Historical Investigations

7.3

Image via iStock.com/Zoinierek

Anchoring Phenomenon

Tiny seedlings grow and transform into trees with a great quantity of matter.

Lesson Concept

Obtain and evaluate information about historical investigations that sought to explain where all the matter in a tree comes from when it begins as a small seedling.

Investigative Phenomenon

Data from historical investigations show that plants don't add mass from water or soil, but they do purify the air when in sunlight.

Standards

Refer to Appendix 7.3 for NGSS, CCSS (ELA), and California ELD Standards.

7.3 Historical Investigations

Storyline Link

In the previous lesson, Lesson 7.2: Planning Plant Investigations, students planned investigations to test where the matter comes from that changes a seedling into a tree. In this lesson, students will obtain information about historical investigations that led to our understanding that plants change the composition of air. In the next lesson, Lesson 7.4: Investigating Gases, students will carry out an investigation to gain evidence that a gas exchange is involved when plants gain matter (live and grow). Students will continue to develop and use models to communicate their thinking by extending to the development of models to represent information obtained from the text about historical investigations. Students will also consider the components of the system and focus on how investigations might provide additional evidence regarding what is entering and leaving the system.

Throughout the lesson, a flag (▶) denotes formative assessment opportunities where you may change instruction in response to students' level of understanding and making sense of phenomena.

Time

60 minutes

One 60-minute session

Materials

Group

- ❑ 7.3.G1: Information about Historical Investigations
- ❑ Chart paper, butcher paper, or 11"x 14" sheet of paper
- ❑ Markers

Individual

- ❑ 7.3.H1: Modeling Historical Investigations
- ❑ 7.3.H2: Exit Ticket
- ❑ 7.3.H3: Exit Ticket Assessment Rubric

Teacher Use

- ❑ 7.3.R1: Exit Ticket Assessment Rubric: Possible Instructional Responses

Advance Preparation

1. Print one set per group of **7.3.G1: Information about Historical Investigations** or give students digital access.
2. Print one copy per student of **7.3.H1: Modeling Historical Investigations** or provide the template on the screen (when indicated in the lesson) so students can use their science notebook to record their ideas instead of the handout.

3. Print one copy per 2 students of **7.3.H2: Exit Ticket** or post the question and have students answer the question on a card or in their science notebook.
4. Print one copy per student of **7.3.H3: Exit Ticket Assessment Rubric.**

Procedure

Explore (30 minutes)

Obtain and evaluate information about historical investigations that sought to explain where all the matter in a tree comes from when it begins as a small seedling.

1. In Lesson 7.2: Planning Plant Investigations, students planned investigations to try to determine where the matter that makes up a tree comes from. Have students review/share their plans. Provide sheets of chart paper, butcher paper, or 11" x 14" sheets of paper for students to draw the main details of their plan as a poster.

> **TEACHER NOTE**
>
> If students did not collaboratively develop a plan in Lesson 7.2: Planning Plant Investigations, ask the students to share ideas and either pick one person's plan or develop a common plan now. The goal is to have students collaborate in groups and to have their ideas visible to the class and for you to assess how students are thinking about how the transfer of energy drives the motion and/or cycling of matter. This is also an opportunity for students to move their verbal conversations to a public, written format. The scaffolds for discussion described in Lesson 7.2: Planning Plant Investigations can be used to support student discussion.

2. Facilitate a class discussion as students share their plans. Direct students to visit at least two other groups and review their plans. Tell students to review in pairs or trios and direct them to look for things that are similar and different in the plans.

> **TEACHER NOTE**
>
> English Learners may benefit from linguistic scaffolds to support their ability to express and share their ideas. A few sentence starters can be provided such as: *The dependent variable in both plans ______, but the independent variables ______. The plans use different/similar tools to measure ______.The plans are different because the data collected ______*. Allowing the use of native language, non-standard, or social language can be productive in this process.

3. Tell students that people wondered about similar things in the past and did investigations to find out more information. Sequence the ideas in order so that you can provide the handouts when the ideas are brought up by the students.

4. Explain to students that they will read and discuss information from past investigations. Review the student-generated questions from Lesson 7.1: Tree Matter. Ask students which questions they were attempting to answer when they designed their investigation. Tell students that they worked on developing investigations in Lesson 7.2: Planning Plant Investigations, and now they will have an opportunity to compare their plans to investigations that were actually conducted by scientists in the past. As they discuss the readings, students should evaluate the scientist's plan, the data collected from the plan, and the conclusions drawn from the data. Explain to students that we are analyzing these historical investigations to help us answer our questions related to how matter flows in and out of the plant or tree.
5. Have students obtain information from **7.3.G1: Information about Historical Investigations**. As they read, they should make notes about their evaluation of the plan, the data collected from the plan, and the conclusions drawn from the data. They should also make notations, revisions, and additions to their group poster. As students work, visit each group, listen to their discussion, and review their work on the group poster. If there is no evidence on the group poster that students have considered how the investigation can provide evidence about how the transfer of energy is driving the motion of matter flowing into the tree (system), facilitate their thinking with a few questions:
   - Which component of the system is the focus of the investigation?
   - What inputs were manipulated? Controlled? Measured?
   - What outputs were manipulated? Controlled? Measured?
   - What forms of energy are involved in this system?
   - What molecules are involved in this process?
   - How are the molecules being rearranged?

For English Learners or students reading below grade level, the text of **7.3.G1: Information about Historical Investigations** may be challenging. Before they read, preview the reading to look for terms that are unfamiliar. Annotate the text by identifying words that they won't understand, ideas that relate to their plans, and ideas that bring up questions. This will help them to understand the investigation and its results. Students who are above the target level for this lesson may wish to conduct some individual research. Suggested websites are provided at the end of this lesson.

TEACHER NOTE

The goal of this experience is that students see that their ideas are similar to what scientists actually did. It is important to relate the historical investigations to the student ideas. Conduct a discussion where the students describe their investigations and then provide the matching historical investigation when needed. It is also important to sequence the discussion in the order of questions in **7.3.G1: Information about Historical Investigations**. For example, if a student or group planned an investigation seeking to find out if soil made up the matter of the tree, the student could share that investigation, and then you could provide the part of the reading that describes Helmont's investigations of

TEACHER NOTE (Continued)

"Is soil the source of matter in plants?". Another group may have planned an investigation about water. This group could share their plan, and then you could provide the information on "Is water the source of matter in plants?" The discussion should lead to reading all of **7.3.G1: Information about Historical Investigations**. The main idea is that the students see that the historical investigations relate to the investigations they planned in Lesson 7.2: Planning Plant Investigations.

"Is water the source of matter in plants?" on page 7.3.10 of **7.3.G1: Information about Historical Investigations** includes some flawed logic on the part of the researcher. The stated reasoning is that because MOST of the water was not going into the plant, one can reject the idea that water is the source of the extra 1 g of mass in the plant. While the conclusion to the experiment is reasonable and accurate, there is a discrepancy in the reasoning that students may need support to identify and reconcile.

Explain (30 minutes)

Obtain and evaluate information about historical investigations that sought to explain where all the matter in a tree comes from when it begins as a small seedling.

6. Give students **7.3.H1: Modeling Historical Investigations** or display the template on a screen so the students can enter their work directly into their science notebook.

TEACHER NOTE

These historical investigations are designed to elicit and address some common alternate conceptions common in middle school students. For example, many middle-age students think that plants gain mass from the soil or use soil for food. This can lead to the prediction that when a plant grows, the soil will lose weight. This idea is brought up in the Van Helmont investigation. Similarly, middle school students often think that plants gain mass from water, which is addressed in the Woodward investigation. Other student alternative conceptions include seeing food as a requirement for growth, rather than a matter for growth; seeing organisms, such as plants, as very different types of matter from other materials in the environment such as water or air. The connection between matter, energy, and food will start to be addressed in this lesson and developed over the next several lessons in the unit.

7. Ask the students to think about what each investigation was trying to figure out. To which component of the system does the investigation relate? Does it connect to some aspect of their model? Direct students to part 1 of **7.3.H1: Modeling Historical Investigations**. Have students process the information they obtained in the reading by creating models of the investigations using **7.3.H1: Modeling Historical Investigations**. The models should include words and drawings that show the steps of the investigations and conclusions. Any critiques

(good or bad) about each investigation should also be included in each model. As students work in their groups, walk around the room, and visit groups to assess their progress. This is another opportunity to check for evidence that students have considered how the investigation can provide evidence about how the transfer of energy is driving the motion of matter flowing into the tree (system). Facilitate their thinking with the same questions used in step 3:

- What component of the system is the focus of the investigation?
- What inputs were manipulated? Controlled? Measured?
- What outputs were manipulated? Controlled? Measured?
- What forms of energy are involved in this system?
- What molecules are involved in this process?
- How are the molecules being rearranged?

8. Have students compare their drawings with other students and make changes or add information if necessary. At this point, students should be able to produce models that accurately display the steps of each investigation (first drawing includes a sprig of mint under an enclosed clear jar with a burning candle, the second drawing shows a similar set-up with candle burned out, etc.), the data collected (burnt-out candle is capable of relighting and burning after 27 days with the plant) and conclusion (plants change the composition of the air). Remind students to use the discussion prompts introduced in Lesson 7.2: Planning Plant Investigations when they share their models:

   - I am not sure I understood ______. Can you tell me more?
   - I agree with ______ because ______.
   - I disagree with ______ because ______.
   - What you said ______ about _____ made me wonder ______.
   - I want to build on your idea about ______.

   After students have discussed their models with another group and received feedback, allow them a few minutes to consider the feedback they received and revise their models.

9. Direct students to Part II of **7.3.G1: Information about Historical Investigations**. Tell students that if they have not considered how each investigation contributes to our understanding of the flow of matter, they can add that to their models now. Tell students that at this point, their models should use evidence from these investigations about how matter can be tracked in terms of weight.

10. Direct students to consider how they can add details about how the transfer of energy is contributing to how matter is flowing in and out of the tree. These points should have been discussed in steps 3 and 5, but students may not have recorded their ideas in their science notebook yet. These ideas will be built on later, so it is important they are recorded in their science notebook.

11. Ask a few groups to share their thinking or select groups to share based on conversations you have had while observing their group work. If students are uncertain how to include energy transformation to their models, ask them what evidence there is that the plant is getting the energy it needs (it is growing, it is healthy, etc.) and then how they might indicate that on their models (additional arrows or labels). Students who are not yet proficient in English may feel uncomfortable sharing with the entire class. You can ask those students ahead of time if they would be willing to share something in the small group, providing additional time to prepare what they want to say. Other options are suggesting that students use the visual model as support or co-sharing the idea with a table partner.

12. Direct students to add a short paragraph summary of each model in their science notebook. Remind students that the summaries should identify the main ideas of each handout without directly repeating information. Students above the target level should be encouraged to include descriptions of matter cycling and energy flow in the investigation descriptions. If students are having trouble summarizing in paragraphs, they could summarize using the models constructed during their group work and add a few sentences about the model. English Learners would benefit from this multimodal strategy as well as a few sentence frames to describe the investigations:

    - The variable changed was ________.
    - The data ______ was measured.
    - The conclusion was ________ because _______.

    ▶ These summaries can be reviewed to assess both whole class and individual student progress and combined with the exit ticket assessment data (step 14.) However, students need to have a record of these discussions in their science notebook to refer back to later in the unit as they plan and conduct their own investigations.

13. Five minutes before the end of the class, direct students to look at their initial model from Lesson 1: Tree Matter and add any new ideas or wonderings they have to their model. Remind them that they will be adding to this model throughout their learning experiences. Ask students to consider ways in which their models are limited in describing the phenomenon of the tree growing and what information would be useful to improve their model.

14. Distribute **7.3.H2: Exit Ticket** or post the question and have students answer the question on a card or in their science notebook. Tell students: Now that we have learned about results from investigations done in the past, what can we say about where a tree's mass comes from? What cause-and-effect relationships are supported with evidence from the historical investigations? What cause-and-effect relationships are not supported? What is a question that you still have?

15. ▶ Direct students to record their ideas on a slip of paper or notecard and hand it to you as they leave the class. These notecards can provide you with evidence of student learning (FORMATIVE ASSESSMENT) and help plan for the next series of lessons. At this point, students should state that plants need sunlight to add mass, but soil and water are not adding to the new mass or growth of the tree.

TEACHER NOTE

▶ **7.3.H2: Exit Ticket** is answered individually by each student. The exit tickets should be reviewed and returned to the individual students with your evaluation using the **7.3.H3: Exit Ticket Assessment Rubric**. Mark each row of the rubric with yes/no to provide feedback to each student. As you have judged each students work, put a tally in the yes or no column of **7.3.R1: Exit Ticket Assessment Rubric: Possible Instructional Responses** to identify trends across the entire class. Suggestions located in the last column of **7.3.R1: Exit Ticket Assessment Rubric: Possible Instructional Responses** may be used to support individual students as well as used with the entire class.

References

Rubin, J. T. (n.d.). The Discovery of Photosynthesis. Retrieved from http://www.juliantrubin.com/bigten/photosynthesisexperiments.html

Toolbox Table of Contents

Information about Historical Investigations

Is soil the source of matter in plants?

In the 1600s, a man named Jan Baptista van Helmont was investigating how plants take in mass. He asked the question, “Do plants get their mass by taking up minerals from the soil?” For 5 years, he grew a tree inside a pot and measured the mass of the tree and the soil. His measurements showed that the tree weighed 74 kg more compared to the start of his experiment, but the mass of the soil had hardly changed at all. He concluded that the increase in mass as a plant grows does not come from the soil. Van Helmont thought that the extra mass was coming from the water that plants absorb.

Things to consider:

Evaluate the investigation plan, the data collected from the plan, and the conclusions drawn from the data.

How do the results of the investigation help us think about how the transfer of energy is driving the motion of the matter moving into and out of the tree (system)?

Information about Historical Investigations (continued)

Is water the source of matter in plants?

Building on the work of Van Helmot, John Woodward designed an experiment to test the idea that the increase in tree mass comes from water. In the late 1600s, he conducted a series of experiments to measure the water consumed by plants.

Over the course of 77 days, Woodward's evidence showed that plants gained very little mass compared to the amount of water they absorbed. For example, one plant had gained 1 gram of mass but had received almost 76,000 grams of water. Woodward concluded that most of this water was not staying in the plant itself but was absorbed and then moved through the pores of the leaves and released into the air. This led him to reject the hypothesis that water was the source of the additional mass.

Things to consider:

Evaluate the investigation plan, the data collected from the plan, and the conclusions drawn from the data.

How do the results of the investigation help us think about how the transfer of energy is driving the motion of the matter moving into and out of the tree (system)?

Information about Historical Investigations (continued)

Does the air have something to do with the source of matter in plants?

It would not be until 1771 that Joseph Priestley designed an experiment to investigate how plants interact with the air. In his experiment, Priestley placed a branch of mint (plant) and a candle in a transparent closed space. He observed that the candle would burn until the air was used up (oxygen was not discovered yet) and then the candle would quickly go out. He waited 27 days and then he relit the extinguished candle without opening the closed space. Priestley observed that the candle was able to burn again in the same air that had previously failed to support it. To light the candle without opening the space, Priestley focused beams of sunlight with a mirror onto the candlewick.

Priestly's evidence showed that plants somehow change the composition of the air.

In another experiment, Priestley kept a mouse in a closed jar of air until it collapsed. When he placed a plant in the jar with the mouse, the mouse would survive. DO not repeat this experiment. Do not endanger animals.

His observations from these experiments led Priestley to an interesting hypothesis: plants put back into the air whatever material is taken out by breathing animals and burning candles.

Things to consider:

Evaluate the investigation plan, the data collected from the plan, and the conclusions drawn from the data.

How do the results of the investigation help us think about how the transfer of energy is driving the motion of the matter moving into and out of the tree (system)?

Information about Historical Investigations (continued)

Even though light is not matter, why is it important to plants?

Jan Ingenhousz built upon Priestley's work. In 1779, Ingenhousz placed a plant and a candle into a transparent closed space. This was similar to the design of Priestley's experiment, but Ingenhousz did not light the candle. Ingenhousz let the system stand in the sunlight for two or three days. He wanted to make sure that the plant had made the air inside the container pure enough to support a candle flame. He then placed a black cloth over the closed container and left it covered for several days. When Ingenhousz tried to light the candle, it would not light.

Ingenhousz concluded that plants must act like breathing animals when placed in darkness. Plants must also breathe, and plants need sunlight in order to purify the air.

In his next experiment, Ingenhousz, placed a small green aquatic plant in a transparent container of water. He placed the container in bright sunlight and observed the plant. He saw gas bubbles forming around the leaves and around the green parts of the stems. When Ingenhousz moved the system into darkness, the bubbles stopped forming. Ingenhousz thought that the bubbles could be the material produced by plants that purifies air after it has been changed by animals or candles.

His experiments showed, for the first time, that light is needed for plants to complete the process that purifies the air.

Things to consider:

Evaluate the investigation plan, the data collected from the plan, and the conclusions drawn from the data.

How do the results of the investigation help us think about how the transfer of energy is driving the motion of the matter moving into and out of the tree (system)?

Modeling Historical Investigations

Part 1: In each box, draw a model that shows the steps of the investigations and the conclusions the scientists made.

Is soil the main source of matter in plants?	***Is water the main source of matter in plants?***
Does the air have something to do with the source of matter in plants?	***Even though light is not matter, why is it important to plants?***

Part 2: Add to your model: how does the investigation provide evidence the flow of matter in terms of weight was involved in the investigation and how the transfer of energy is driving the flow of matter.

Exit Ticket

Name: ________________

What do the historical investigations tell us about where a tree's mass comes from? What cause-and-effect relationships do we have evidence for?

What questions do you still have?

Exit Ticket

Name: ________________

What do the historical investigations tell us about where a tree's mass comes from? What cause and effect relationships do we have evidence for?

What questions do you still have?

Exit Ticket Assessment Rubric

Name: ___________________________

	Yes	No	Comment
Components			
Historical investigations show that new mass is not coming from the soil.			
Historical investigations show that new mass is not coming from water.			
Historical investigations show that sunlight is needed for new mass.			
Cause-and-Effect Mechanisms Response indicates a reasonable connection between evidence of source such as water or soil (cause) and claim for source of new mass (effect).			
Questions New questions posed are based on evidence from historical investigations OR seek to clarify additional information to explain tree growth.			

A project of CA NGSS K–8 Early Implementation Initiative.

Exit Ticket Assessment Rubric: Possible Instructional Responses

Possible Student Responses	Yes	No	Possible Instructional Response To Trends in Student Work
Components			Review evidence from each investigation. Record data in a table to clarify evidence gathered and draw a conclusion about growth. Group: Review evidence on the class chart with columns titled YES adds mass, NO does not add mass, and UNCERTAIN.
Historical investigations show that new mass is not coming from the soil.			
Historical investigations show that new mass is not coming from water.			
Historical investigations show that sunlight is needed for new mass.			
Cause-and-Effect Mechanisms Response indicates a reasonable connection between evidence of source such as water or soil (cause) and claim for source of new mass (effect).			Review cause-and-effect relationships in more familiar examples or examples related to students' lives. Introduce the cause and effect sentence stems: If this ______ then ______. If ______ happens then ______. The _____ caused _____ the effect of _____.
Questions New questions posed are based on evidence from historical investigations OR seek to clarify additional information to explain tree growth.			Gather questions from exit tickets and summarize new questions into groups. Review these chunks of questions with students highlighting questions that connect to the historical discussions and would lead to investigations that could add to or clarify aspects of our current understanding. Invite students to reword or revise other questions so they connect or clarify or add to our understanding.

Next Generation Science Standards (NGSS)

This lesson is building toward:

PERFORMANCE EXPECTATIONS (PE)	
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. [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.]

NGSS Lead States. 2013. Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press.

SCIENCE AND ENGINEERING PRACTICES (SEP)

Obtaining, Evaluating, and Communicating Information

- Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).

DISCIPLINARY CORE IDEAS (DCI)

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.

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.

Appendix 7.3

CROSSCUTTING CONCEPTS (CCC)
Energy and Matter
• 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.
Systems and System Models
• Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within a system. (From Grade 3–5)
Cause and Effect
• Cause and effect relationships are routinely identified, tested, and used to explain change. (From Grade 3–5)

Common Core State Standards (CCSS)

CCSS ELA READING
CCSS.ELA-LITERACY.RI.7.1
Cite several pieces of textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.
CCSS.LA-LITERACY.RI.7.2
Determine two or more central ideas in a text and analyze their development over the course of the text; provide an objective summary of the text.

California English Language Development (ELD) Standards

CA ELD		
Part I 7.6 Reading/viewing closely		
EMERGING	EXPANDING	BRIDGING
P1.7.6a Explain ideas, phenomena, processes, and text relationships (e.g., compare/contrast, cause/effect, problem/solution) based on close reading of a variety of grade-appropriate texts and viewing of multimedia with substantial support.	**P1.7.6a** Explain ideas, phenomena, processes, and text relationships (e.g., compare/contrast, cause/effect, problem/solution) based on close reading of a variety of grade-level texts and viewing of multimedia with moderate support.	**P1.7.6a** Explain ideas, phenomena, processes, and text relationships (e.g., compare/contrast, cause/effect, problem/solution) based on close reading of a variety of grade-level texts and viewing of multimedia with light support.