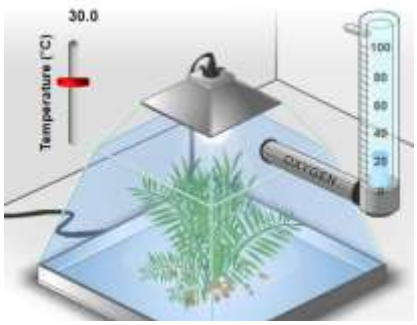
Answer the PRIOR KNOWLEDGE QUESTIONS BEFORE using the Gizmo. (What do you THINK the answers are?)

GIZMO WARM-UP



During **photosynthesis**, plants use the energy of light to produce **glucose** ($C_6H_{12}O_6$) from **carbon dioxide** (CO_2), and water (H_2O). Glucose is a simple sugar that plants use for energy and as a building block for larger molecules.

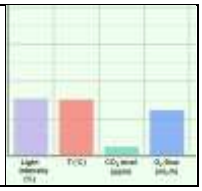
A by-product of photosynthesis is oxygen. Plants use some of the oxygen they produce, but most of it is released. In the *Photosynthesis Lab* Gizmo™, you can monitor the rate of photosynthesis by measuring oxygen production.

1. Observe the left pane closely.

2. Select the BAR CHART tab. On the graph, notice the **Oxygen production** bar. Move the **Light intensity** slider back and forth.

3. Experiment with the vertical **Temperature** slider (upper left) and the **CO_2 level** slider.

STOP HERE AND HAVE YOUR ANSWERS CHECKED BEFORE MOVING ON

Activity A: **Ideal conditions**	**Get the Gizmo ready**: • Be sure that the BAR CHART tab is selected. • Turn on **Show numerical values**.	

Question: In the Gizmo, what are the ideal conditions for photosynthesis?

1. Form hypothesis: During photosynthesis, light energy is used to synthesize carbon dioxide (CO_2) and water (H_2O) into glucose ($C_6H_{12}O_6$) and oxygen (O_2). The complex series of chemical reactions is summarized by the following formula:

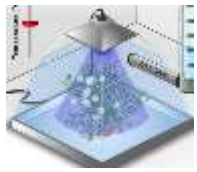
$$6CO_2 + 6H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6O_2$$

2. Experiment: Use the Gizmo to find the ideal conditions for photosynthesis. Use any method you like. When you think you have the answer, list the conditions below.

3. Revise and repeat: One way to test if you've found the ideal conditions is to change each variable slightly from the value that you recorded above. If the oxygen production decreases with each change that you make, it is likely you have found the ideal conditions. If a small change causes oxygen production to increase, continue to experiment.

   If necessary, revise your numbers in the table.

4. Think and discuss: Think about the process of finding the ideal conditions.

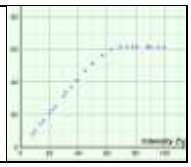
Activity B: **Colored light**	**Get the Gizmo ready:** • Select the COLOR tab and the BAR CHART tab. • Set the **Temperature** to 24°C, the **Light intensity** to 90%, and the **CO_2 level** to 1,000 ppm.	

Introduction: Plants use a green pigment called **chlorophyll** to absorb light and convert its energy into a form that the plant can use. Chlorophyll gives plants their green color.

Question: What color of light is the best for photosynthesis?

1. Observe: The color of a light wave is determined by its **wavelength**. On the COLOR tab, slowly drag the **Light wavelength** slider back and forth and observe the effect on oxygen production.
2. Form hypothesis: Which color of light do you think will maximize the rate of photosynthesis?
3. Gather data: Set the **Light wavelength** to 400 nm. (The symbol "nm" stands for **nanometers**. A nanometer is a billionth of a meter.) Visible light ranges from 400 to 700 nm.

   On the TABLE tab, click **Record data**. Then set the **Light wavelength** to 420 nm, and repeat. Continue recording data in the Gizmo every 20 nm until the wavelength is 700 nm.
4. Make a graph: Select the GRAPH tab and select **Wavelength**. Sketch the graph in the space at right.
5. Think and discuss: When we look at a leaf, we see the colors of light that are reflected off its surface. How does this explain the relatively low flow of oxygen in green light?

Extension: **Limiting factors**	**Get the Gizmo ready:** • Select the WHITE tab and the BAR CHART tab. • Turn on **Show numerical values**.	

Introduction: Photosynthesis requires light, water, and CO_2 to work. When one of these factors is in short supply, it is called a **limiting factor**. Temperature can also be a limiting factor when it is too hot or too cold for photosynthesis to work well.

Question: What is the effect of limiting factors on photosynthesis?

1. Observe: Set **Temperature** to 24°C, **Light intensity** to 50%, and **CO_2 level** to 200 ppm.
   A. Move the **Temperature** slider up and down. Were you able to increase oxygen production? (Return the slider to 24°C when finished.)
   B. Move the **Light intensity** slider back and forth. Were you able to increase oxygen production? (Return the slider to 50% when finished.)
   C. Move the **CO_2 level** slider back and forth. Were you able to increase oxygen production? (Return the slider to 200 ppm when finished.)
2. Analyze: In this situation, what was the limiting factor? How do you know?

3. Challenge: In each of the situations below, use the Gizmo to find the limiting factor.

4. Think and discuss: Suppose you were a farmer trying to grow plants in a greenhouse. Why would it be important to know what the limiting factor is?