Photosynthesis

Sample chapter from Zyntac AI · 3 pages · written for practice quizzes

1. What photosynthesis is

Photosynthesis is the process by which green plants, algae and some bacteria make their own food. They take in carbon dioxide from the air and water from the soil, and use the energy in sunlight to turn them into glucose, a simple sugar. Oxygen is released as a by-product.

carbon dioxide + water → (light, chlorophyll) → glucose + oxygen

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

Because plants make their own food, they are called **autotrophs**. Animals, fungi and most bacteria cannot do this and must eat other organisms; they are **heterotrophs**. Almost every food chain on Earth starts with photosynthesis, and nearly all the oxygen in the atmosphere comes from it.

2. Where it happens

In plants, photosynthesis happens mainly in the leaves, inside cells of the **palisade layer** just below the upper surface. These cells are packed with **chloroplasts**, small structures that contain the green pigment **chlorophyll**. Chlorophyll absorbs red and blue light strongly and reflects green light, which is why leaves look green.

Leaves are adapted for photosynthesis in several ways:

- **Broad and flat:** a large surface area catches more light.
- **Thin:** carbon dioxide has only a short distance to diffuse to the cells.
- **Stomata:** tiny pores, mostly on the lower surface, let carbon dioxide in and oxygen out. Guard cells open and close them.
- **Veins:** xylem brings water from the roots; phloem carries the sugars away to the rest of the plant.

> **Key idea:** chlorophyll does not get used up. It captures light energy so the plant can use it to build glucose.

3. The two stages

Photosynthesis happens in two linked stages inside the chloroplast.

	Light-dependent reactions	Light-independent reactions (Calvin cycle)
Where	Thylakoid membranes (stacks called grana)	Stroma, the fluid around the thylakoids
Needs	Light, water, chlorophyll	Carbon dioxide, ATP and NADPH from stage 1
What happens	Light energy splits water (photolysis), releasing oxygen. The energy is stored as ATP and NADPH.	Carbon dioxide is fixed by the enzyme RuBisCO and built up into glucose using ATP and NADPH.
Products	Oxygen, ATP, NADPH	Glucose (and ADP, $NADP^+$ returned to stage 1)

The oxygen released by plants comes from the **water** molecules split in the first stage, not from carbon dioxide. The second stage does not need light directly, but it stops quickly in the dark because it runs out of ATP and NADPH.

4. What the plant does with glucose

- **Respiration:** broken down to release energy for the plant's own cells.
- **Starch:** stored in leaves, roots and seeds, because starch is insoluble and does not affect water movement.
- **Cellulose:** used to build cell walls.
- **Proteins:** combined with nitrates from the soil to make amino acids.
- **Fats and oils:** stored in seeds as an energy reserve.

Test for starch: a leaf is boiled, softened in warm ethanol to remove the chlorophyll, rinsed, and covered with iodine solution. Parts that contained starch turn blue-black; parts without starch stay orange-brown.

5. Limiting factors

The rate of photosynthesis depends on several conditions. Whichever one is in shortest supply holds the rate back; this is called the **limiting factor**.

- **Light intensity:** more light increases the rate, until another factor becomes limiting and the graph levels off.
- **Carbon dioxide concentration:** more carbon dioxide increases the rate, up to a point. Greenhouses sometimes add carbon dioxide to grow crops faster.
- **Temperature:** the reactions are controlled by enzymes. Warming speeds them up, but above about 40 °C the enzymes begin to denature and the rate falls sharply.
- **Water and chlorophyll:** a shortage of water closes the stomata, and leaves without enough chlorophyll (for example, from a lack of magnesium) absorb less light.

6. Photosynthesis and respiration

Photosynthesis and aerobic respiration are roughly the reverse of each other. Photosynthesis stores energy in glucose and releases oxygen; respiration releases the energy from glucose and uses oxygen. Plants respire all the time, day and night, but they only photosynthesise when there is light.

At dawn and dusk, the rate of photosynthesis can exactly equal the rate of respiration. At this **compensation point**, the plant takes in no carbon dioxide overall and gives out no oxygen overall.

Summary

- Plants use light energy, carbon dioxide and water to make glucose and oxygen.
- It happens in chloroplasts, mainly in palisade cells, using chlorophyll.
- Stage 1 (thylakoids) needs light and splits water; stage 2 (stroma) fixes carbon dioxide into glucose.
- Light, carbon dioxide and temperature can each be the limiting factor.
- Glucose is used for respiration or turned into starch, cellulose, proteins and oils.