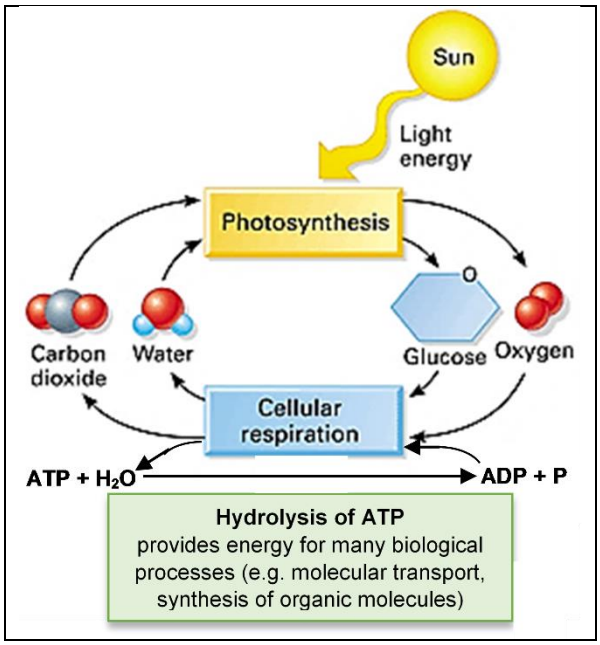
Photosynthesis and Cellular Respiration
– Understanding the Basics of Bioenergetics and Biosynthesis[1]

This figure summarizes the processes that provide the energy for plant cell biological activities.

First, **photosynthesis** uses the energy in sunlight to make glucose from carbon dioxide and water.

Then, in **cellular respiration**, glucose and oxygen are 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.



1a. 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:

1b. Why do animals need to carry out cellular respiration and hydrolysis of ATP, but not photosynthesis?

2a. Which molecules are outputs from photosynthesis and inputs for cellular respiration?

2b. Which molecules are outputs from cellular respiration and inputs for photosynthesis?

2c. Notice that photosynthesis and cellular respiration make a cycle where the products of each process are input molecules for the other process. Draw an oval around the part of the figure that shows this cycle.

3a. Cellular respiration produces ATP and H_2O which are inputs for _____.

3b. The hydrolysis of ATP produces ADP and P which are inputs for _____.

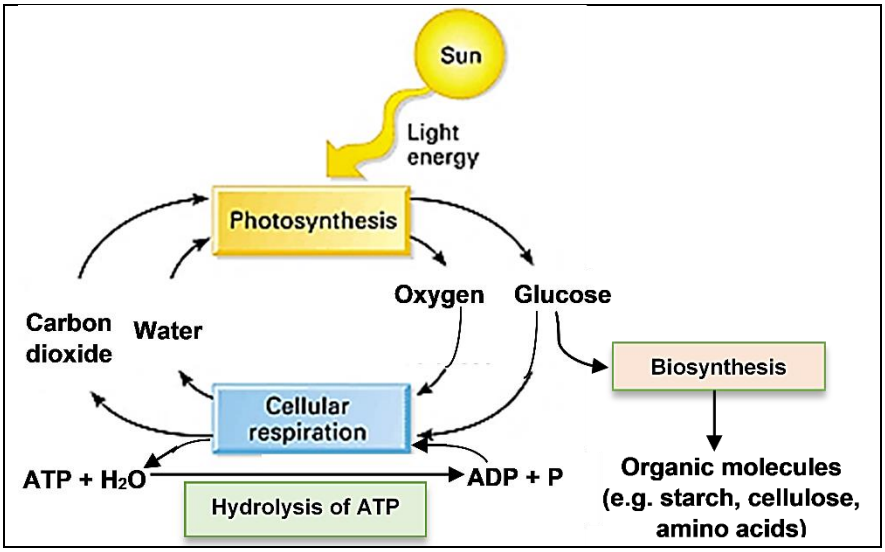
3c. Cellular respiration and hydrolysis of ATP make a cycle where the products of each process are inputs for the other process. Draw a triangle around the part of the figure that shows this cycle.

---

[1]By Dr. Ingrid Waldron, Department of Biology, University of Pennsylvania, © 2021. This Student Handout and Teacher Notes with background information and instructional suggestions are available at https://serendipstudio.org/exchange/bioactivities/photocellrespir.

This figure shows that the glucose produced by photosynthesis is used for two different purposes:

- as input for cellular respiration to make ATP
- as a raw material for the synthesis of other organic molecules such as the cellulose in plant cell walls and the amino acids in proteins.

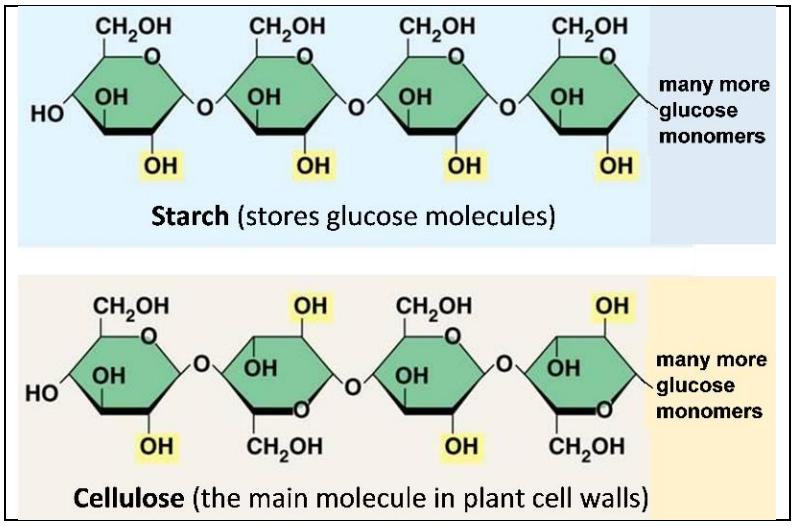


To make starch or cellulose, multiple glucose monomers are joined together in a long polymer.

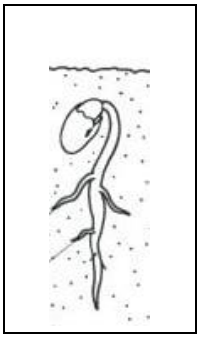
4a. Circle one glucose monomer in each polymer in this figure.

4b. Put a C next to the location of each unlabeled carbon atom in one glucose monomer in cellulose.

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



5a. When a seed sprouts, the starch stored in the seed is broken down to glucose which is used by the growing seedling. Give two reasons why the seedling needs glucose.



5b. Does a seedling that is growing underground in the dark give off CO_2 ___ or take up CO_2 ___?

5c. Explain your reasoning.

A plant is made up primarily of water and organic molecules (e.g. cellulose and proteins). To grow, plant cells add more water and more organic molecules. After cells increase in size, many of them divide to form more cells, which also contributes to plant growth.

6. How does photosynthesis contribute to plant growth?

Plant Growth Puzzle

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

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

To evaluate the effects of water and light on changes in biomass, an experimenter put equal amounts of seeds in petri dishes kept under three different conditions:

- light, no water,
- light and water
- water, no light.

After ten days, the dry seeds had not sprouted, but the seeds that were exposed to water had sprouted to produce small plants. To determine the biomass of each batch of seeds/plants, they were dried in an oven overnight (to remove all the water) and then weighed.

To predict the results of this experiment, you will need to think about the effects of photosynthesis and cellular respiration on biomass.

7a. Explain how photosynthesis can increase biomass. Which types of molecules are the source of the atoms in the added organic molecules?

7b. Explain how cellular respiration can decrease biomass. Where do the atoms from the organic molecules go?

8. For each condition, predict the change in biomass after ten days; circle the appropriate arrow. Explain why you predict a decrease (↓), no change (→), or increase (↑) in biomass.

Condition for each batch of seeds	<u>Light, no water</u> (seeds didn't sprout) 	<u>Light, water</u> (seeds sprouted) 	<u>Water, no light</u> (seeds sprouted) 
Predicted change in biomass	↓ → ↑	↓ → ↑	↓ → ↑
Reason for predicting decrease, no change, or increase in biomass			

9a. Your teacher will show you the biomass observed after 10 days in each condition. Enter these observed results in this table.
9b. At the beginning of the experiment, each batch of seeds had approximately 1.46 g of biomass. For each condition, circle the arrow that represents the observed change in biomass.
9c. If any of the observed results differ from your predictions in question 8, explain the biological reasons for the observed results.

Condition for each batch of seeds	Light, no water (seeds did not sprout)	Light, water (seeds sprouted to produce plants)	Water, no light (seeds sprouted to produce plants)
Observed biomass at 10 days (grams)			
Observed change in biomass	↓ → ↑	↓ → ↑	↓ → ↑
If any result did not match your prediction, explain a possible reason for the observed result.			

The figure below summarizes a paradoxical result – after 10 days, the dry seeds had the lowest total mass, but the plants that developed in the dark had the lowest biomass.

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

Bonus Question
Suggest a hypothesis to explain why the plants that grew in light had dark green leaves, while the plants that grew in the dark had light green leaves.