Category V Life Science Examples

Guiding student interpretation and reasoning

Food for Plants

Consider the following benchmark 5E6-8#1:

> Food provides the molecules that serve as fuel and building material for all organisms. **Plants use the energy from light to make sugars from carbon dioxide and water**. This food can be used immediately or stored for later use. Organisms that eat plants break down the plant structures to produce the materials and energy they need to survive. Then they are consumed by other organisms. (American Association for the Advancement of Science, 1993)

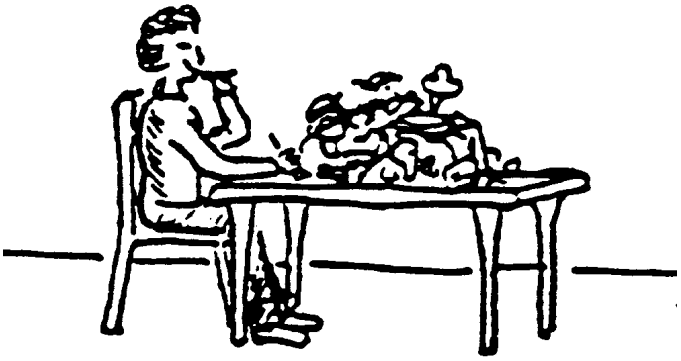
Food for Plants presents Van Helmont's experiment, which provides evidence that plants do not use food from the soil to support their growth. (Van Helmont planted a young tree in a bucket of soil. He watered the tree regularly but did not add any more soil. After five years, the tree gained a lot of mass, but the mass of the soil was nearly unchanged).

Before students are asked to think about Van Helmont's experiment, they are asked to suppose that a child was given 200 pounds of food to eat. They are asked (a) what would happen to the weight of the child and (b) what would happen to the weight of the food (*Student Book*, p. **36**). Then they are asked to imagine that a young tree was planted in a bucket of soil and are told that as the tree grows, it gains weight. They are asked to write down whether they think the weight of the soil will go up, go down, or stay the same as the tree grows (*Student Book*, p. **37**). These questions help students to interpret Van Helmont's experiment within the frame of conservation of matter (If soil is a kind of food for plants, the weight of the soil should decrease as the weight of the tree increases) and to focus their attention on a very important aspect of the experiment (although the weight of the tree increases a lot, the weight of the soil hardly decreases).

Students are encouraged to link the experiment to their own ideas. Before they read about the experiment, they are asked to (a) write down and justify their ideas about whether they think that soil is food for plants (*Student Book*, p. **35** and *Teacher's Guide*, p. **41**) and (b) make predictions about the outcome of Van Helmont's experiment (*Teacher's Guide*, pp. **42-43**). After they read about the experiment, students are encouraged to think whether soil is food for plants and explain their answers (*Student Book*, pp. **38-39**). The material suggests that teachers emphasize "the contrast between the students' predictions and what actually happened in the experiment" (*Teacher's Guide*, p. **44**) and provides the teacher with suggestions for dealing with students' questions (*Teacher's Guide*, p. **45**).

The material provides a carefully selected and sequenced series of questions to guide student interpretation and reasoning about the reading.

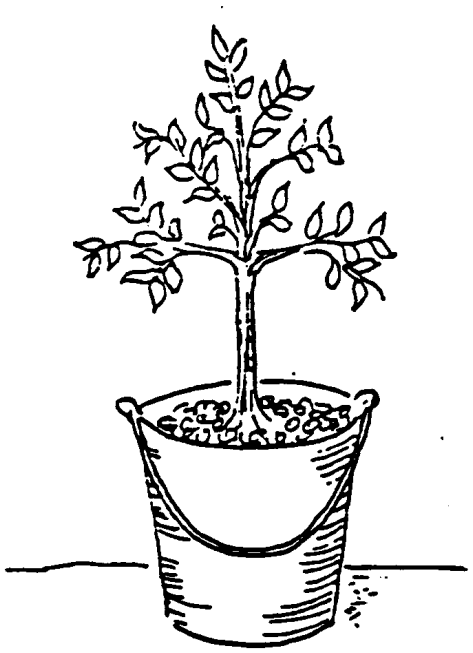
Is soil food for plants?



Suppose a child was given 200 pounds of food to eat. Predict what would happen to the weight of that child as he or she gobbled up the food. Does the child's weight go up, go down, or stay the same? Write your answer under the box marked "Weight of Child":

Weight of Child	Weight of Food

What would happen to the weight of the food on the table as the child ate it? Does the weight of the food go up, go down, or stay the same? Write your prediction under the box marked "Weight of Food".



Now think about a young tree planted in a bucket of soil. As the tree grows it gains weight. Does it gain weight from the soil the way a child gains weight from food? Is the soil a kind of food for the plant? What do you think? Write down below whether you think the weight of the soil will go up, go down, or stay the same as the tree grows:

Weight of the Tree	**Weight of the Soil**

In the 1600's everyone thought that the soil and minerals in the soil were the food for the plants. A scientist named Jan Van Helmont did an experiment to see if this was true. He planted a five pound young tree in a bucket containing 200 pounds of soil. He watered the tree regularly but he did not add any more soil. Look at the picture on the next page and see what happened to the weight of the tree and the weight of the soil after five years.

ACTIVITY NINE: Dr. Van Helmont
Is Soil Food for Plants?

How many people in your class think that soil might be food for plants? _____

How many people in your class think that water might be food for plants? _____

What are their reasons?

Traveling Back in Time

We have started doing experiments to find out about how plants get their food. Scientists have been doing experiments for many, many years to find out about food for plants. Aristotle lived years ago, and he thought about plants and how they got their food to grow. In fact, people have probably been wondering about how plants make their food for thousands of years. Even before we called people "scientists", people were wondering about plants and trying to come up with explanations about how they live and grow. And scientists today are still doing experiments to find out about how plants get their food -- we still do not have all the answers!

Let's travel back in time 350 years. It is now the year 1642. We are in Europe. It is a time of excitement and exploration and travel in this part of the world. Some people have found what they call a New World across the ocean (it is actually a very old world to the Native Americans living in this "New" World)! And more people are getting interested in finding out about the why's of the world around us -- more people are interested in and finding benefactors who will pay them to do science experiments.

We are going to meet one of these early scientists. He is a physician but he also does experiments withplants. His name is Jan Van Helmont. He is from the country of Belgium and the year 1642. He wants to visit with us today. He is going to help us think about our hypothesis that soil is food for plants. He was very interested in that hypothesis. Almost everyone back in 1642 was sure was the soil was the food for plants. Jan Van Helmont decided to prove them right (or wrong?).

ACTIVITY NINE: Dr Van Helmont
Is Soil Food for Plants?

Purpose: On the next four pages, students' ideas about soil as food for plants are challenged as they think about an experiment done by the Belgian Jan Van Helmont in 1642. In this experiment he showed that plants do not use food from the soil to support their growth.

Advance Preparation: If you feel inclined to dress up as Dr. Van Helmont for a role play activity, start collecting things to use for your costume. The idea is to give the impression of someone who lived long ago -- so don't worry too much about historical accuracy. Something akin to colonial male dress seems to work well in communicating the message of time distance (knickers, white knee highs, jacket with long tail in back, scarf around neck, a beret?, rimless reading glasses).

Materials: Copies of student pages 31-35 for each student.

A Possible Teacher Narrative

FRAME

"Today we are going to think about our hypothesis that soil is food for plants. Write down in your journals what you think right now. Is soil food for plants? Why do you think yes or no? What evidence are you using to support your position?"

Discuss ideas that students wrote down.

ACTIVITY

Read or tell about page 31. Get the students in a time traveling mood.

ACTIVITY

The questions on this page are preparing students to make a prediction about Van Helmont's experiment on the next page.

Additional Background for Teachers:
Using the History of Van Helmont's time to Be Sensitive to Diverse Students

Van Helmont was a Flemish physician and physiologist. The Flemish were people of Germanic descent who inhabited Flanders, which is today the northern part of Belgium. In the 1600's this area was sandwiched between the new and economically powerful Dutch Republic to the north and France to the south. Parts of this area were under Dutch control; others under Spanish.

Show students the countries of Belgium and the Netherlands on a map or globe. Ask them if they know anything about this area of the world and the people who live there. Have you ever heard of Belgium or the Netherlands? They may have heard of the Belgian horses Belgian sheepdogs, Dutch shoes and tulips, etc. Ask if any them have family histories tracing back to Belgium or the Netherlands.

The Dutch Republic of the 1600's was economically strong. The Dutch in this time period were active explorers, claiming lands and building colonies and trading stations in Africa and the Indies (the Dutch East India Company). The young republic's commercial supremacy was firmly established. Wealthy homes in London or Paris were full of goods provided by Dutch traders and sailors , and Flemish tapestries covered the walls of their homes. The art of painting flourished. Every town of any size had its community of professional artists.

Science and medicine also flourished, with money available to support the work of professional scientists and physicians. The microscope was invented during the first decade of the seventeenth century, and its power was realized in the middle of the century when a Dutch civil servant, Antoni van Leeuwenhoek decided to develop the magnifying glasses used by drapers to inspect cloth. In so doing, he created an instrument powerful enough to discern red blood cells and bacteria. Leeuwenhoek became a famous scientist of his time. He had no university education but compensated for that with a sharp mathematical mind, great manual dexterity and keen eyesight. He was so admired that he received kings as admiring guests.

What was life like for other people at that time period? Were all people as privileged as Dr. Van Helmont and van Leeuwenhoek? These scientists had the luxury of time and support to do experiments like this. But there were still many poor in the Netherlands. Van Helmont was among the privileged class of people who could devote their time to science or art.

And what was life like in America at that time? This was the time when the Pilgrims and Puritans and the Jamestown settlers were just getting established in the New World. Interestingly, the Pilgrim's story has a Dutch connection. The Pilgrims lived in the Netherlands for awhile to escape the persecution they felt in England at the time. However, they became upset with their children learning to speak Dutch and being influenced by Dutch ways of life. Eventually, they left the Netherlands, too, to find religious freedom in the New World.

Dutch explorers were active in claiming lands and colonies in the New World. The colony of New Netherland was founded by the Dutch West India Company, which exercised a monopoly over Dutch trade in the New World. The Dutch built trading posts along the Atlantic coast and up the Hudson and Connecticut rivers, frequently clashing with Indians and English settlers in their efforts to acquire furs, timber, and other natural resources. In 1655, they annexed New Sweden (later to become the state of Delaware. The main Dutch settlement was New Amsterdam at the south tip of Manhattan Island. The Dutch, however, had trouble attracting settlers since few could be tempted to leave their rich and tolerant mother country to start anew in a hostile land.

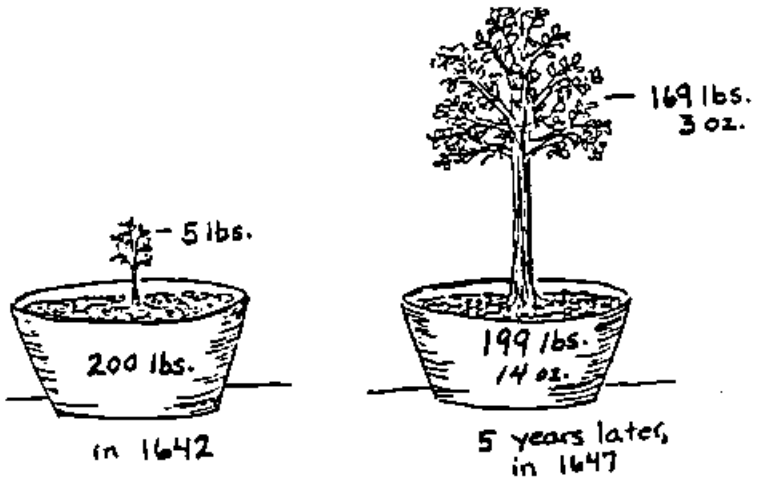
And the Dutch were early on connected to the slave trade in the New World. In 1619, a tragic social revolution began with the arrival in Jamestown of twenty slaves on a Dutch privateer. At first, the Africans were employed under the same terms as white indentured servants. Later in the century, they were denied all rights.

ACTIVITY

Have students read about Van Helmont's experiment and make their predictions.

Student Responses

Students who believe that plants get some or all of their food from the soil should predict that the weight of the tree will go up and the weight of the soil will go down.



Weight gain by tree	Weight loss by soil

The tree gained a whole lot of weight, but the soil did not lose hardly any weight! What do you think Van Helmont concluded? Is soil a food for plants? Why or why not?

_____

_____

_____

_____

Van Helmont decided that soil is NOT a food for plants. The tree did not use any of the soil to grow bigger. In order to grow bigger, the tree (like all living things) needs _____ that is in food.

Think about our scientific definition of food.
Does Van Helmont's experiment give us evidence to say that soil is or is not food for plants?_____

Explain your thinking._____

_____

_____

Are minerals in the soil food for plants?

Everyone says that plants take in minerals from the soil. Minerals do not have very much weight, but they do weigh something. So do you think Dr. Van Helmont's tree took in minerals from the soil? _____

About how much weight did the tree get from the minerals?_____

Do you think this amount of minerals could explain how the tree gained 164 pounds?

_____ Explain your thinking._____

_____

Think about Van Helmont's experiment. Does that experiment give us any evidence to say whether or not minerals in the soil are food for plants? _____

Explain your thinking.

_____

_____

_____

Is water food for plants?

Van Helmont thought that his experiment was evidence that water must be food for plants. He thought that if soil and minerals in the soil were not giving the tree its food, then the tree must be gaining weight by getting food from the water. After all, he had been watering the tree everyday for five years.

But remember our scientific definition of food. Water helps the tree to grow, but does it give the tree energy? Could the tree live and grow if all it took in was water? Let's think about the evidence from our experiment with the grass plants. It might help us decide whether or not water is energy-giving food for plants.

ACTIVITY

Read and discuss the results of Van Helmont's experiment and his conclusions.

The contrast between the student's predictions and what actually happened in the experiment should be emphasized. Make sure that students realize that the experiment provides evidence that plants do not take in food from the soil. You might ask students a question that gets them thinking about the biologists' definition of food: Do you think the soil contains energy that plants can use to live and grow?

A Visit with Dr. Van Helmont?

If you feel inspired, dress up (or have a colleague dress up) as Dr. Van Helmont. Tell the class that we are going to time travel back to the year 1647 and talk to the scientist who did this experiment. Students will be asking Dr. Van Helmont questions about his experiment and his conclusions. They might ask him:

- How did you do your measuring?
- Why did you do this experiment?
- Do the people of your day listen to you and your findings?

Then Dr. Van Helmont can ask the students questions like:

- In your experiments, in the future, what have you found out? Did you find any more evidence to support my conclusion that soil is not food for plants?
- Does my experiment make sense to you?
- Do you agree with my conclusions about soil?
- Do you agree with me that my experiment proves water is food for plants?

Expected Student Responses

Students may begin to wonder at this point, if plants do not get their food from the soil, then where do they get it from? This is an important first step in getting students prepared to find the explanation of photosynthesis sensible.

Students may ask about the tiny bit of weight lost by the soil. The weight lost consisted of minerals that plants absorbed through their roots. Plants need these minerals in small amounts for a variety of functions in the plant. They are needed to make the enzymes that regulate photosynthesis, for example. But this idea is not likely to have much meaning for students at this point. It might make more sense to some students after photosynthesis has been explained.

Some students will argue that the tree did get its food from the soil, because minerals have no weight. These students are not using conservation of matter as a principle in their thinking. It does not bother them that "something" (the weight of the tree) is coming from "nothing" (the weightlessness of minerals in the soil).

Some students may ask, "Do plants poop?" These students are thinking that soil could be food for the tree, but that the weight of the soil does not change much because plants "poop" out waste that adds weight back to the soil. An interesting aspect of this way of thinking is that there is some attempt to consider the need for conservation of matter. This would be an interesting question to return to after the students have learned about the "waste products" of photosynthesis.

Addressing the Nutrients Issue

Students may have questions about what minerals and fertilizers do for the plant if they are not "food." Why do people spend so much money on fertilizers and minerals? Don't they help plants grow?

With some students it is better to set the nutrient issue aside and keep the focus on the energy issue. Your students, however, may be ready to consider a more complicated definition of food:

> *Food is a substance that gives both nutrients and energy to a living thing. A NUTRIENT is a mineral that organisms need to be healthy, but nutrients don't provide energy that living things need to be active. Examples of nutrients are nitrogen, phosphorous, potassium. So for something to be food it has to have ENERGY, in addition to nutrients. It is the energy that enables living things to be active.*

In the Van Helmont experiment, the tree did get some nutrients from the soil, but these are not providing energy for the tree to grow. In addition, the small weight of the minerals taken in by the tree could not account for the massive weight gain of the tree. The weight gain comes largely from matter that is built from carbon dioxide and water in the photosynthesis process. Thus, the argument that many make that most of the weight of a tree comes from the carbon dioxide in the air.
(See the Private Universe Teacher Workshop video, "Lesson Pulled from Thin Air").

Activity Ten will continue to address the food energy issue.

Addressing the Water Issue

Most students are reluctant to abandon the idea that water is food for the plants. Telling them that water does not have energy in it is not very convincing to them. They argue that maybe it doesn't have energy for people, but it does for plants. There is no one single activity that will convince students otherwise. The strategy employed in this unit is to repeatedly raise questions about the water, so that students are at least questioning their original certainty that water is food. This questioning stance towards water will enable them to hear photosynthesis as a way to solve the puzzle they are experiencing: "Water must be food for the plants because they cannot live without it, but water does not provide energy to living things so water cannot be the food. I'm confused."

Confusion is a good sign at this point!