



### Photosynthesis Lesson 1: *The Solve*

#### Educator's Resource Guide: Live Video Phenomenon

*The Solve* contains two mini lessons: The live video lesson and the [animation lesson](#). For the most comprehensive learning experience, conduct both. If you're short on time, choose one. Which lesson?

- For a more structured lesson, choose [the animation](#).
- For a more inquiry-based lesson, choose the live video lesson (the lesson below) and assign the animation for homework.

#### Objective

In *The Solve*, students will:

1. Observe a video clip of a phenomenon to gather information about an alleged crime involving photosynthesis.
2. Develop an understanding of how trees make their energy and what would happen if this process was stopped.

#### Phenomenon Description

Students will review information and video footage to determine how a famous chef was trying to kill his neighbor's tree using a herbicide.

**Time Required:** 45–70 minutes

#### Materials Required

##### Materials for Remote Use

- Computer for student use (all video recordings for the lesson will be provided for students)
- [Video Clip of news story](#)
- [Video of celery experiment for remote use](#)

##### Materials for In-Person Use:

- [Video Clip of news story](#)
- Student Guide
- Computer with speakers (for projecting video) or headphones (for student viewing on laptops)
- One blank diagram of photosynthesis in a tree diagram.

Demonstration: Color-Changing Celery *Note: Set up one day before.*

- Fresh-cut celery stalks with leaves
- Food coloring
- Water, paper towels
- Scissors



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<ul style="list-style-type: none"><li>● 2 magnifying lenses</li><li>● 2 500-mL beakers or jars</li></ul>	
Safety Considerations	Science & Engineering Practices
Use care when cutting the celery with scissors	<ul style="list-style-type: none"><li>● Developing and Using Models</li><li>● Constructing Explanations or Arguments From Evidence</li></ul>

Remote Use: Show the video of the celery experiment instead of carrying out the in-person demonstration.

### Level 1: Most teacher-driven

Review the background information with the class. View the video clip and encourage students to write their initial observations. After the first viewing, prompt students with questions to lead them to more observations, and get them to ask questions about what they are seeing. View the video one more time, encouraging students to focus on the details of the alleged actions of the accused chef. Discuss answers as a class. Introduce students to their role as a forensic botanist and the focus of their investigation. Review the meaning of herbicide as a class and complete the remaining parts of the lesson, filling out the diagram of photosynthesis, completing the celery demonstration and completing the “constructing an explanation” section. Complete the exit ticket questions, at first individually and then review as a class.

### Level 2

Review the background information with the class or have students review in small groups. View the video clip and encourage students to write their initial observations. Working in small groups, students view the video one more time. Encourage students to focus on the details of the alleged actions of the accused chef. Discuss answers as a class. Instruct student groups to review the meaning of herbicide. Introduce students to their role as a forensic botanist and the focus of their investigation. Instruct student groups to complete the diagram of photosynthesis. Carry out the celery demonstration. Guide student groups to answer the questions, complete the constructing an explanation section and exit ticket questions.

### Level 3: Most student-driven

Review the background information with the class or have students review individually or in small groups. View the video clip and encourage students to write their initial observations. Working individually or in small groups, students view the video one more time. Encourage students to focus on the details of the alleged actions of the accused chef. Discuss answers as a class. Instruct student groups to review the meaning of herbicide. Introduce students to their role as a forensic botanist and the focus of their investigation. Instruct students to complete the diagram of photosynthesis individually or in groups. Carry out the celery demonstration. Guide students to answer the questions, complete the constructing an explanation section and exit ticket questions in their student groups or individually.



### The Activity

In this section you will review the background information about the alleged actions of the accused chef Adam Harvey. Next, you will share a video clip of an *Inside Edition* news report, encouraging students to focus on the details and to write what they think is happening.

### Video Clip of Phenomenon

In the summer of 2017, Adam Harvey, a chef known for his appearance on the television show *Top Chef*, purchased a home in Brooklyn, New York. He decided to install solar panels on the roof of his house so that these panels would turn energy from the sun into usable energy in his home. But after the installation, he realized that his neighbor's seven-story maple tree was blocking the sun from reaching his solar panels.

He asked the neighbor to cut the tree down, but she declined. The tree had been in her yard for over 60 years and had become a staple in the neighborhood!

Several months later, a neighbor looked out the window to find the chef drilling holes in the tree's trunk and filling the holes with a mysterious liquid.

How was the chef trying to kill the tree? *Inside Edition* reports: [neighbor's footage](#).

### Review Questions

1. What does the chef in the video appear to be doing? Record your observations.

*Possible Responses: The chef appears to be trying to kill the tree. He first cuts down branches and then drills holes into it. He also pours a liquid into it.*

2. What questions do you have about this video?

*Possible Responses: Why would the chef do this? What did he use to poison the tree? How does the poison kill the tree?*

Explain to students that their job in this next section is to play the role of a forensic botanist. A forensic botanist studies plant material as it relates to crime scenes. They examine the plant remains and/or conditions of a plant and its parts to determine if a crime has been committed.

Your role is to investigate to develop an understanding of how trees make their energy and how food and liquid travel throughout the tree to determine if the defendant is guilty of trying to kill the beloved maple tree.

Students will follow in their Student Guide:

Now, it's time for the court date. You've been called to the courtroom as a forensic botanist to answer this question: *Do you think the defendant is guilty of trying to kill the beloved maple tree?*



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In order to solve the mystery, you will construct two parts to the argument. You will investigate:

1. How trees make their energy and what would happen if that process was stopped.
2. How food and liquid travel throughout the tree.

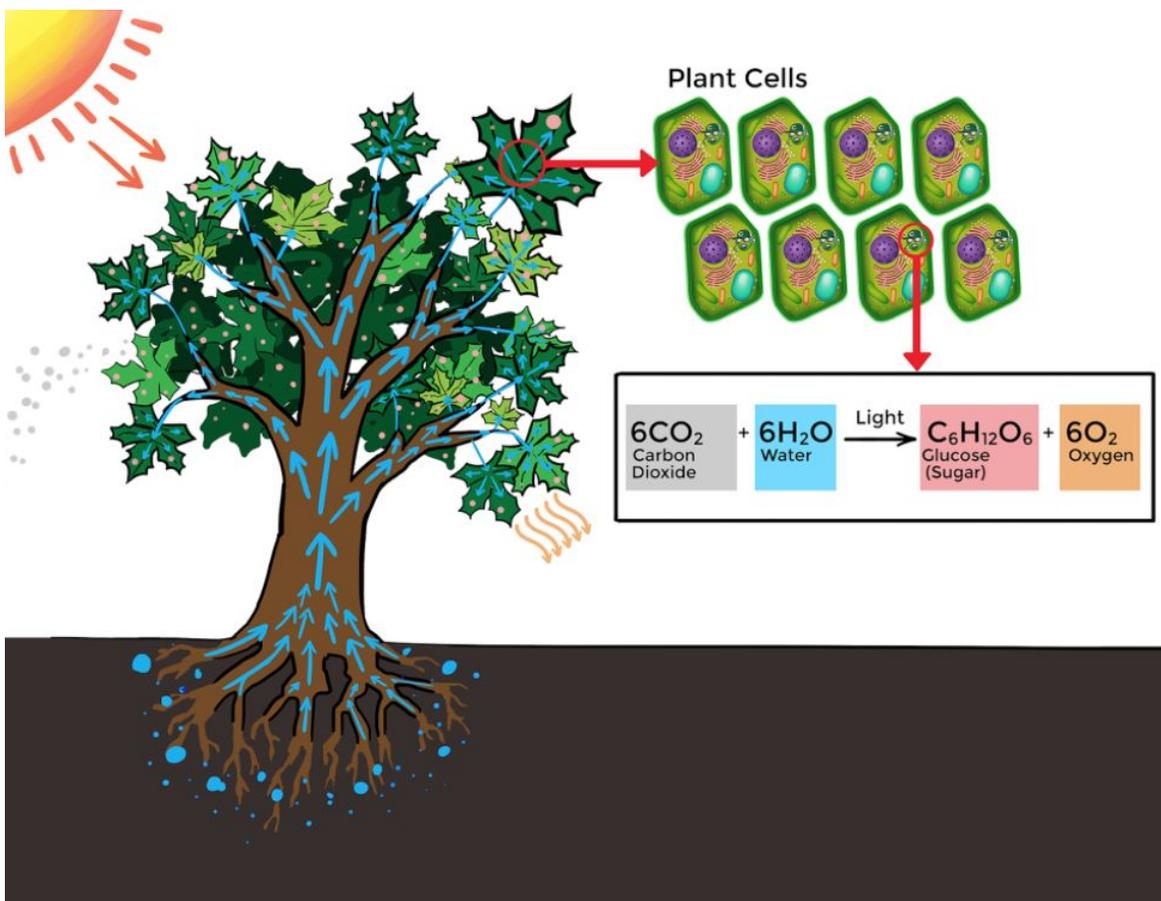
### Part 1: How trees make their energy

In your research, you find the following information.

#### *About Photosynthesis*

Review this section with students as a class using the illustration below. Point out the key reactants (inputs) and products (outputs) required for trees to carry out the process of photosynthesis to make energy that plants and animals use. Be sure to ask students to identify the main source of energy guiding this process and from where trees get their water and oxygen.

Photosynthesis is a process used by plants and other organisms. In photosynthesis, plants convert light energy into simple sugars that they can use as food. It is a chemical reaction that takes place in the chloroplast of the leaf.



Let's explore what happens in the chloroplast.



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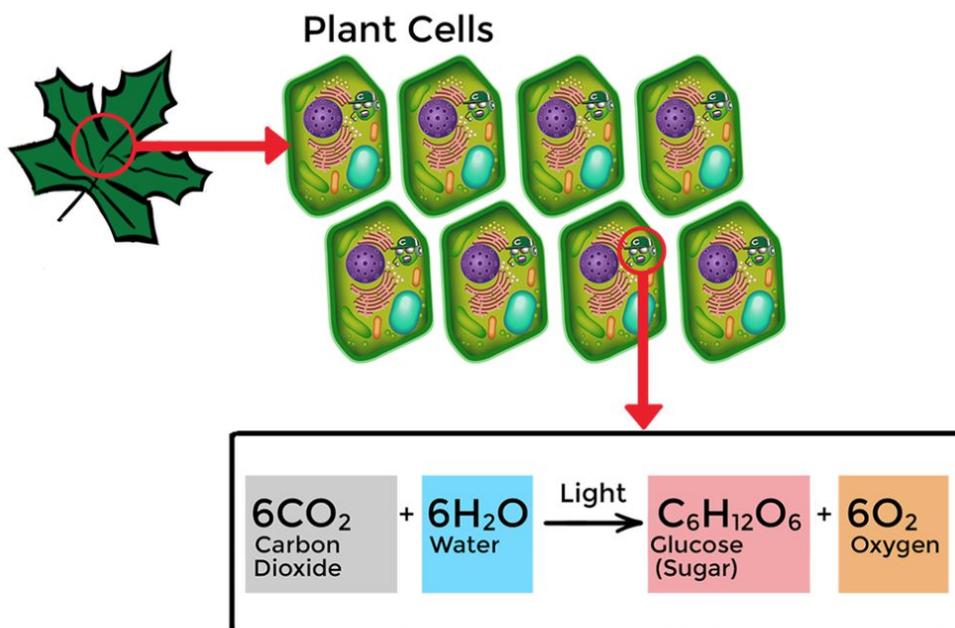
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When **carbon dioxide** and **water** react in the presence of light, **glucose (sugar)** and **oxygen** are produced. This process is called photosynthesis.

The products (outputs) of photosynthesis:

- The **oxygen** is released.
- The **glucose (sugar)** is stored in the plant's cells. **The plant needs this glucose (sugar) for energy to survive.**

Instruct students to look more closely at the structures inside of leaves called chloroplasts. Explain to them that in the chloroplast a very important chemical reaction takes place known as photosynthesis. Guide students to identify the substances that go into the reaction (reactants): carbon dioxide ( $6\text{CO}_2$ ) + water ( $6\text{H}_2\text{O}$ ). Ask students to identify from where the chloroplasts get the energy to complete this reaction. They should point out that light energy from the sun is the source that drives this reaction. Then have students identify the substances produced in this reaction: glucose ( $\text{C}_6\text{H}_{12}\text{O}_6$ ) and oxygen ( $6\text{O}_2$ ). The glucose and oxygen produced (products) are used by both plants and animals for energy to carry out their daily life processes. Without this glucose and oxygen plants and animals would die because they would not have a source of energy.



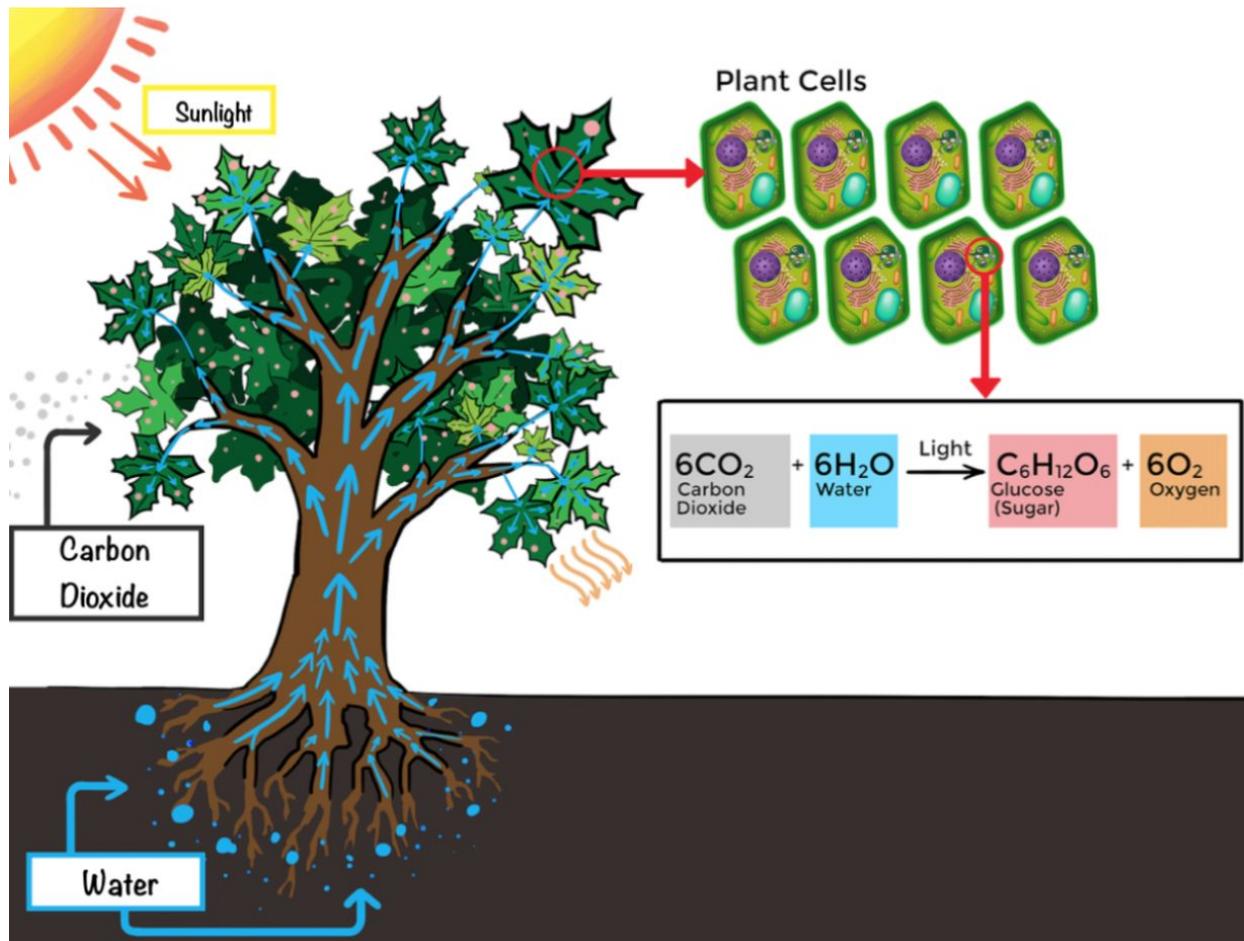
Here you will explain to students that they will be labeling a diagram to show where the reactants (inputs) come from.



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Based on your reading, you decide you'd like to create a diagram of where the reactants (inputs) of photosynthesis come from. In the diagram below, label where the water, carbon dioxide, and sunlight come in.



Review this section with students, focusing on how herbicides may affect trees. Guide students to understand that their next step will be to figure out *how* the herbicide impacts the tree. Once they determine that the herbicide prevents carbon dioxide from being used by the tree, ask students to think about the process of photosynthesis and how the herbicide would harm it.

After finalizing your diagram, you feel confident you understand how a tree makes energy when working correctly. You discover that the mysterious liquid was a herbicide (also known as a weed killer), a liquid that harms trees. Now it's time to figure out how the herbicide could work. You secure a sample of the



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liquid in the chef's possession. You discover that the herbicide prevents **carbon dioxide** from being used by the tree.

How would this herbicide kill the tree? Use your knowledge of photosynthesis to explain your answer.

*Answer: If the carbon dioxide cannot be used by the tree's cells, then photosynthesis cannot occur. Specifically, carbon dioxide cannot combine with water in the presence of sunlight to produce oxygen and glucose.*

*Note: Identify to students that this means the tree cannot produce glucose for its energy. If the tree does not have energy it will die.*

### Part 2. How could this herbicide travel throughout the tree?

In this section, explain to students that they need to determine how the herbicide that Adam Harvey allegedly used could harm or kill the tree. Have students focus on thinking about how a herbicide that is just poured into a few holes could actually kill an entire tree. You will carry out a demonstration that reveals how water moves in plants and how it would move in a tree, thus harming or killing the tree.

#### In-Class Demonstration Setup Instructions:

Prepare the day before the lesson

- **Colored celery stalks.** *To prepare:* Place fresh-cut stalks of celery (5–6 with leaves still intact) in a beaker of strongly dyed water. Approximately 10–15 drops of food coloring in 500 mL of water will do the trick. Let stand overnight. *Tip: If time allows, set up the celery on the previous day's class and have students predict what will happen and why. Note that performing the preparation in a sunny location will decrease the time needed for full absorption of the dye to the leaves.*
- **Control celery:** *To prepare:* Place fresh cut stalks of celery (5–6 with leaves still intact) in 500 mL of water. Let stand overnight.



Remote use: Use the [video of celery experiment](#) instead.

#### The Science

**Celery:** The celery plant transports food and water through tubes that run the length of the stalk. Students will be able to see these transport structures because the dye makes these structures visible. *(Note: The tube-like structures are called "xylem" and "phloem." Students do not need to know these terms.)* Water moves up the celery stalk like water moves into a sponge through a process called capillary action.

In addition to proving the herbicide prevented photosynthesis from occurring, you need to prove whether pouring herbicide into just a couple of holes in the tree could actually kill the entire tree, and not just damage the area around the holes. Your teacher will carry out a demo to help you answer this



question. *Remote Use: Students will view a video of this demonstration.*

### Color-Changing Celery



1. What evidence is there that water moves from the beaker to the leaves of the celery?  
*Answer: The blue dye in the water is now visible in the leaves of the celery. This means that the water must travel up the celery stalks and into the leaves.*
2. How would water travel through the maple tree?  
*Answer: The water would move up the trunk of the tree.*
3. How would a herbicide inserted into the trunk travel to the leaves?  
*Answer: The herbicide, which is a chemical that is a liquid, would move up the trunk of the tree, as it did in the stalk of the celery, and then travel into the leaves.*

### Part 3: Constructing an Explanation

Explain to students that in this section they will answer the question as to whether or not they think the defendant is guilty of trying to kill the maple tree. They will present their findings in an exhibit to share with the jury in court. They can choose to fill in the template provided and complete a written explanation or create their own poster by following the instructions provided. Review all of the information that students should include in their exhibit/poster. Share an example exhibit with them to be sure that they have a thorough understanding of the layout and what should be included.

*Is the defendant guilty of trying to kill the beloved maple tree?*

On your final day in court, you need to present all of your findings. You will be putting together an exhibit for the jury to help them understand the science behind your findings. They will use this information to determine if the defendant is guilty of the charges. You can either (A) fill in the template and complete a written explanation or (B) create your own poster by following the instructions below.



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Be sure to include the following information in your poster:

- a. Do you think the defendant is guilty of trying to kill the tree? *Include a full sentence answer at the top of your poster.*
- b. How did the herbicide kill the maple tree?
  - i. *Use a diagram to explain how trees normally make their energy. You may use the diagram below or you can draw your own.*
  - ii. *Include an annotation on your diagram to indicate how and where photosynthesis is interrupted.*
- c. How did the herbicide kill the whole tree despite being poured into only a small area of the tree? *This can be written or drawn.*

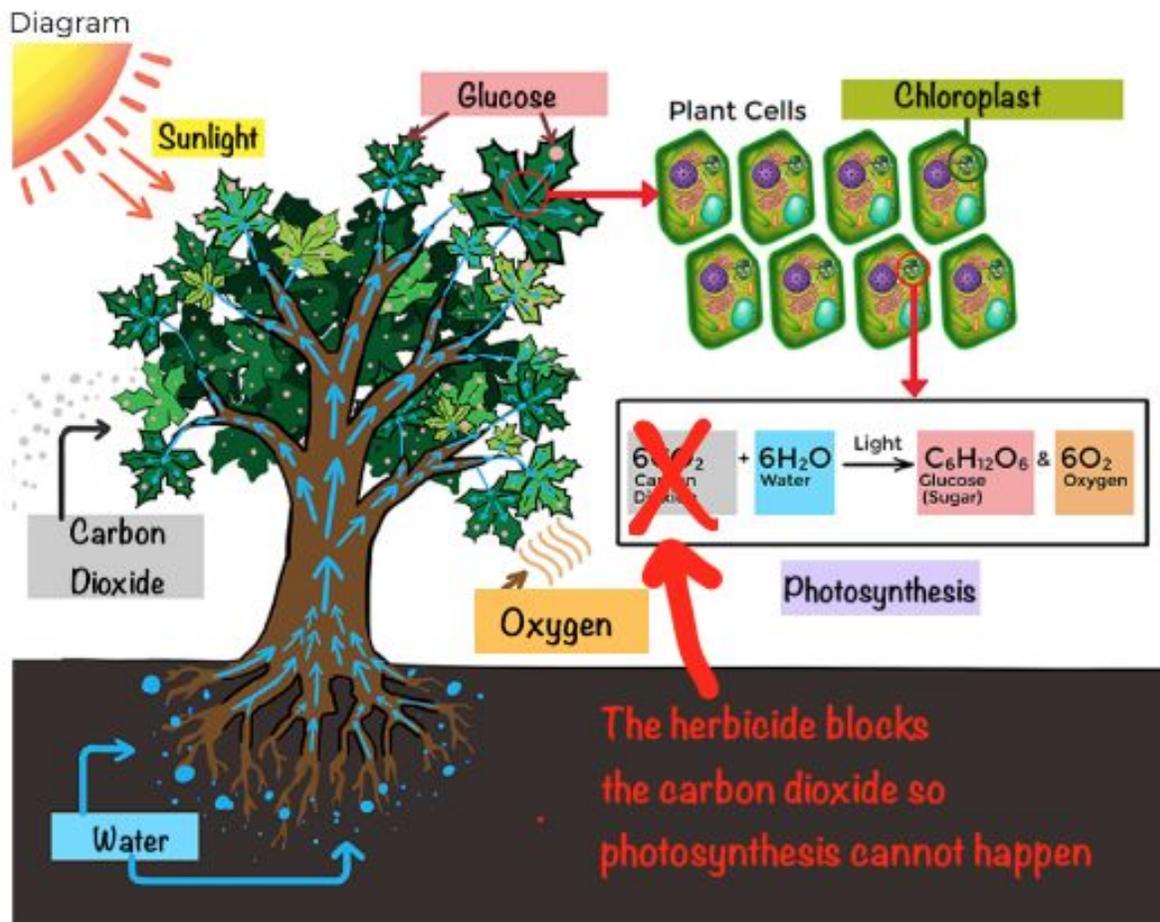
In your written explanation, try to use as many of the following terms as possible:

- **Water:** basis of fluids of living organisms, used in photosynthesis
- **Chloroplast:** the cell part in plants responsible for photosynthesis
- **Oxygen:** a molecule that is released as a byproduct of photosynthesis
- **Sunlight:** light from the sun, used as energy in photosynthesis
- **Glucose:** a simple sugar that can be converted into usable energy, made through photosynthesis
- **Carbon dioxide:** a molecule used to make glucose during photosynthesis
- **Photosynthesis:** a process used by plants and other organisms to convert light energy into chemical energy that can later be released to fuel the organism's activities

*Key for Template*



The defendant is **GUILTY** of trying to kill the tree!



In photosynthesis, plants use carbon dioxide and water, along with energy from the sun, to produce glucose and oxygen. Photosynthesis happens in the chloroplast of the plant cells. The herbicide that was poured into the tree, traveled throughout the tree into the chloroplasts of the leaves. Once in the chloroplast, the herbicide blocked carbon dioxide from being used. If there's no carbon dioxide available, photosynthesis cannot occur. Because the tree could not make glucose, the tree would not have sugar for food.

Part 4. Quiz: Check for Understanding



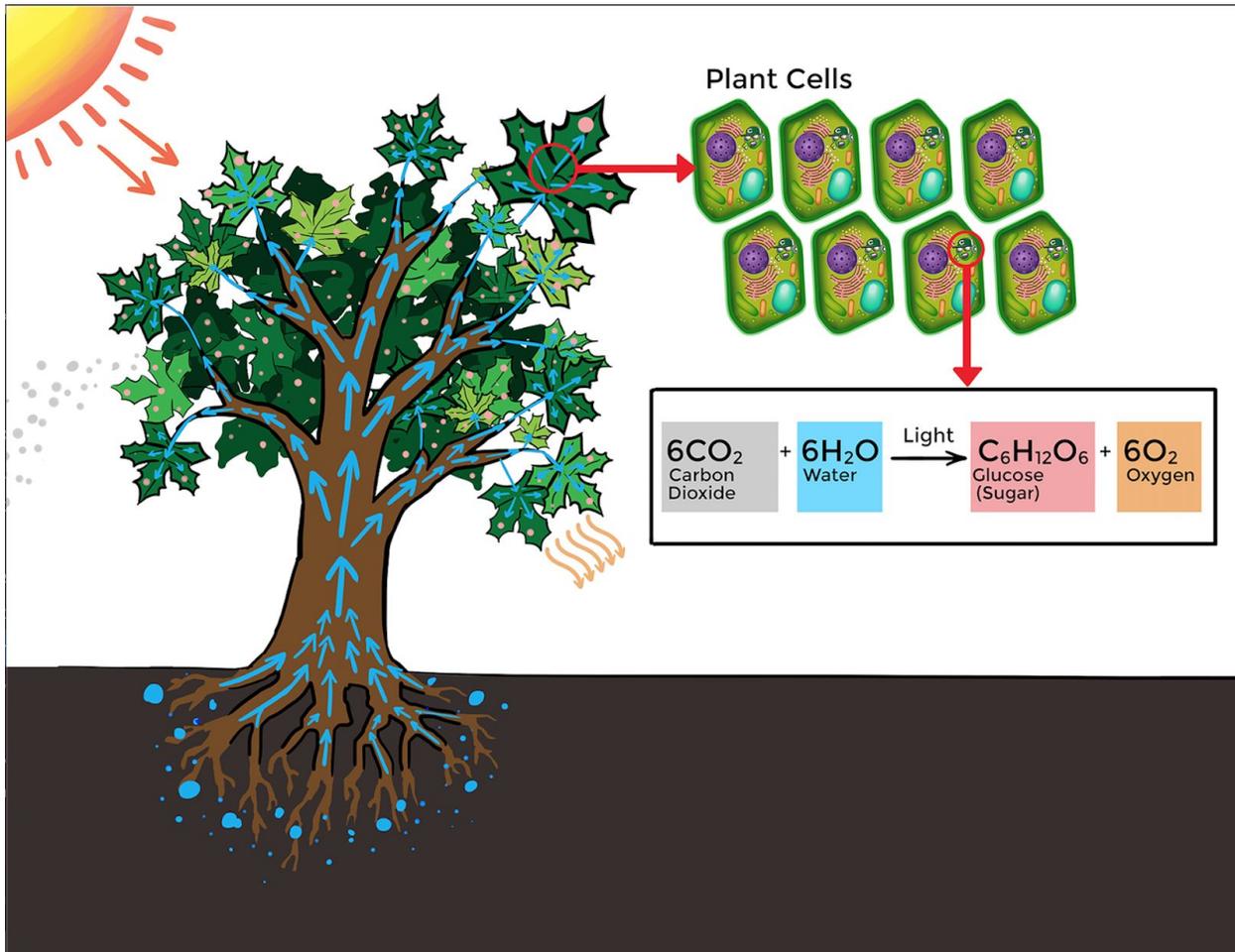
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Complete the exit ticket below or you can take the quiz online!

Name: \_\_\_\_\_

Date: \_\_\_\_\_



Use the image to answer the following questions:

1. What process is demonstrated in the image?
  - a. Carbon Dioxide
  - b. Photosynthesis**
  - c. Mitochondria
  - d. Glucose
  
2. What products (inputs) are needed for the tree to carry out the process of photosynthesis?
  - a. Glucose + Oxygen



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- b. Oxygen+ Water
  - c. **Carbon Dioxide + Water**
  - d. Carbon Dioxide + Glucose
3. What outputs are created through the process of photosynthesis?
- a. **Glucose + Oxygen**
  - b. Glucose + Water
  - c. Carbon Dioxide + Oxygen
  - d. Water + Carbon Dioxide
4. Where does photosynthesis occur in plants?
- a. Roots
  - b. Soil
  - c. Bark
  - d. **Chloroplast**
5. When the herbicide was put into the tree, the result was that the tree could not use carbon dioxide. How does this impact photosynthesis?
- a. Photosynthesis cannot occur because light cannot hit the tree.
  - b. Photosynthesis cannot occur because carbon dioxide cannot react with oxygen to produce energy.
  - c. **Photosynthesis cannot occur because carbon dioxide cannot react with water to produce energy.**
  - d. Photosynthesis is not impacted.