux&utm_mediu m=internal-email&utm_campaign=article-general&utm_content=text

B. Biofuel

Biofuel is fuel that is produced from living things on Earth instead of using oil from fossil fuels. Algae is a promising option for creating fuel for transportation. In order to create biofuel from algae, scientists and companies use the following process:

- Grow algae in big tanks outside or under artificial light.
- Use a press to extract the oil from the algae plants.
- Add chemicals to purify the oil and remove anything extra.
- Oil can be used directly in diesel engines or refined further to work in other engines.



Sources:

- https://www.slideshare.net/shoebjafri/algal-production-for-biofuel
- https://algae.ucsd.edu/about/resources.html#How-to:-The-Extraction-of-Algal

C. Health Supplements

Many people take health supplements called Omega-3s. Omega-3s are fatty acids that the human body needs to function. There are two important kinds of Omega-3s called DHA and EPA. Most people take DHA and EPA in the form of fish oil–oil from fish that contains the fatty acids. Fish get their DHA and EPA from eating algae. DHA and EPA are created by chemical processes occurring inside the algae and then when the fish eat the algae, it accumulates in their bodies. Now for people who do not like the taste of fish or want a more sustainable option, DHA and EPA are available in supplements made from algae oil.

Source:

- https://ods.od.nih.gov/factsheets/Omega3FattyAcids-HealthProfessional/

Answer the questions below using the scientific information you obtained from the infographic and one of the readings.

1. The product I chose is: _______________________.
2. Describe how the matter in the material you chose comes from a naturally occurring plant. Use words or drawings to show how the carbon in the product you chose got from the algae into the product.
3. Why is using algae a sustainable, beneficial, environmentally-friendly, or healthy choice for making your product?

Name: ______________________ Date: ______________________

LESSON 15: ANSWER KEY

Key: Whale Fall Task (End of Unit Assessment)

Part 1 - Whale Fall: As you saw in the video when whales die, they fall to the seafloor. This is called a Whale Fall. Before a whale fall, down on the seafloor, there are very few food sources, and there is no light. A dead whale creates a whole new part of the system on the bottom of the ocean.

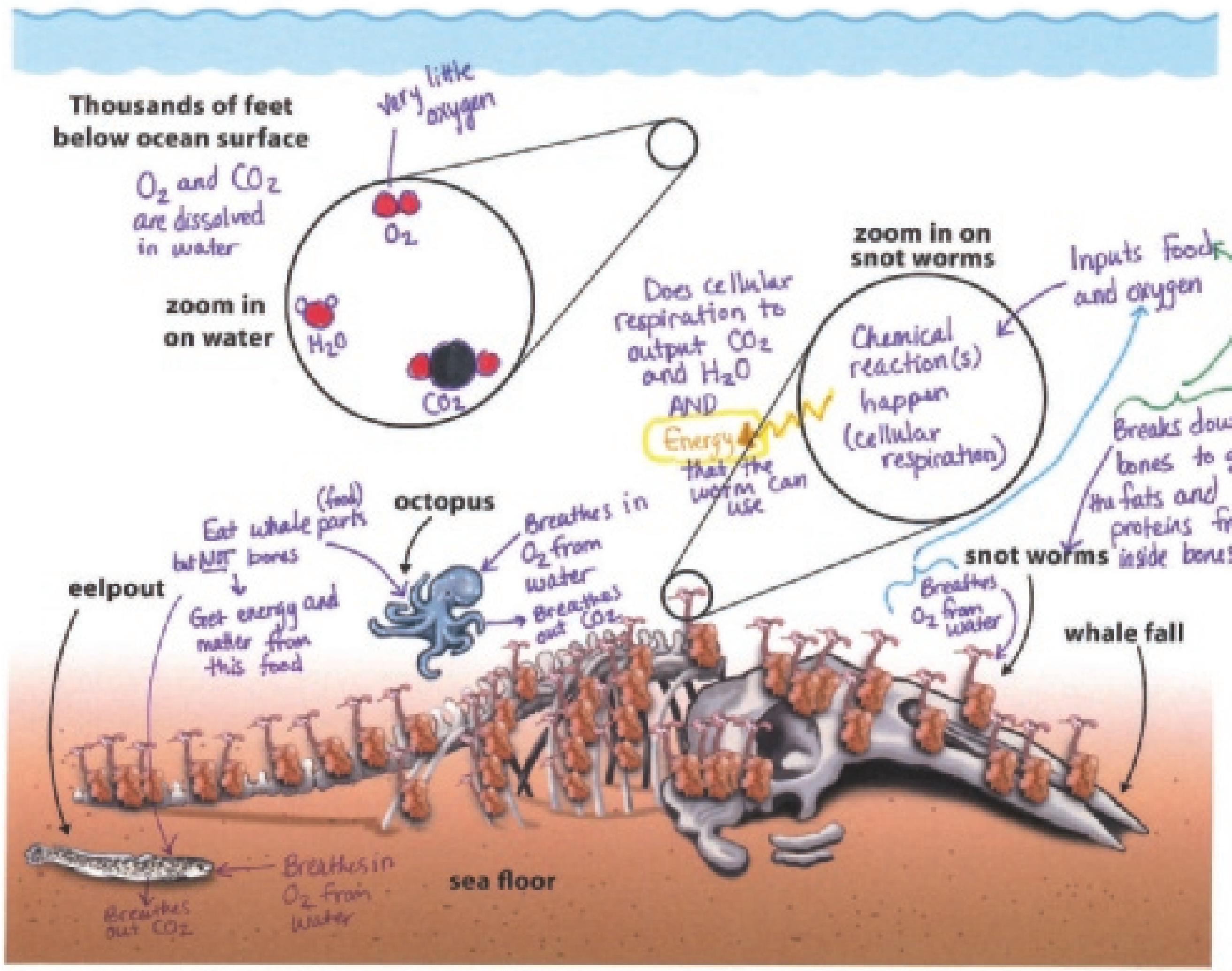
In the video, the whale's body is mostly bones. The octopuses and eelpouts (a type of fish) eat parts of the dead whale but not the bones. The snot worms (the brown, hairy-looking animals on the bones in the video) burrow into the bones to get the fats and proteins trapped inside.

1. The organisms this far down in the ocean need matter and energy to survive but there is very little oxygen dissolved in the water and no light miles below the surface.

The whale fall brings tons of matter and energy with it and that's why it's so exciting.

Use a model to explain how the snot worms make it possible for the system to access all this new matter and energy from the whale fall. Include inputs and outputs of each component of the system in your model. In the zoom-in, show what changes or processes you would expect to see happening in the water or snot worms that you couldn't see with just your eyes.

A remarkable diversity of bone-eating worms (Osedax; Siboglinidae; Annelida). BMC Biol 7, 74. CCBY 2.0.



Use the modeling rubric to interpret student models.

Note: For the zoom in on the snot worm, students can show the inputs as oxygen and fats/proteins from bones and outputs as water, carbon dioxide, and energy. For the zoom in on water, students can show carbon dioxide going into the water from the living things and oxygen going into the living things from the water.

2. There is no light, no plants, and very little oxygen in the seafloor system around this whale fall. The snot worms are living animals that need oxygen and the fats and proteins from the whale bones to get the matter and energy to survive.

   a. Complete the table below using High(er) or Low(er) to indicate the levels of the nonliving inputs and the outputs of the system over time.

Inputs/outputs in the system	Before the whale fall	During the whale fall	After the whale fall decomposes
Oxygen	*Low*	*Low(er)*	*Low(est)*
Available food molecules for the worms	*Low*	*High(er)*	*Low(er)*
Carbon dioxide	*Low*	*High(er)*	*High(er)*

   B. Over time, the whale fall is completely consumed. If nothing else is added to the system, will the worms be able to live there after the whale fall is gone? Use the table above to explain your response and think about the inputs and outputs of plants, animals, and decomposers necessary for survival and what happens when plants are missing from the system.

   + No, worms will not be able to live there after the whale fall is gone.

   + There are no plants because there is no light and plants can't exist because without light they cannot absorb energy from the sun to make food.

   + Plants take in carbon dioxide and give off oxygen. Without plants there is very little oxygen as described in the table.

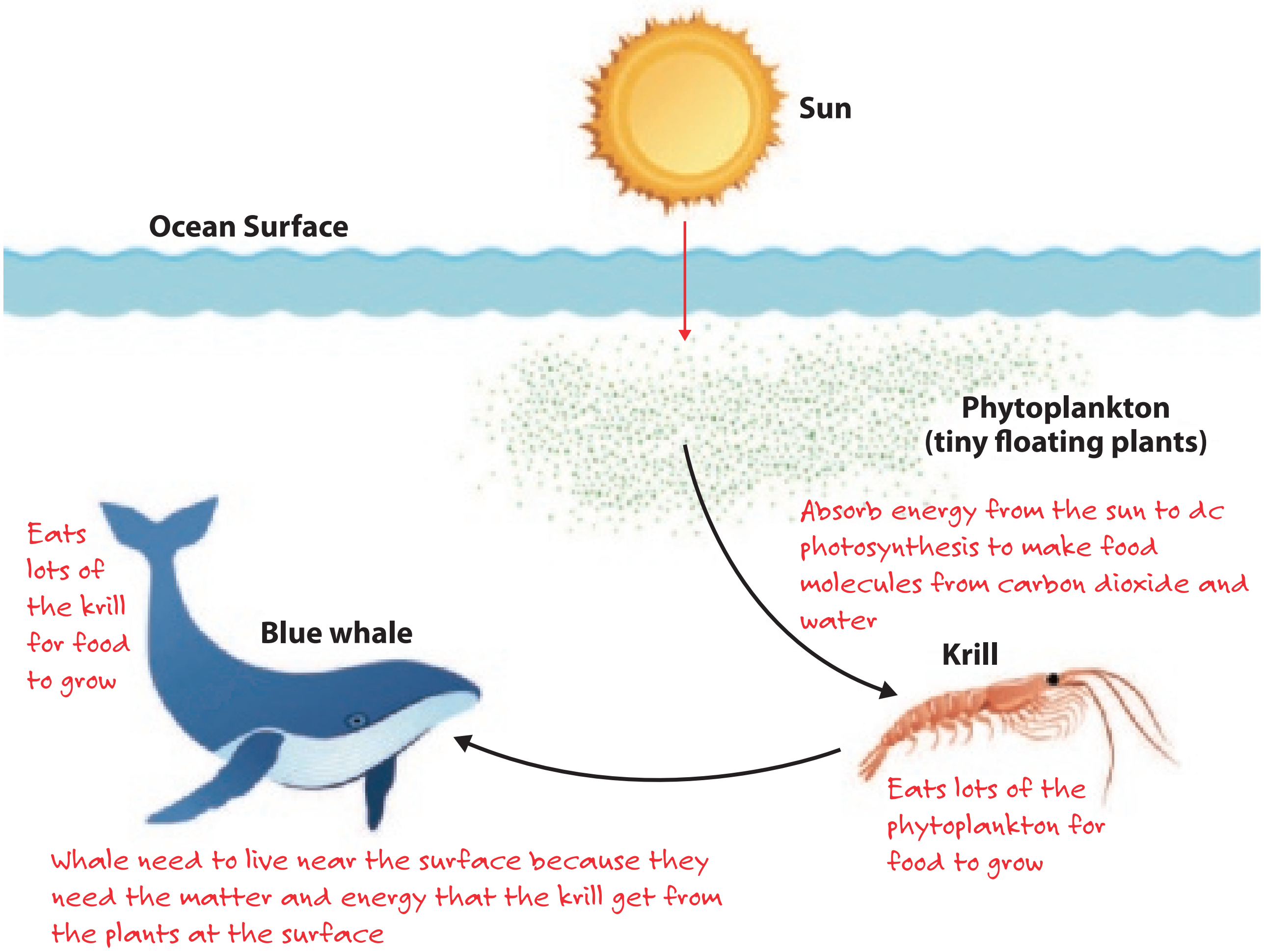
   + Without plants, the carbon dioxide in the system stays high.

   + Once the whale fall is gone there is no more food for the worms.

   + Worms need oxygen and food to do cellular respiration and have the matter and energy to survive.

3. During their lives, blue whales live near the surface of the ocean and only eat little tiny animals called krill. Krill only eat phytoplankton (tiny floating plants on the surface of the ocean).

   Add words and arrows to the partial food web (representation) below to explain why the whale needs to live in the part of the ocean system near the surface.



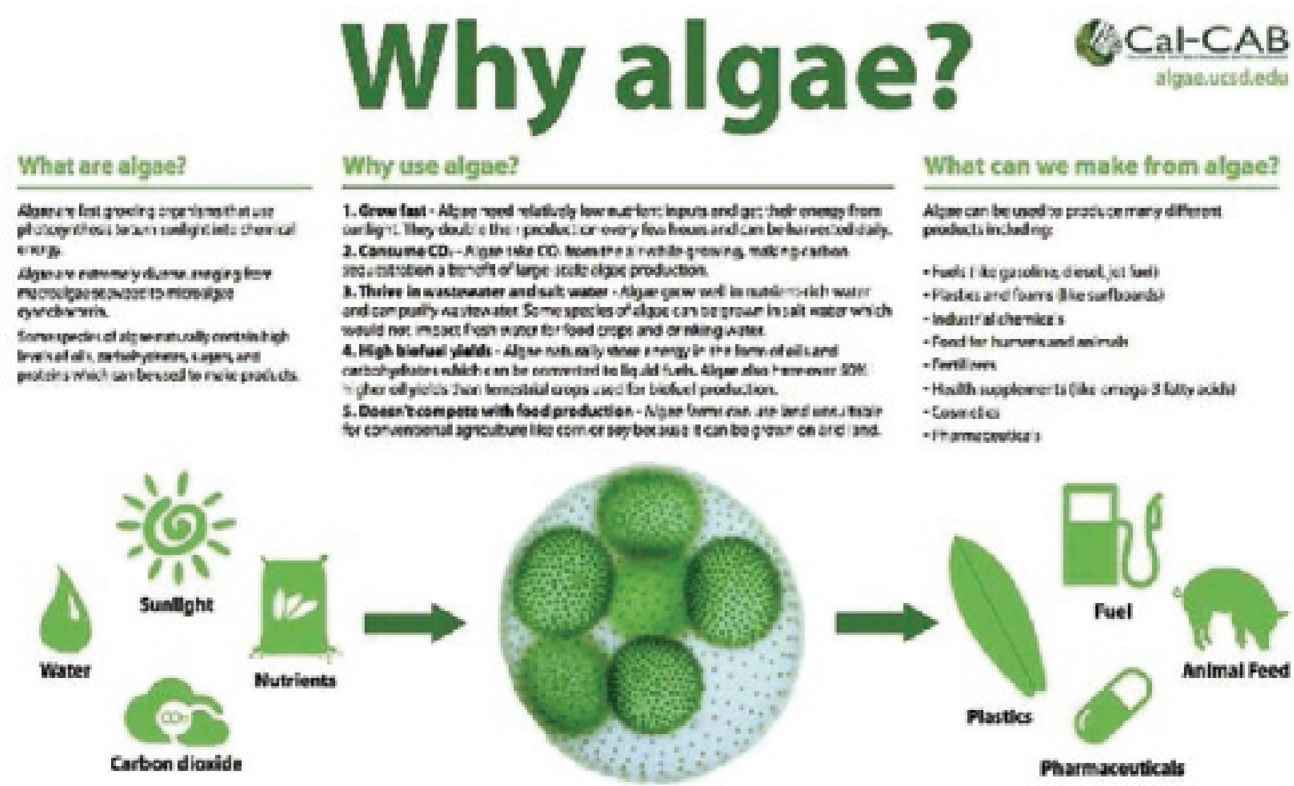
Part 2 - Phytoplankton and Synthetic Materials

The same phytoplankton that krill eat are used by humans to make new products. One type of phytoplankton is algae and there are many different species of algae-all of which are tiny plants.

In the image below (an infographic), there is some information about using algae for bio-based products and below that there is information about three different products that are being developed today.

Choose ONE of the READINGS (A, B, OR C) and use the information from the INFOGRAPHIC to answer the questions below.

Algae Infographic:



Products Made from Algae

A. Flip-flops

Scientists at the University of California San Diego are creating flip-flops made from the oil of algae plants. Scientists extract oil from algae and use it as a main ingredient in the foam used to make the flip-flops. They are called sustainable because the carbon used to make them was taken from the atmosphere, rather than oil from underground. The flip-flops are biodegradable and will break down in a compost pile.

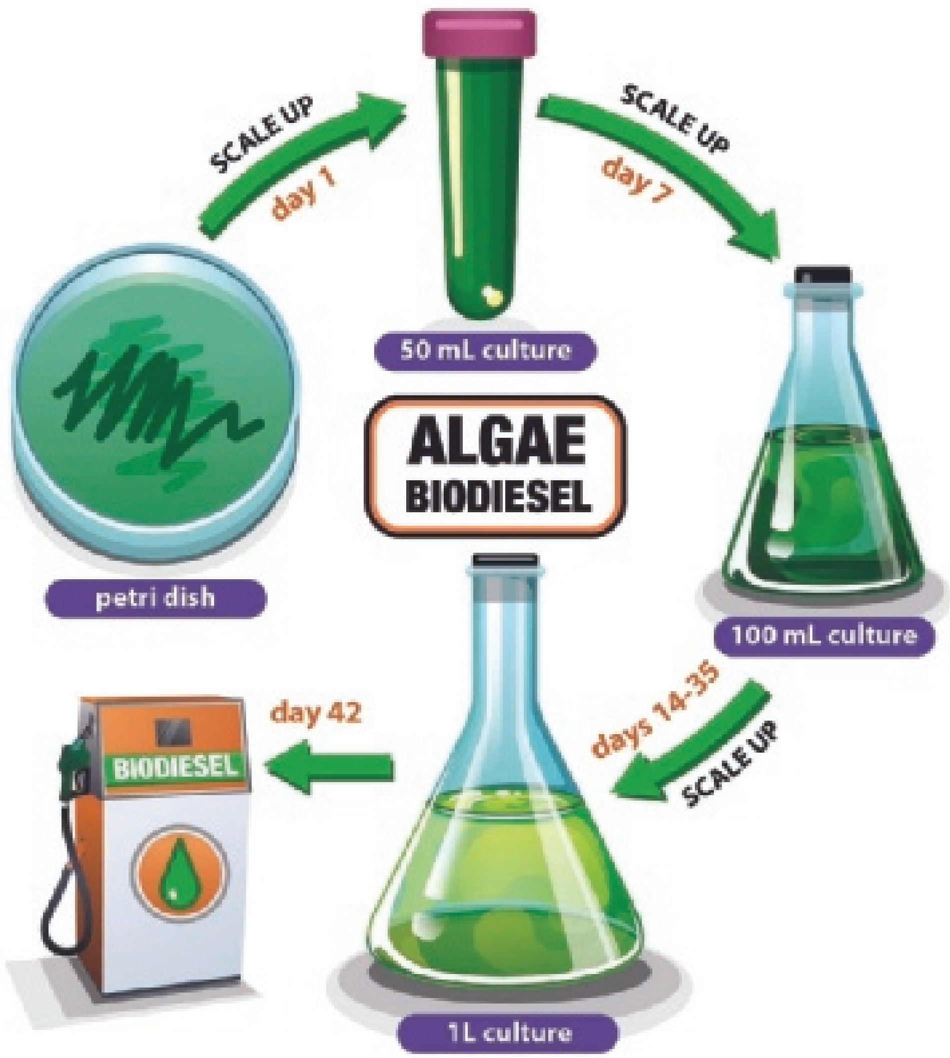
Source:

- https://www.universityofcalifornia.edu/news/guilt-free-flip-flop?utm_source=fiat-lux&utm_mediu m=internal-email&utm_campaign=article-general&utm_content=text

B. Biofuel

Biofuel is fuel that is produced from living things on Earth instead of using oil from fossil fuels. Algae is a promising option for creating fuel for transportation. In order to create biofuel from algae, scientists and companies that are creating algae biofuel use the following process:

- Grow algae in big tanks outside or under artificial light.
- Use a press to extract the oil from the algae plants.
- Add chemicals to purify the oil and remove anything extra.
- Oil can be used directly in diesel engines or refined further to work in other engines.



Sources:

- https://www.slideshare.net/shoebjafri/algal-production-for-biofuel
- https://algae.ucsd.edu/about/resources.html#How-to:-The-Extraction-of-Algal

C. Health Supplements

Many people take health supplements called Omega-3s. Omega-3s are fatty acids that the human body needs to function. There are two important kinds of Omega-3s called DHA and EPA. Most people take DHA and EPA in the form of fish oil–oil from fish that contains the fatty acids. Fish get their DHA and EPA from eating algae. DHA and EPA are created by chemical processes occurring inside the algae and then when the fish eat the algae, it accumulates in their bodies. Now for people who do not like the taste of fish or want a more sustainable option, DHA and EPA are available in supplements made from algae oil.

Source:

- https://ods.od.nih.gov/factsheets/Omega3FattyAcids-HealthProfessional/

Please answer the questions below using scientific information you obtained from the infographic and one of the readings.

1. The product I chose is: ________________________________.
2. Describe how the matter in the material you chose comes from a naturally occurring plant. Use words or drawings to show how the carbon in the product you chose got from the algae into the product.

+ The matter in the food, medicine, or fuel came from algae (a plant).

+ Describe the matter cycling from the algae to the product.

+ Uses info from the reading and infographic to describe how it got from the plant to the synthetic thing; it was processed in some way and changed.

3. Why is using algae a sustainable, beneficial, environmentally-friendly, or healthy choice for making your product?

+ Uses information from the reading and infographic.

+ Algae are easy to grow and the sun provides them energy so we can grow a lot them over and over again.

+ Algae use sunlight for photosynthesis and transform the energy from the sun into extractable energy in food molecules that can be used for a variety of purposes.

+ That energy and matter can be used to make products.

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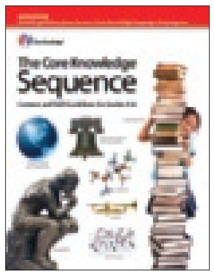

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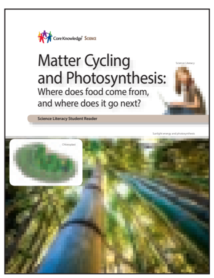

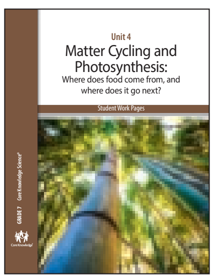

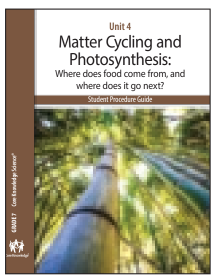

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