

Plant nutrition

IGCSE Biology

Photosynthesis



Green leaves capture sunlight for photosynthesis.

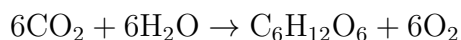
Photosynthesis is the process by which plants make **carbohydrates** from simple **raw materials**, using **energy** from light. It is how plants feed themselves.

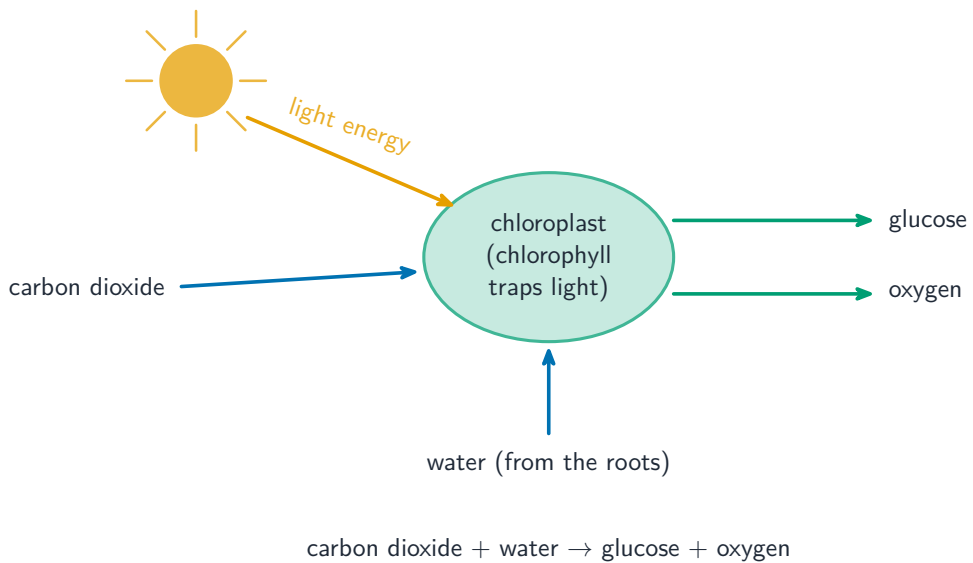
■ The word equation

carbon dioxide + water → glucose + oxygen

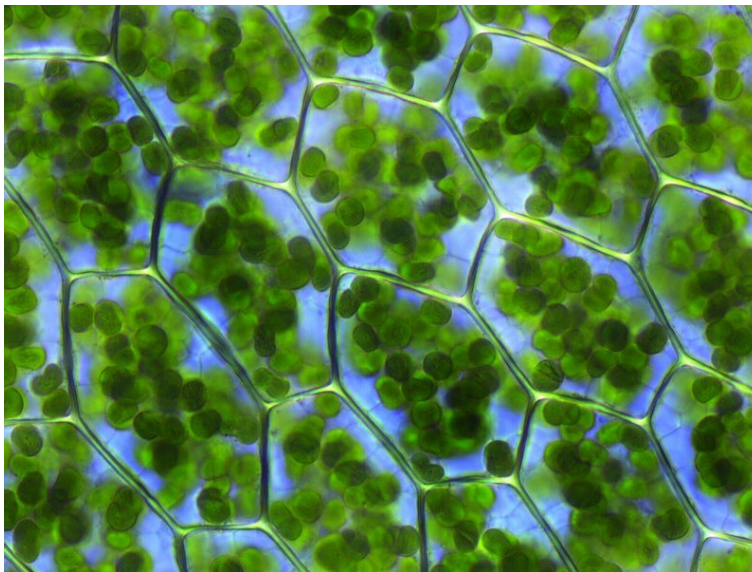
In words: plants take in **carbon dioxide** and water, and make **glucose** and **oxygen**. This reaction can only happen in the light, and only where there is **chlorophyll**.

(**Supplement**) The balanced chemical equation is:





Photosynthesis takes in carbon dioxide and water and makes glucose and oxygen, using light



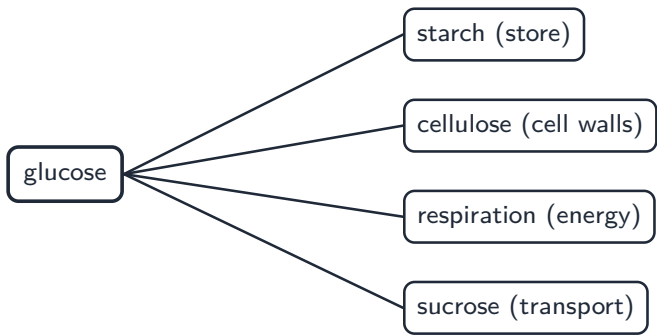
The same chloroplasts under a microscope, packed inside moss leaf cells – the green is chlorophyll

■ What chlorophyll does

Chlorophyll is a green **pigment** found in the **chloroplasts**. It traps light and transfers the energy from light into energy stored in chemicals. That chemical energy is then used to build carbohydrates.

■ What the plant does with the glucose

Use	What happens		
store	changed to starch	, an energy store that does not dissolve	
build	made into cellulose	to build cell walls	
release energy	broken down in respiration	to release energy	
transport	changed to sucrose	and moved around the plant in the phloem	
attract animals	made into nectar	to attract insects	for pollination



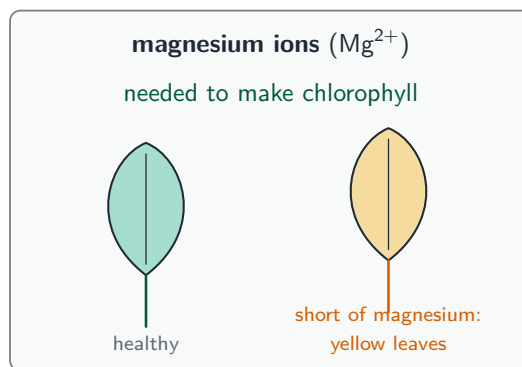
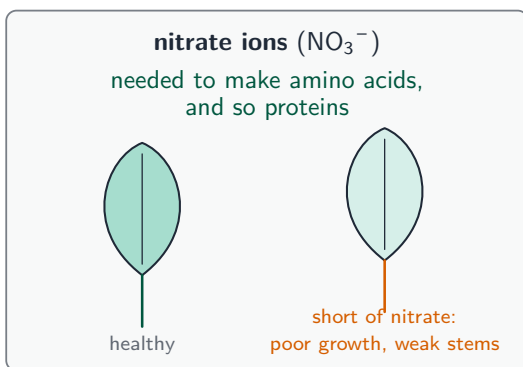
What a plant does with the glucose it makes

■ Minerals from the soil

Plants also take up mineral **ions** from the soil through their roots:

- **nitrate ions** – needed to make **amino acids** (and so proteins).
- **magnesium ions** – needed to make chlorophyll.

A plant short of nitrate grows poorly with weak stems; a plant short of magnesium has yellow leaves (it cannot make enough chlorophyll).



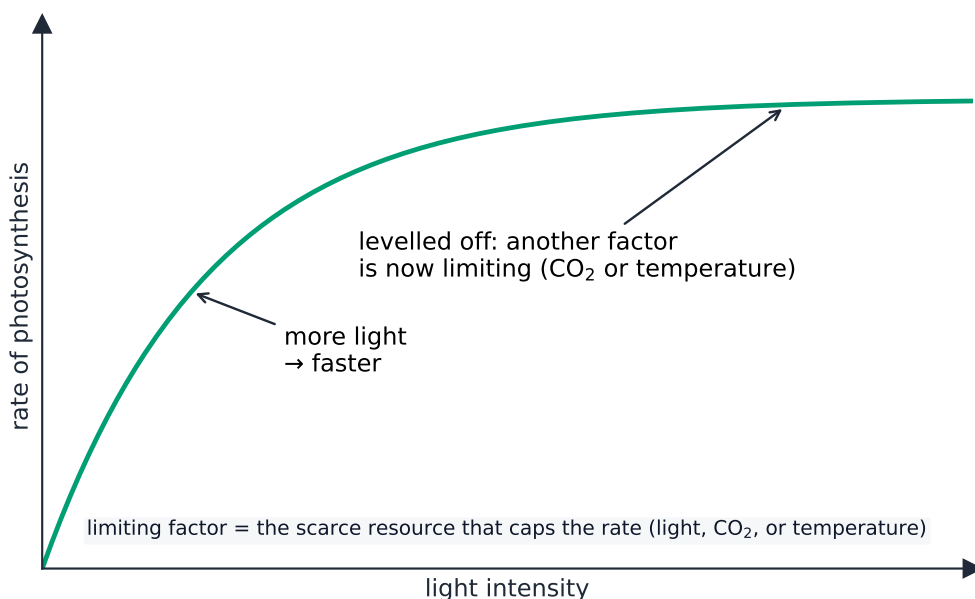
A plant short of nitrate grows poorly; a plant short of magnesium has yellow leaves

■ The rate of photosynthesis

The **rate** of photosynthesis depends on three things:

- **light intensity** – more light gives a faster rate, up to a point.
- carbon dioxide **concentration** – more carbon dioxide gives a faster rate.
- **temperature** – a warmer temperature is faster, until it gets so hot that the enzymes are denatured.

(**Supplement**) At any moment, the one factor that is in shortest supply holds back the rate. This is called the **limiting factor**. For example, on a dull day light intensity is usually the limiting factor; on a bright day carbon dioxide may be.



More light speeds up photosynthesis until another factor becomes limiting

Worked example. On a graph of rate against light intensity, the line rises steeply at first and then levels off flat. Which factor is limiting on each part? On the **rising** part, adding light raises the rate, so **light intensity** is the limiting factor there. On the **flat** part, adding more light changes nothing, so light is no longer limiting - something else is, usually carbon dioxide concentration or temperature. The test is always the same: if adding more of a factor speeds the reaction up, that factor was the one holding it back.

■ Investigating photosynthesis

To show that a plant needs light, chlorophyll and carbon dioxide, you test a leaf for starch after taking one of them away. A **control** keeps every other condition the same, so the test is fair. (First leave the plant in the dark to use up its starch.) A leaf with green and white parts shows starch only in the green parts, which have chlorophyll.

You can also watch **gas exchange** in a water plant using hydrogencarbonate **indicator**, which changes colour as the carbon dioxide level changes. In the light the plant takes in carbon dioxide for photosynthesis; in the dark it gives out carbon dioxide from respiration.

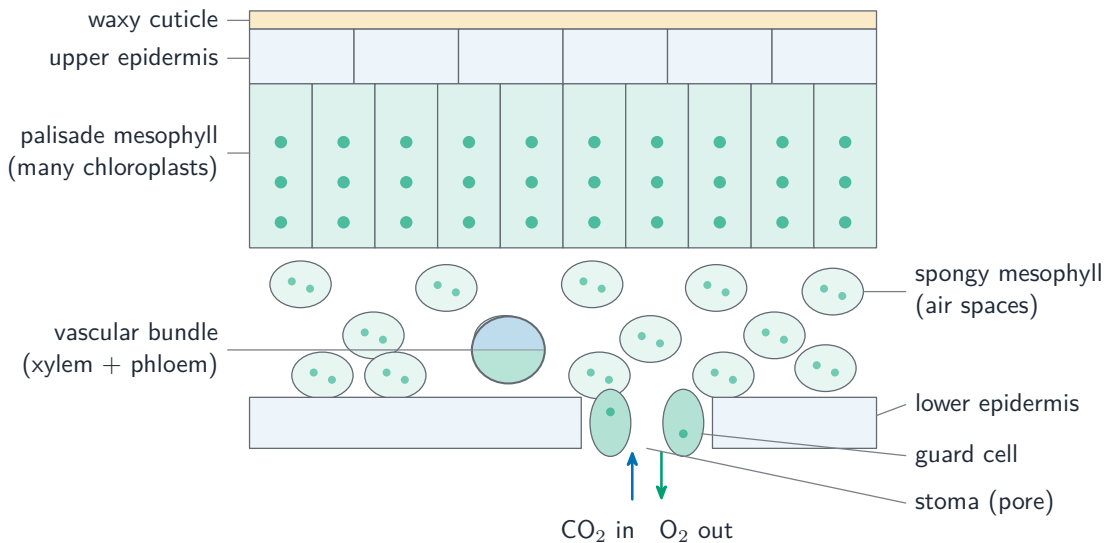
Leaf structure

A leaf is well **adapted** for photosynthesis. Most leaves are broad, with a large **surface area** to catch plenty of light, and thin, so that gases and light quickly reach all the cells.

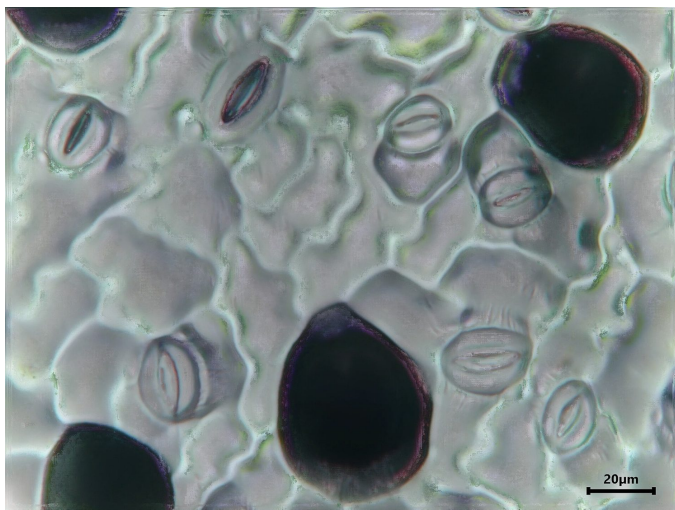
The middle of the leaf, the **mesophyll**, is where most photosynthesis happens. These are the main parts of a leaf:

Structure	Job / how it helps photosynthesis
cuticle	a clear waxy layer on top; it reduces water loss but still lets light through
upper epidermis	a clear layer of cells with no chloroplasts; it lets light pass to the cells below
palisade mesophyll	tall, column-shaped cells packed with chloroplasts, near the top; they do most of the photosynthesis
spongy mesophyll	rounded cells with air spaces between them, so gases can move easily
stomata	tiny holes, mostly on the lower surface, that let carbon dioxide in and oxygen out

Structure	Job / how it helps photosynthesis
guard cells	a pair of cells around each stoma; they open and close it
lower epidermis	a thin layer that holds the stomata
vascular bundles	contain xylem (brings water to the leaf) and phloem (carries sugars away)



A leaf in cross-section: each tissue is adapted for photosynthesis and gas exchange



Real stomata in the lower surface of a leaf – each pore has two guard cells (scale bar 20 μm)

Exam tips

- Learn the word equation exactly: carbon dioxide + water → glucose + oxygen (in light, with chlorophyll).
- Chlorophyll is in the chloroplasts; it does not get used up – it transfers light energy.
- Link each factor to the rate: more light, more carbon dioxide, warmer (but not too hot) → faster, until a **limiting factor** stops further increase.
- For leaf structure, always link the part to its job: broad and thin to catch light; palisade cells full of chloroplasts; stomata and air spaces for gas exchange.
- Nitrate ions → amino acids; magnesium ions → chlorophyll.