

Ages 13–16 · Science

LESSON SLIDES

Photosynthesis

Biology · How plants turn light into food

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Photosynthesis

SPEAKER NOTES

Open with a puzzle: a seed weighing a fraction of a gram grows into a tree weighing tonnes. Where did all that mass come from? Take guesses (soil, water, sunlight, air) and write them on the board. Come back to the answers at the end of the lesson.

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By the end of this lesson you can

- 🎯 Write the word and balanced equations
- 🎯 Explain where the energy in glucose comes from
- 🎯 Describe how a leaf is built for photosynthesis
- 🎯 Explain what limits the rate of photosynthesis
- 🎯 Describe what plants do with glucose

By the end of this lesson you can

SPEAKER NOTES

Read the objectives aloud. Tell students that the five-question quiz at the end checks one objective each, so they should make a note under each heading as you go.

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Why photosynthesis matters

- Plants, algae and cyanobacteria make their own food
- They use light energy to build sugar from simple substances
- Oxygen is released as a by-product
- Animals, fungi and most bacteria rely on that food

Why photosynthesis matters

SPEAKER NOTES

Introduce the terms producer and consumer if your class has not met them.

Organisms that make food using light are called photoautotrophs; organisms that must eat food made by others are heterotrophs. Every food chain students know starts with a photosynthesiser.

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The engine of life on Earth

99%

of Earth's ecosystems are powered by
photosynthesis

- The rare exceptions include deep-sea vents, powered by chemical energy

The engine of life on Earth

SPEAKER NOTES

The 99 per cent figure comes from the OpenStax Biology textbook. Ask students to trace their breakfast back to a plant: milk comes from a cow that ate grass, bread comes from wheat. Every route ends at photosynthesis.

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The word equation

- Carbon dioxide + water → glucose + oxygen
- Reactants: carbon dioxide from the air, water from the soil
- Products: glucose, a sugar, and oxygen gas
- Needs light energy, absorbed by green chlorophyll

The word equation

SPEAKER NOTES

Write the equation on the board with 'light' and 'chlorophyll' above the arrow. Stress that light is not a reactant: it is the energy source. Energy is taken in from light and stored as chemical energy in glucose, which is why the plant can later release it by respiration.

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The balanced symbol equation

- $6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$
- Six carbon dioxide and six water molecules in
- One glucose and six oxygen molecules out
- Count the atoms: 6 C, 12 H and 18 O on each side

The balanced symbol equation

SPEAKER NOTES

For younger or less confident groups, the word equation may be enough; this slide is for students working towards GCSE or IGCSE level. Ask students to check the atom count themselves. Carbon: 6 on each side. Hydrogen: 12 on each side. Oxygen: $12 + 6 = 18$ on the left, $6 + 12 = 18$ on the right.

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Photosynthesis step by step

- Light captured, water and carbon dioxide delivered
- Water split, sugar built, oxygen released

SCIENCE · BIOLOGY AGES 11–16

How Photosynthesis Works

Plants turn light, water and carbon dioxide into sugar and release the oxygen we breathe.

- 1 Light is captured**

Chlorophyll in the chloroplasts absorbs mostly red and blue light and reflects green, which is why most leaves look green.
- 2 Water arrives from the roots**

Roots absorb water from the soil. It travels up through the xylem to the cells of the leaf.
- 3 Carbon dioxide enters**

CO₂ from the air diffuses into the leaf through tiny pores called stomata, found mostly on the underside of leaves.

- 4 Water is split**

In the thylakoid membranes, light energy splits water. Oxygen is released and the energy is stored in ATP and NADPH.
- 5 Sugar is built**

In the stroma, the Calvin cycle uses ATP and NADPH to fix CO₂ into sugar. The enzyme RuBisCO does the fixing.
- 6 Energy is used or stored**

Glucose powers growth and respiration, or is stored as starch. Oxygen leaves the leaf through the stomata.

The overall equation

$$6\text{CO}_2 + 6\text{H}_2\text{O} + \text{light energy} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 \text{ (glucose)} + 6\text{O}_2$$

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Photosynthesis step by step

SPEAKER NOTES

Walk through the poster from top to bottom. Older students can follow the two stages; younger students only need the inputs and outputs. Point out that the oxygen released comes from the water molecules, not from the carbon dioxide.

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Inside a leaf

- Waxy cuticle cuts water loss from the surface
- Palisade cells, packed with chloroplasts, sit near the top
- Spongy layer has air spaces for gases to move
- Stomata, opened and closed by guard cells, let gases in and out
- Veins bring water in xylem and carry sugar away in phloem

Inside a leaf

SPEAKER NOTES

Sketch a leaf cross-section on the board as you go, or project a microscope image. Ask: why are palisade cells at the top? (That is where the most light arrives.) Why are most stomata on the underside? (It helps reduce water loss.) A broad, flat leaf gives a large surface to catch light.

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Why leaves are green

- Chlorophyll absorbs mostly red and blue light
- Green light is mostly reflected, so leaves look green
- Chlorophyll sits inside the chloroplasts
- Absorbed light energy drives the reactions

Why leaves are green

SPEAKER NOTES

A common wrong answer is that plants use green light most. Ask: if leaves reflect green light into our eyes, can they be using much of it? Link back to the chloroplasts in the cells lesson.

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What limits the rate?

- Light intensity: more light, faster rate, until it levels off
- Carbon dioxide: more carbon dioxide, faster rate, until it levels off
- Temperature: enzymes speed up when warmer, but too hot damages them
- Water: short of water, stomata close and carbon dioxide is cut off

What limits the rate?

SPEAKER NOTES

Define a limiting factor: whichever factor is in shortest supply holds the rate back, so raising another factor makes no difference. Sketch the graphs: light and carbon dioxide rise and then plateau; temperature rises to an optimum and then falls steeply as enzymes are damaged.

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Photosynthesis vs respiration

Photosynthesis

- Happens in chloroplasts
- Only in light
- Takes in carbon dioxide and water
- Stores energy in glucose

Respiration

- Happens in mitochondria
- Day and night, in every living cell
- Takes in glucose and oxygen
- Releases energy from glucose

Photosynthesis vs respiration

SPEAKER NOTES

This is the most important comparison in the lesson. Plants do both: in bright light they photosynthesise faster than they respire, so overall they take in carbon dioxide; in the dark they only respire. The products of one process are the reactants of the other.

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What plants do with glucose

- Release energy from it by respiration
- Store it as starch, for example in roots and seeds
- Build cellulose for new cell walls
- Turn it into sucrose to carry round the plant in phloem

What plants do with glucose

SPEAKER NOTES

Plants turn spare glucose into starch for storage, for example in roots and seeds, and build cellulose from glucose for cell walls. Sucrose is the main sugar moved from leaves to roots, seeds and fruits. Ask students which of these uses they have eaten today: potatoes and rice are starch stores.

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 Example

Example: a greenhouse on a cold, bright morning

- 1 Sun is shining strongly through the glass
- 2 Air inside is cold and the vents are shut
- 3 Which factor is most likely limiting the rate?
- 4 What could the grower change, and what would it cost?

Example: a greenhouse on a cold, bright morning

SPEAKER NOTES

Give students two minutes in pairs. With bright light, temperature is the most likely limiting factor in the early morning, so warming the greenhouse would help most. Later in the day, with vents shut, carbon dioxide may become limiting instead. Discuss the trade-off: heating costs money, so growers only pay to raise the factor that is actually limiting.

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Going further: two stages

- Stage 1, in the thylakoid membranes, needs light
- Light splits water, releasing oxygen and capturing energy
- Stage 2, the Calvin cycle in the stroma, fixes carbon dioxide
- The enzyme RuBisCO helps build carbon dioxide into sugar

Going further: two stages

SPEAKER NOTES

This slide is extension for ages 15–16 or for fast finishers; skip it with younger groups. Stage 2 does not use light directly but depends on the energy carriers ATP and NADPH made in stage 1, so it soon stops in the dark.

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Common mix-ups

- Plants respire all the time, not only at night
- The carbon in sugar comes from the air, not the soil
- The oxygen released comes from water
- Light is an energy source, not a reactant

Common mix-ups

SPEAKER NOTES

Return to the opening puzzle: the carbon in a tree's wood and leaves comes from carbon dioxide taken in from the air. Soil supplies water and minerals, not food. Ask students to vote true or false on each statement before you reveal it.

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 Quick check

A plant has plenty of light and water, but the rate of photosynthesis has stopped rising. What could be the limiting factor?

A The amount of oxygen

B The carbon dioxide concentration

C The amount of glucose stored

D The colour of the pot

Quick check

SPEAKER NOTES

Answer: carbon dioxide concentration (temperature would also be a fair answer if it were offered). Oxygen is a product, not a reactant, so adding it does not speed photosynthesis up.

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Key takeaways

- ✓ Carbon dioxide + water → glucose + oxygen, using light energy
- ✓ It happens in chloroplasts, mainly in leaf palisade cells
- ✓ Leaves are broad and flat, with air spaces and stomata
- ✓ Light, carbon dioxide and temperature can limit the rate
- ✓ Glucose is used for respiration, starch, cellulose and sucrose

Key takeaways

SPEAKER NOTES

Go back to the guesses from the opening puzzle and ask students to correct them. Then move to the five-question quiz on the page. Homework idea: draw and annotate a leaf cross-section, explaining how each part helps photosynthesis.