APPENDIX F

SELECTD TEACHER PAGES FROM *FOOD FOR PLANTS*

REFLECT AND CONNECT

Have students respond to the questions on p. 9.

Use a discussion of these questions to remind students about the central question of this unit: How do plants get their food?

"We need to have a shared understanding of the word "food" in order to investigate this question together."

Common Student Responses and Suggested Teacher Responses:

Common Student Responses	Suggested Teacher Interpretations and Responses
1. Why couldn't you live on water alone? •Because water does not have energy. •Because your body needs a balanced diet. •You can live on water alone, at least for a pretty long time. •Because you said so. •Because of the skit Bobby acted out.	This question is an application question--students have been told a new definition of food. Now they need chances to work with the idea. They will get many such chances in this unit, but this first application question is heavily scaffolded, reminding the students to use the energy-providing definition of food. Most students will dutifully follow directions and use the scientific definition of food provided on the previous page. They will state that water does not have energy, but at this point that will not mean much to them. Do not be fooled into believing that they really understand it at this point. An understanding of energy will evolve as students use it in a variety of contexts during this and other science units.
2. Why couldn't you live on dirt? •Because dirt must not have energy in it that we can use to live and grow. •Because our digestive systems are not made to handle dirt -- but worms' bodies are. •Because dirt is not food for humans. •Because dirt is food for plants but it is not food for humans.	This is another heavily scaffolded application question. It challenges the student to use the new definition of food in talking about dirt . This question is laying groundwork to later challenge students' conceptions that soil is food for plants. It is intended to lead students to the conclusion that dirt is not a food, that it does not provide living things with energy. Ideally, this would challenge their common conception that soil is food for plants. However, most students will assume that even though soil is NOT food for humans, it IS food for plants. The last response if not uncommon -- plants and people are different is the most common explanation..

[T9]

ACTIVITY--Writing about our Ideas

A Possible Teacher Narrative:
"In this unit, we will be trying to come up with a better **model** of how plants get their food than the picture we just looked at. We will start by finding out as much as we can about what we as a class already know about food for plants. What are our ideas, or **hypotheses**, about how plants get their food?"

"A **hypothesis** is an idea about an answer to a question. It is an idea that can be tested through experiments. We are going to do some tests to find out the different hypotheses that we come up with."

"Answer the questions on p. 11, trying to get down as many of your ideas as possible. Remember, the best answers will tell honestly what you think (optional: and why you think that). There is no one right answer. We want to find out how many different ideas we have as a class of scientists."

Allow students time to write. Encourage students to write **WHAT THEY THINK**. Do not try to correct them, edit them, or guide them to different answers as they write. Tell them to spell words as best they can.

Common Student Responses and Suggested Teacher Actions

Common Student Responses	Suggested Teacher Interpretations and Actions
•Food for plants is water that they take in through the roots. •Plants get food by taking it in from the soil. •Food for plants is what they need to grow. •Sun, water, air, soil, and fertilizer are food for plants. •People give plant food to plants -- it's little sticks that you buy at the store. •Plants make their food in the soil.	**Interpretation** Both of the questions on this page are exploratory questions designed to elicit students' ways of thinking about food for plants and to establish a problem that the group will investigate throughout this unit. Water is one of the most common responses. Many students list multiple sources of food for plants. Some students tend to think about anything plants need as food for the plant. Others think that whatever plants take into their bodies ("eat") is food for plants. Still others identify only fertilizers or minerals as food for plants. **Scientific Conception** While many students consider raw materials in the plants' environment as the plants' food, the scientific conception is that plants get their food by making it themselves by using energy from the sun to change water and carbon-dioxide into energy-containing food (glucose). This process, photosynthesis, takes place inside special cells in the leaves. This is the goal concept of the unit. The unit is designed to support students in changing their initial hypotheses to this scientific conception. They will be asked to come back to what they have written on these pages and revise their answers based on what they have learned from the unit.

[T11]

Sensitivity to Student Diversity
Be aware that students may use beans as a source of unkind teasing. For example, we have heard students in a science class use the occasion of discussions about beans to tease in a derogatory way Mexican American students, calling them "Mexican burritos" and "Mexican jumping beans." An appropriate response would be to call attention to this behavior, to clarify the inappropriateness of this kind of name calling in a scientific (or any other) community. Letting it go unacknowledged communicates to Mexican American students that this kind of behavior is condoned. It further marginalizes them in the science classroom. I'm sure you can also imagine students teasing other individuals regarding their flatulence problems! While some of this teasing might be done with the intent of good humor, it is still inappropriate if it isolates and humiliates another student.

Common Student Responses and Suggested Teacher Actions

Common Student Responses	Suggested Teacher Interpretations and Actions
•Most students do not think about the seed as being a source of food for the plant.	•Do not expect students to be thinking about the cotyledon as a source of food for the growing embryo. Accept all ideas at this point.
•Most students will not know the terms "embryo" and "cotyledon." They will frequently call the embryo the baby plant.	•Do not introduce these terms yet.
•Some students have difficulty seeing the embryo. They believe that it is the cotyledon ("the big part of the seed") that will grow into the plant.	•Help students see the embryo and examine it closely.
•Students generally have very few ideas about experiments at this point, but they often come up with ideas after completing the bean seed experiment.	•Tell the students that it is OK not to have any experiment ideas today, but that they should keep thinking about ideas of experiments that will help us answer our central question.
•Some students come up with experiment ideas but they have little to do with the central question.	•This is not surprising at this point. Students will need many opportunities to be involved in doing experiments and linking them to a central question before they will be able to generate their own experiment ideas.

[T16]

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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.

[T31]

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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.

[T32]

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Explore and Challenge
Is soil food for plants?

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.

[p. T33]

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Explore and Challenge
Is soil 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.

[T34]

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Explore and Challenge
Are minerals and water from the soil food for plants?

<u>Addressing the Nutrients Issue</u>

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?

<u>With some students it is better to set the nutrient issue aside and keep the focus on the energy issue.</u> 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.

<u>Addressing the Water Issue</u>

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!

[T35]

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REFLECT AND CONNECT

1. Have students look at their data charts to write down items they found that are NOT food by our scientific definition.

Anticipated responses: vitamin pills, plant food, fertilizer stakes, water, minerals, Diet Coke

2. Have students predict whether vitamin pills and plant food sticks will burn. Ask for their reasons.

Desired response: Since they do not contain calories (food energy), they will not burn.

3. Burn the vitamin bills and plant food sticks. Have students write down their explanations of what happened. Why didn't they burn?

4. Distribute post-it notes. Have each student write about some evidence to either support or challenge the hypothesis that minerals and plant food are food for plants. Have students place their post-its on the class data chart. Discuss the evidence that they cited.

Anticipated Responses:

CHALLENGING THE HYPOTHESIS:

- They are not food because they do not contain any calories, which tells you they have no food energy.
- They do not have energy in them but they are important to plants because my Mom and I did an experiment at home, and the ones that got fertilizers grew better than the ones that didn't.
- In the van Helmont experiment, the tree gained a lot of weight but only took in a few minerals from the soil. So the minerals could not be their food.

SUPPORTING THE HYPOTHESIS

- In the van Helmont experiment, the tree took some minerals from the soil so this must be one source of their food.
- They do not have energy in them but they are important to plants because my Mom and I did an experiment at home, and the ones that got fertilizers grew better than the ones that didn't.
- Why would they call fertilizers “Plant Food” if they were not food for the plants?
- My family always fertilizes the plants, and it helps them grow better so it must be food.

5. Have students draw something they learned today -- either a diagram, a picture, a concept map, or some other visual representation of their learning. This more open-ended response is intended to help students reflect and synthesize and to help the teacher understand the various ways in which students understood this lesson.

[T40]