Puzzled by Photosynthesis

OVERVIEW

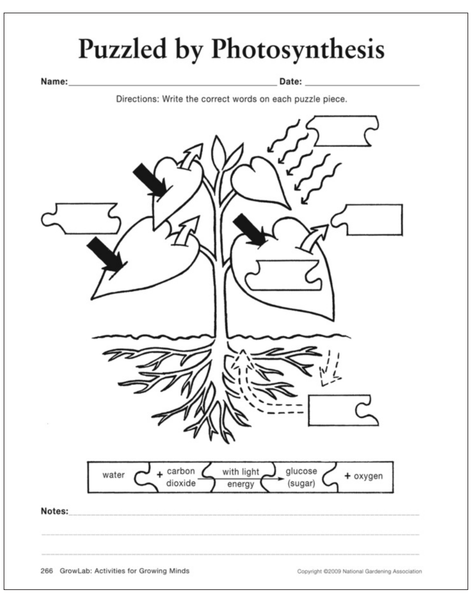
Students compare green and nongreen parts of leaves for starch production and explore the key roles light and chlorophyll play in photosynthesis.

Laying the Groundwork

Objective: To consider how green plants are able to use elements from their environment to make their own food.

1. Facilitate a class discussion about how plants are different from animals. Ask questions such as, *What do you think animals and plants need in order to live and grow? What have you observed about animals that you think helps them meet their food needs? What have you observed about plants that you think helps them meet their food needs? You can go to the cafeteria or the refrigerator to get food, but how do you think plants get the nourishment they need for growth and energy?* Ask students to describe what they know about how green plants use the environment to make their own food.

2. Hand out the Puzzled by Photosynthesis reproducible. Help students fill in the blank puzzle using their own ideas as well as background information from page 74. (Also see the sidebar, Food Making at a Glance, on page 82.)



TIME

Groundwork: 30 to 40 minutes
Exploration: Part 1 — 45 minutes
Part 2 — 40 minutes setup; 4 days later, 40 to 60 minutes
Making Connections: ongoing

MATERIALS

- iodine solution (see Advance Preparation)
- laundry or corn starch
- plastic straw
- assorted foods (see Exploration)
- four mature plants — two with a green and white pattern (e.g., variegated spider plant, silver-leaf geranium, or variegated Swedish ivy) and two solid green plants (e.g., geranium, tomato, or bean plant)
- rubbing (ethyl) alcohol
- hot plate
- double boiler
- tweezers
- scissors
- Puzzled by Photosynthesis reproducible, page 266

BACKGROUND

Page 74

ADVANCE PREPARATION

Make iodine solution for starch test by adding approximately 40 drops iodine to 1/2 cup (approximately 125 ml) water.

Caution: Iodine is toxic. Store away from heat and direct light. For long-term storage, place bottle in a plastic bag, close with twist tie, and place in empty paint can. Fill can with cat litter. Follow proper disposal procedures. Iodine will stain skin and clothing.

3. Tell students that a brownish-yellow iodine solution turns blue-black when it touches starch. Demonstrate by adding several drops of the iodine solution (prepared during Advance Preparation) to some laundry or corn starch mixed with water. Also add some drops of iodine to plain water as a control. Remember to use caution.

Food Making at a Glance

All living things need food to give them energy and help them grow. Lacking legs, wings, or fins to carry them in pursuit of food, plants make their own food from raw materials in their immediate environment. Leaves are the main food-making factories in green plants. They have a special ability to trap light energy and use it to change carbon dioxide (taken in through the leaves) and water (taken in through the roots) to food, in the form of a sugar called glucose. During this process, called photosynthesis, plants give off oxygen, which humans and other animals need to live.

If the plant needs food right away, it uses the glucose. Since plants don't usually need all of the glucose right away, they change it to sucrose (table sugar), starch, or other materials (such as the oils or proteins in seeds), and store it for later use. Starch and other sugars are found stored in plant leaves as well as in roots (carrots) and stems (potatoes).

4. Ask students if they think they could produce starch in the classroom using the ingredients a plant uses: light, carbon dioxide, and water. Under the GrowLab lights, use a straw to exhale some carbon dioxide into a jar of water. Add a few drops of iodine solution. Ask, *What does the color change (or lack of change) tell you about the ability of carbon dioxide, water, and light to produce starch? If we cannot produce starch from these three ingredients, how do you think leaves of green plants are able to do so?*

If students have not yet discussed the role of chlorophyll in photosynthesis, hold up a few solid green plants and ask, *What do the leaves on all of these green plants have in common?* Students should realize that all the plants are green! Explain that the green in leaves is caused by a pigment, chlorophyll, that colors the leaves, just as a pigment in people's bodies gives color to our eyes, skin, or hair. Chlorophyll has a key role in trapping the light energy that green plants use to make their own food. Add chlorophyll to the "Photosynthesis Puzzle."

Exploration — Part 1

Objective: To demonstrate that plants store starch.

1. Hand out several plant-originated foods, e.g., table sugar, cooked pasta, crackers, potato chips, and raw or cooked starchy fruits or vegetables like corn, beets, or sweet potatoes. Have pairs of students taste the items, describe the tastes to each other, and record their observations. Ask, *How are all of these things alike? Before they arrived at the grocery store, where did the items come from?*

2. Ask, *Has anyone tasted starch stored by plants?* Have pairs of students choose several of the items they tasted, test them for starch, as you did with the laundry or corn starch, and record their results. After students have compared results, ask, *How do you think the starch got into the plant-originated items?*

Exploration — Part 2

Objective: To discover that light is necessary for starch production in leaves. To infer that something in the green parts of plants is needed for starch production.

1. Hold up some plants with variegated leaves (see Materials) and ask, *Do you think the leaves on these plants can make food? Why or why not? How do you think we could confirm that the green parts of* *plants are needed to produce starch? How do you think we could confirm that light is needed to produce starch?*

2. Have students follow the Problem Solving for Growing Minds process, page 10, to conduct an investigation based on their own ideas, or use the following as a model:

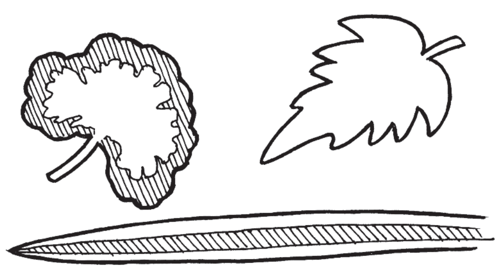
Group A
One variegated plant and one solid green plant in GrowLab

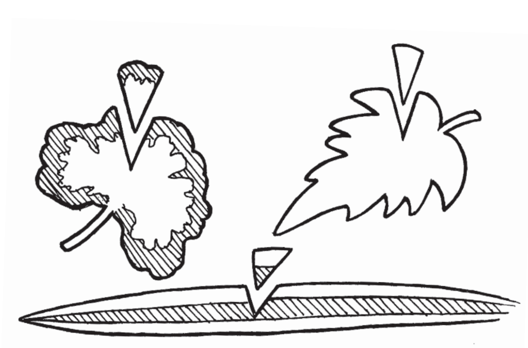
Group B
One variegated plant and one solid green plant in closet

Make sure that the same type of plant in each group (e.g., both variegated plants) are of similar size, health, and age. Care for all plants equally. Have students predict what they think will happen when the leaves of the plants are tested for starch.

3. After four days, remove plants from the closet and GrowLab and have small groups of students remove one leaf from each of the plants. They should cut a notch in the leaves that were in the closet, to distinguish them from those that were in the light and to identify them after they've tested for starch. Have students sketch the leaves, outlining and shading the coloration. For example:

Leaves from Group A (GrowLab) plants

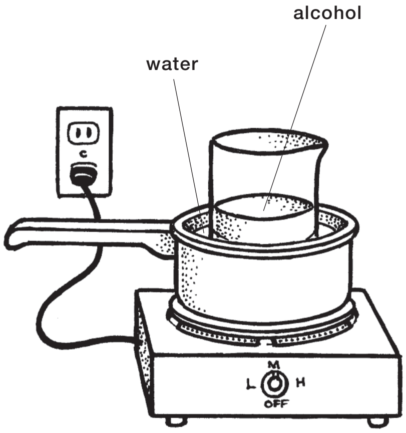




Leaves from Group B (closet) plants

Why Not Test for Sugar?

The primary end product in photosynthesis is glucose, which is highly soluble in water. As soon as it's formed, however, most plants convert the glucose to insoluble storage products such as starch.



Caution: Alcohol boils at a lower temperature than water does and ignites easily. Never heat alcohol directly. Do not breathe fumes from the alcohol.

4. Help students test for starch production in the leaves, carefully following these directions:

Test for Starch in Leaves

Boil one leaf from a Group A plant in water for 10 minutes to break down cell walls. In a well-ventilated area, pour approximately 200 ml of alcohol into a small pot, beaker, or metal cup. Make a double boiler with a larger pot. Place the boiled leaf in the container of alcohol in the double boiler and boil for 15 minutes to extract chlorophyll.

When the leaf is pale and flimsy, remove it with tweezers, rinse it in hot water and pat it dry. Place the leaf in a shallow container and put several drops of tincture of iodine on the leaf. Repeat the experiment for a leaf from a Group B plant, using new alcohol.

5. After treatment, compare the two leaves with the students' leaf sketches. Ask, *What color changes(s) took place in the treated leaves? How did the leaves from the Group A plants (growing in the light) react differently from the leaves of the Group B plants (growing in the dark). What does the color change tell you about what is present or absent in the leaves?*

What to expect: After four days, the plants in Group B will have used up any starch they had stored. Since they were not in the light, they were unable to photosynthesize and produce new starch. The plants in Group A, having received light energy, will have turned blue-black from the iodine because starch was being produced in these leaves. Any parts of the leaves that are not green (do not contain chlorophyll) cannot produce starch and, therefore, will not have turned blue-black from the iodine.

Question Your Answer

Students should realize that this experiment did not prove that the starch in the leaves was produced as a result of photosynthesis. Couldn't the starch have been made in another part of the plant and transported to the leaf for storage? Also, students tested only leaves for starch, not roots or any other part of the plant, and thus they cannot conclude that the leaf alone is the food factory. Caution students to be aware of the limitations of their conclusions.

Based on prior knowledge and observations, however, students should feel confident to infer that photosynthesis occurred in the green parts of the leaves. Encourage students to think about other ways to substantiate their claims, for example, by asking, *What would happen to starch production if we removed all of the leaves?*

Making Connections

Possible discussion questions:

• *What factors do you infer caused the differences in the plants you tested for starch? How can you explain why starch is found only in some of the leaves or portions of the leaves? What else could have caused the differences?*

• *Besides water and carbon dioxide, what can you infer about what else a plant needs to photosynthesize?*

• *Why do you think carbon dioxide, water, and light alone could not produce starch?*

• *What evidence do you have at this point to support the claim that the leaf is the food factory of a green plant? Discuss why you can or* *cannot draw that conclusion from this activity.* (See the Question Your Answer sidebar, page 84.)

• *If we had watered one group of plants and not the other, could you be as sure of your explanation? Why or why not?*

• *Does anything still puzzle you about photosynthesis? How might you go about finding the solution to your puzzle?* (Remind students that there is a lot about the process of photosynthesis that still puzzles scientists!)

• Use the Futures Wheel, page 292, to address the following question: *What do you think the world would be like if there were no green plants?* Have students consider questions such as, *What do plants require that humans give off? What do humans require that plants give off? Where do plants fit in food chains?*

Branching Out

• Try testing young sprouts for the presence of starch. Try testing mushrooms and other fungi for starch. Find out where fungi get their food if they can't photosynthesize. (Fungi do not contain chlorophyll and, therefore, are not considered food producers; they are food absorbers.)

• Clip a film negative to a leaf (see illustration below), leave the plant in the GrowLab for about four days, and see what "develops"!

• A serious environmental problem is the global warming resulting from excess carbon dioxide produced by the burning of fossil fuels. This carbon dioxide traps heat, much as heat is trapped in a glass greenhouse (for more information, see Global ReLeaf background, page 255). Considering how green plants photosynthesize, discuss how plants might be used to lessen the negative effects of global warming.

Photophictionary

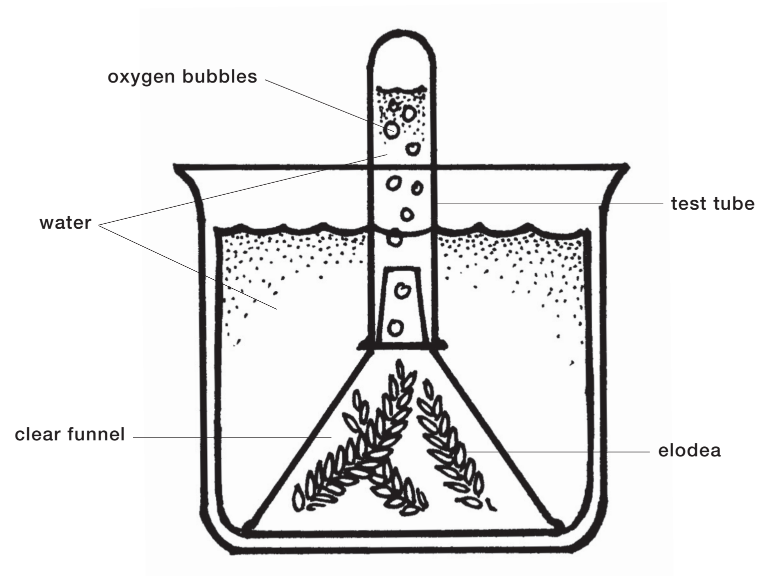
Use a list of words relating to the process of photosynthesis to play a few rounds of Photophictionary. For each round, ask students to write a creative definition of one of the words. The goal is to make each pseudo-definition sound like the real thing in order to convince classmates that it is, indeed, the actual dictionary definition. For example:

Glucose – (n.) A type of paste that comes only from trees in Costa Rica.

Read each of the fake definitions to the class along with the actual definitions supplied (see background information, page 74). Have the class vote for the definition they think is the real one. Read and discuss the actual meaning of each of these terms as they relate to the process of photosynthesis.

• Using a microscope, look for green chloroplasts. Elodea is a plant with large and very visible chloroplasts. You can easily obtain it from a local aquarium or pet store.

• Use water plants such as elodea to see evidence of photosynthesis by observing and measuring oxygen bubble production.



• Read *Top Secret* by John Reynolds Gardiner, a novel about a boy who becomes the first human photosynthesizer (see Appendix E). Discuss the implications of the possibility of "human photosynthesis" — e.g., economic impact and environmental effects.

• Write and perform creative skits to teach younger students about the process of photosynthesis.