

Plant Growth Puzzle – Photosynthesis, Biosynthesis, and Cellular Respiration¹

A plant is made up of water and organic molecules (e.g., sugars, cellulose and proteins).

Biomass is the weight of the organic molecules in a plant. So:

Biomass = (a plant's weight) – (the weight of the water in the plant).

A scientist wanted to evaluate the effects of light and water on changes in biomass. She put 1.5 grams of seeds in petri dishes which were kept in the conditions shown in this figure.



After ten days, the dry seeds had not sprouted, but the seeds that were exposed to water had sprouted to produce small plants. The seeds or plants from each petri dish were dried in an oven overnight to remove all the water. Then, the dried seeds and/or plants were weighed to determine their biomass.

- 1a.** Do you think that, after 10 days, the biomass of the seeds in the light, no water condition
- decreased?
 - stayed about the same?
 - increased?

1b. Explain your reasoning.

2a. Think about the effects of photosynthesis and cellular respiration on the biomass of the plants in the two water conditions. Fill in the blanks to indicate what you think are the most likely answers.

After 10 days, the biomass of the plants in light, with water, was _____ the biomass of the seeds that the plants came from.
(less than / about the same as / more than)

After 10 days, the biomass of the plants in no light, with water, was _____ the biomass of the seeds that the plants came from.
(less than / about the same as / more than)

2b. Explain your reasoning.

¹By Dr. Ingrid Waldron, Department of Biology, University of Pennsylvania, © 2024. This Student Handout and Teacher Notes with background information and instructional suggestions are available at <https://serendipstudio.org/exchange/bioactivities/photocellrespir>.

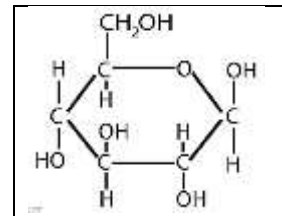
3a. At the beginning of the experiment each batch of seeds had about 1.46 g of biomass. This table shows the biomass of the seeds or plants after 10 days. For each condition, circle the appropriate arrow to describe the change in biomass after ten days.

Condition for each batch of seeds	<u>Light, no water</u> (seeds didn't sprout)	<u>Light, water</u> (seeds sprouted)	<u>No light, water</u> (seeds sprouted)
Biomass after 10 days	1.46 g	1.63 g	1.20 g
Change in biomass	↓ → ↑	↓ → ↑	↓ → ↑

3b. For each condition, compare the actual change in biomass with your prediction on the previous page. Mark any differences with an asterisk (*) in the above table.

We will first analyze the causes of the change in biomass in the plants exposed to both light and water.

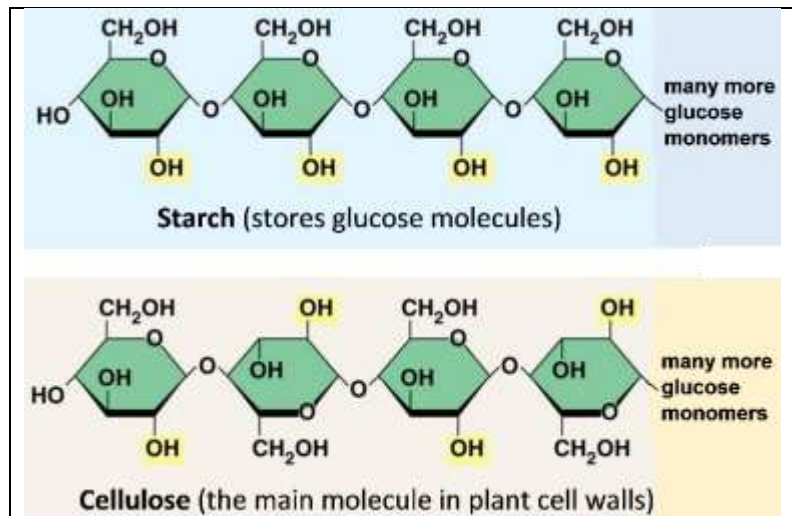
4. Photosynthesis uses the energy in light to convert CO₂ and H₂O (which are *not* organic molecules) to sugars (which are organic molecules and thus part of a plant's biomass). This figure shows the sugar, glucose. Most plants get CO₂ from the _____ and H₂O from the _____.



Biosynthesis uses the sugars produced by photosynthesis to make other organic molecules. For example, plant cells join many glucose monomers together to make a starch or cellulose polymer.

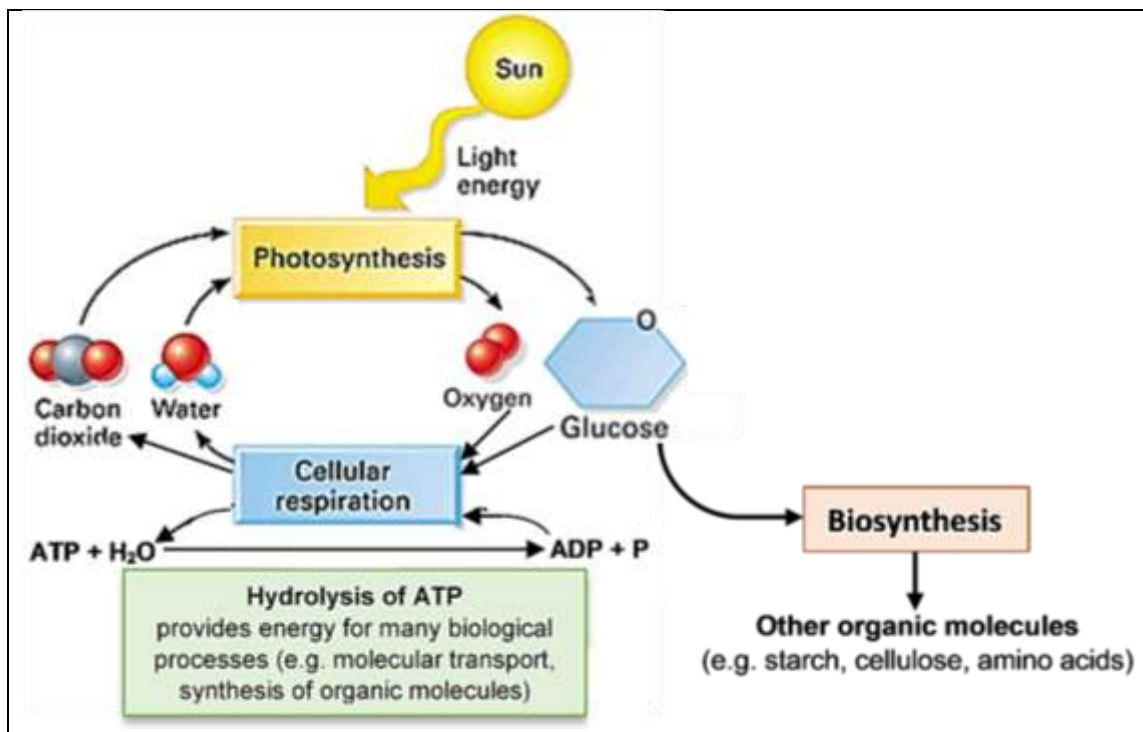
5. Circle one glucose monomer in each polymer in this figure.

Starch stores glucose for future use. Cellulose gives strength to plant cell walls.



6. To make amino acids, plant cells combine molecules derived from glucose with nitrogen-containing ions from the soil. Then, amino acids are joined together to make _____.

7. Draw a diagram to show the processes responsible for the increase in biomass in the light with water condition. Show where the atoms in the increased biomass came from.



To understand the trends in biomass in all three experimental conditions, we need to review energy metabolism in plants. The left part of this figure summarizes the processes that provide the *energy* for plant cells' biological processes.

- First, **photosynthesis** uses the *energy* in sunlight to make glucose and oxygen from carbon dioxide and water.
- Then, **cellular respiration** uses glucose and oxygen as inputs for reactions that provide the *energy* to make ATP from ADP and P.
- Finally, **hydrolysis of ATP** provides *energy* in the form needed for many biological processes.

8. Why do plants need to carry out all three of these processes?

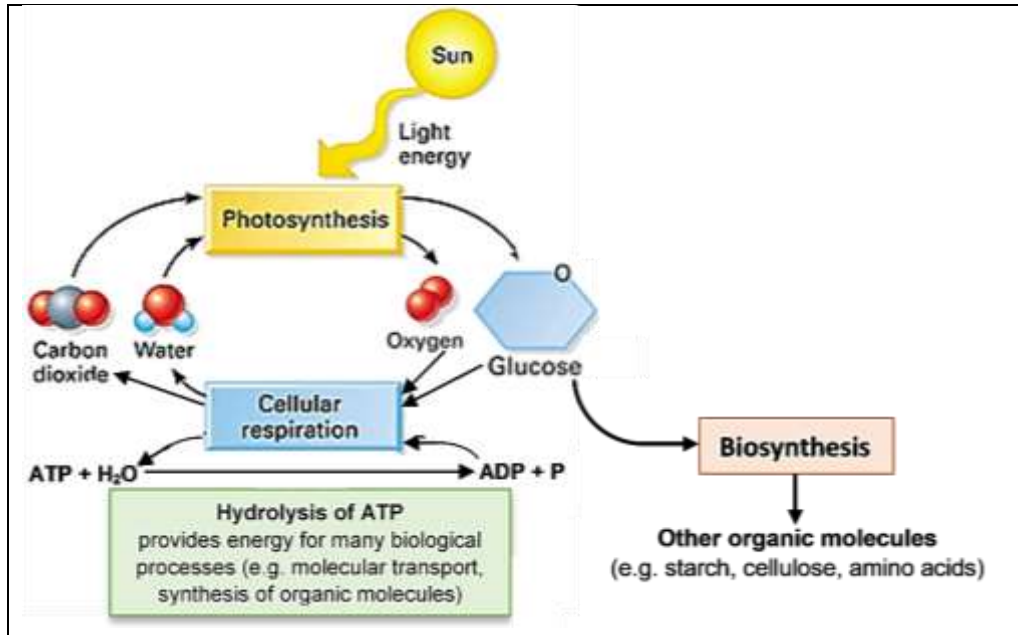
Explanation of why hydrolysis of ATP is needed:

Explanation of why cellular respiration is needed:

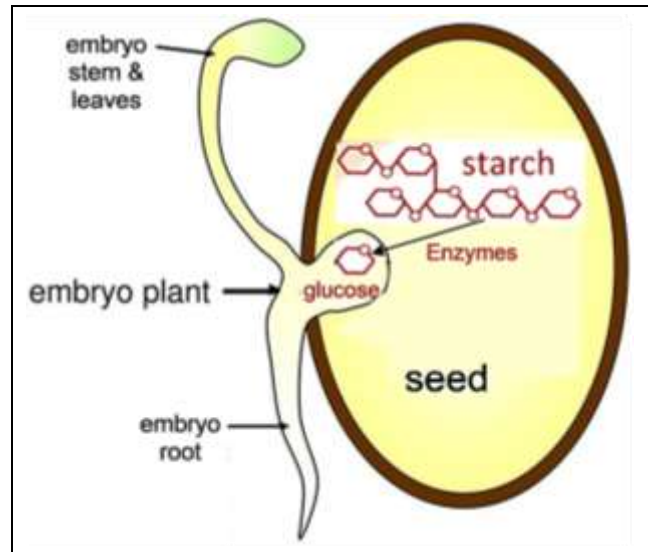
Explanation of why photosynthesis is needed:

9. For the plants growing in light and water, photosynthesis and cellular respiration have opposite effects on biomass. Explain why. (Hint: Consider the effects of photosynthesis and cellular respiration on the amount of glucose.)

10a. Circle the part of this diagram that could not occur in the plants in the no light, with water condition.



10b. In the no light, with water condition, where did the plants get the glucose needed for cellular respiration and biosynthesis? (Hint: See this figure, and assume that the seeds contained starch.)



10c. The plants in the no light, with water condition had less biomass than the seeds they came from. Explain why. What happened to the atoms in the lost biomass?

The dry seeds stayed dormant, which means that they used almost no ATP and had an extremely low rate of cellular respiration and no photosynthesis. Therefore, the biomass of the dry seeds did not change significantly.

11. Compared to the dry seeds, the plants that developed in the dark had less biomass, but more total mass. Explain why. (Hint: About three-quarters of the total mass of a growing plant is water.)