

Apple Tree

Six friends were picking apples. They each had different ideas about where the apple tree makes the food it needs to live and grow. This is what they said:

Molly: “I think the food is made in the tree’s roots.”

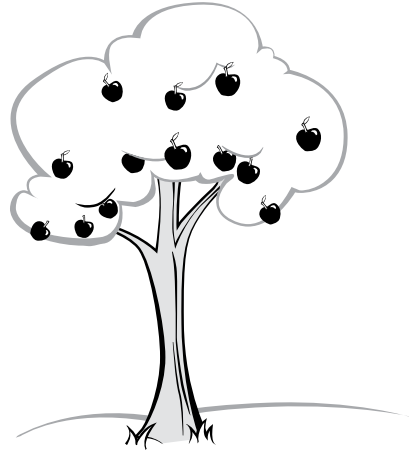
Joan: “I think the food is made in the leaves of the tree.”

Bonnie: “I think the food is made in the apples the tree produces.”

Bev: “I think the food is made in the tiny tubes in the trunk and the branches.”

Susie: “I think the food is made in the apple blossoms.”

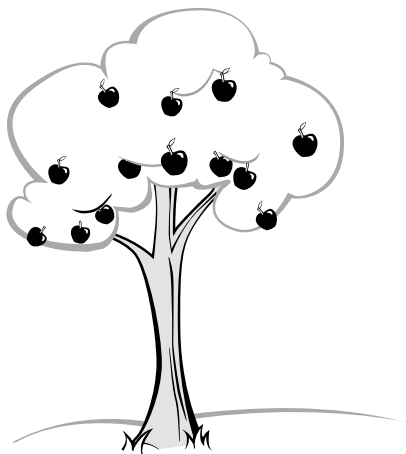
Jared: “I disagree with all of you. I don’t think apple trees make their own food.”



Which friend do you agree with the most? _____ Explain why you agree.

Apple Tree

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about the plant structure where photosynthesis takes place. The probe is designed to reveal whether students recognize that food is made within the leaf of a plant.

Related Concepts

Food, photosynthesis, leaf, plants, energy, chlorophyll, chloroplast

Explanation

The best response is Joan's: "I think the food is made in the leaves of the tree." Trees are plants and, therefore, they make their own food. Plants take in carbon dioxide through their leaves and water through their roots. The chloroplasts in the leaves use energy from sunlight to break apart and reassemble these inorganic molecules into an organic molecule in the form of a simple sugar (glucose), giving off oxygen as a by-product. This process is called photosynthesis and happens inside

the chloroplast of a plant cell. Photosynthesis happens primarily in the leaves of plants. You can think of a leaf as a solar collector full of photosynthetic cells. Solar energy strikes the leaf and is captured by the chlorophyll inside the leaf cells' chloroplasts. The carbon dioxide for photosynthesis enters the leaves from the air, while the roots take up the water that is needed and the xylem transports it to parts of the plant, including the leaves.

Using energy from sunlight absorbed by chlorophyll, these materials are transformed into food (sugar) that is made in the leaves. These sugars travel through vessels in the veins of leaves that transport the food throughout the plant. Oxygen, a by-product of the photosynthetic process, passes out of the leaf into the air. Some of the sugar is also used to make amino acids.

Although this is a simplified description of a complex process, the important point is that the leaf is the structure in plants that functions in transforming materials from the

environment into food (glucose), which is used as building blocks for the plant.

Curricular and Instructional Considerations

Elementary Students

In the elementary grades, students learn that plants need water, sunlight, nutrients, and air. They learn that plants have structures for getting water (roots) and sunlight (leaves). They learn that stems provide support for the plant and flowers are used in reproduction. They are introduced to the idea that plants make their own food, but the details of the process should wait until middle school.

Middle School Students

In middle school, students are introduced to the basic process of photosynthesis and the plant structures involved in the process. They learn about the parts of the leaf and the cells involved in the food-making process. They begin to develop an understanding of the distinction between the role of sunlight as a source of energy for the process, the transformation of light energy to chemical energy, and the inorganic materials transformed during the process. They learn about the vascular tissue (xylem and phloem) within the plant that transports water from the roots and food made in the leaves to all parts of the plant. Middle school is also the time when students develop a scientific conception of *food* that differs from the common, everyday use of the word *food*.

High School Students

In high school, students deepen their understanding of photosynthesis by moving from an emphasis on what happens in the leaf to understanding what happens within the cell, especially at the molecular level. They connect their growing understanding of chemistry to the biological process of photosynthesis. They

learn about the different types of carbohydrates formed by plants from simple sugar (glucose). They distinguish between the energy provided by sunlight and the energy released from the chemical bonds formed between atoms that make up the molecules of sugar.

Administering the Probe

This probe is best used at the upper elementary and middle level, before students learn about the structure and function of plants. It can also be used with high school students before they learn about photosynthesis to determine if their earlier misconceptions are still present.

Related Ideas in National Science Education Standards (NRC 1996)

K–4 The Characteristics of Organisms

- Organisms have basic needs. For example, animals need air, water, and food; plants require air, water, nutrients, and light.
- Each plant or animal has different structures that serve different functions in growth, survival, and reproduction.

5–8 Structure and Function in Living Systems

- ★ Specialized cells perform specialized functions in multicellular organisms. Groups of specialized cells cooperate to form a tissue.

5–8 Populations and Ecosystems

- Plants and some microorganisms are producers—they make their own food.
- For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred by producers into chemical energy by photosynthesis.

9–12 The Cell

- ★ Plant cells contain chloroplasts, the site of photosynthesis. Plants and many micro-

★ Indicates a strong match between the ideas elicited by the probe and a national standard's learning goal.

organisms use solar energy to combine molecules of carbon dioxide and water into complex, energy-rich organic compounds and release oxygen to the environment. This process of photosynthesis provides a vital connection between the Sun and the energy needs of living systems.

Related Ideas in Benchmarks for Science Literacy (AAAS 2009)

K–2 Flow of Matter and Energy in Ecosystems

- Plants and animals both need to take in water, and animals need to take in food. In addition, plants need light.

K–2 Cells

- Most living things need water, food, and air.

3–5 Cells

- Some organisms are made of a collection of similar cells that benefit from cooperating. Some organisms' cells vary greatly in appearance and perform very different roles in the organism.

3–5 Flow of Matter and Energy in Ecosystems

- Some source of "energy" is needed for all organisms to stay alive and grow.

6–8 Cells

- ★ Various organs and tissues function to serve the needs of all cells for food, air, and waste removal.

6–8 Flow of Matter and Energy in Ecosystems

- Food provides 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.

- Plants can use the food they make immediately or store it for later use.

9–12 Cells

- ★ Within the cells are specialized parts for the transport of materials, energy capture and release, protein building, waste disposal, passing information, and even movement.
- In addition to the basic cellular functions common to all cells, most cells in multicellular organisms perform some special functions that others do not.

Related Research

- Universally, the most persistent notion that students of all ages have about how plants get their food is that plants take their food from the environment, particularly the soil (Driver et al. 1994).
- In a study by Tamir (1989), some students thought sunlight, associated with energy, was the food for plants. Many students also considered minerals taken in from the soil as food.
- Food* is colloquially understood to be anything an organism takes in for nourishment; therefore, students believe that anything absorbed from the soil is food. This is an instance where everyday meaning and scientific meaning clash and create confusion. Garden fertilizers labeled "plant food" reinforce this erroneous idea that fertilizer is food for plants (Allen 2010).
- The common misconception that plants get their food from the environment rather than manufacturing it internally, and that food for plants is taken in from the outside, is particularly resistant to change, even after instruction (Anderson, Sheldon, and Dubay 1990).
- Understanding that the food plants make is very different from nutrients they take in may be a prerequisite for understanding the idea that plants make their food rather

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than acquire it from their environments (Roth, Smith, and Anderson 1983).

- Some students do not consider trees to be plants (Driver et al. 1994). Therefore, they may believe trees do not make their own food.

Suggestions for Instruction and Assessment

- Combine this probe with “Is It Food for Plants?” or “Is It a Plant?” in *Uncovering Student Ideas in Science, Vol. 2: 25 More Formative Assessment Probes* (Keeley, Eberle, and Tugel 2007). “Is It a Plant?” will help first determine whether students recognize trees as being plants.
- Take the time to elicit students’ definitions of the word *food*; many students use this word in a way that is not consistent with its biological meaning (AAAS 2009). For example, many students think of food as something that is taken in through the mouth. Have students identify the difference between the everyday use of the word *food* and the scientific use of the word. Contrasting the two uses and providing examples may help students recognize the difference and know when the word is being used in a biological context.
- Some students confuse the sweet apple with the sugars that plants make during photosynthesis. Be sure to teach what happens to the sugars that plants produce in their leaves so that students recognize how the sugars are the building blocks for parts of the plant and are transported to other parts of the plant where they are used or stored for later use.
- Students may confuse the phloem (a structure that transports the sugars throughout a plant) with the site where the sugars are made. Be sure to distinguish between the function of the leaf in manufacturing food and the network of tiny tubes that transport the food to other parts of the plant.

Related NSTA Science Store Publications, NSTA Journal Articles, NSTA SciGuides, NSTA SciPacks, and NSTA Science Objects

- American Association for the Advancement of Science (AAAS). 2001. *Atlas of science literacy*. Vol. 1. (See “Flow of Matter in Ecosystems” map, pp. 76–77 and “Flow of Energy in Ecosystems” map, pp. 78–79.) Washington, DC: AAAS.
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- Littlejohn, P. 2007. Building leaves and an understanding of photosynthesis. *Science Scope* 30 (8): 22–25.
- Mundry, S., P. Keeley, and C. Landel. 2009. *A leader’s guide to science curriculum topic study*. (See Module B6, Photosynthesis and Respiration Facilitation Guide, pp. 144–149). Thousand Oaks, CA: Corwin Press.
- Robertson, W. 2007. Science 101: How does photosynthesis work? *Science and Children* 44 (8): 60–63.
- Wheeler-Toppen, J. 2010. The case of the tree hit man. In *Once upon a life science book: 12 interdisciplinary activities to create confident readers*. Arlington, VA: NSTA Press.

Related Curriculum Topic Study Guides (in Keeley 2005)

“Food and Nutrition”
 “Photosynthesis and Respiration”
 “Plant Life”

References

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- Tamir, P. 1989. Some issues related to justifications to multiple choice answers. *Journal of Biological Education* 11 (1): 48–56.