Photosynthesis: follow the energy and the carbon

A map of the chloroplast

A leaf makes organic molecules using light energy, water, and carbon dioxide. In plant cells, photosynthesis takes place in chloroplasts. Carbon dioxide enters leaves through stomata: pores that also allow water vapor to escape.

Inside a chloroplast, thylakoids are membrane sacs. Chlorophyll in their membranes absorbs light; it does not supply the carbon in sugars. The stroma is the fluid around the thylakoids. Keep these two locations separate when tracing the reactions.

Track two paths through the next pages: energy moves from light into ATP and NADPH, then into organic molecules; carbon moves from CO_2 into organic molecules. Oxygen released by photosynthesis comes from water.

Original ThetaWave learning handout and reviewed practice. Scientific references: OpenStax Biology 2e, sections 8.1–8.3.

OpenStax Biology 2e · 8.1 Overview of Photosynthesis
OpenStax Biology 2e · 8.2 The Light-Dependent Reactions of Photosynthesis
OpenStax Biology 2e · 8.3 Using Light Energy to Make Organic Molecules

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Light reactions: water to energy carriers

Light-dependent reactions operate at the thylakoid membrane. Light excites electrons in photosystems. Splitting water replaces electrons lost from photosystem II and releases H^+ and oxygen (O_2). The released oxygen is not made by splitting CO_2.

Electron transport helps build a high concentration of H^+ inside the thylakoid. H^+ flows back toward the stroma through ATP synthase. This flow powers ATP production. If the gradient collapses, this route of ATP production decreases.

The light reactions also reduce $NADP^+$ to NADPH. ATP supplies energy and NADPH supplies reducing electrons to the Calvin cycle. Neither ATP nor NADPH supplies the carbon skeleton of the new organic molecules.

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The Calvin cycle: carbon into G3P

The Calvin cycle takes place in the stroma. During carbon fixation, the enzyme Rubisco joins CO_2 to RuBP, an existing five-carbon molecule. The carbon added to the cycle therefore comes from CO_2, not from sunlight.

ATP and NADPH support the conversion of the fixed carbon into G3P, a three-carbon molecule. Some G3P is a net output that can help build sugars; the rest is used to regenerate RuBP. The cycle does not directly release a finished glucose molecule each turn.

Light-independent means that the Calvin cycle does not directly absorb photons. It still relies on ATP and NADPH supplied by light reactions. It is not a process that must occur only at night or that can continue indefinitely without those supplies.

Original ThetaWave learning handout and reviewed practice. Scientific references: OpenStax Biology 2e, sections 8.1–8.3.

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