Photosynthetic reaction

4.4.1.1 · Bioenergetics · revision notes

Photosynthesis is the reaction in which plants and algae use energy transferred by light to make glucose from carbon dioxide and water. Expect recall of the word equation and the chemical formulae, 'explain why photosynthesis is endothermic', and questions that link the reaction to leaves, starch tests or gas exchange.

Key facts

- carbon dioxide + water → glucose + oxygen (light above the arrow)
- Grade 6+ only Balanced: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$
- Endothermic: energy is transferred from the environment to the chloroplasts by light
- Water is absorbed by root hair cells and carried in the xylem
- No light, no chlorophyll or no carbon dioxide → no photosynthesis → no glucose → no starch
- Formulae: CO_2 carbon dioxide, H_2O water, $C_6H_{12}O_6$ glucose, O_2 oxygen
- Takes place in chloroplasts; chlorophyll absorbs the light
- Carbon dioxide enters the leaf by diffusion through the stomata
- Starch test: iodine solution turns from orange-brown to blue-black

Notes

The reaction

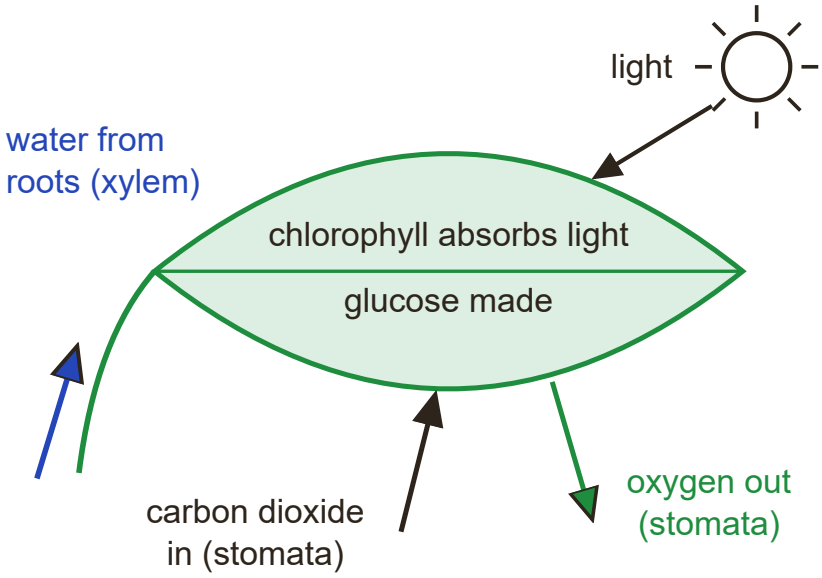
- Photosynthesis takes place in the **chloroplasts** of plant and algal cells.
- **Chlorophyll**, the green pigment in chloroplasts, absorbs the light.
- Word equation: **carbon dioxide + water** → **glucose + oxygen** (write 'light' above the arrow).
- Formulae to recognise: CO_2 (carbon dioxide), H_2O (water), $C_6H_{12}O_6$ (glucose) and O_2 (oxygen).
- Balanced symbol equation: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$. Grade 6+ only

Why photosynthesis is endothermic

- An **endothermic** reaction takes in energy from its surroundings.
- In photosynthesis, energy is transferred **from the environment to the chloroplasts by light**.
- Plants and algae get their energy from light absorbed by chlorophyll, not from food.
- The energy ends up in the chemical energy store of the glucose.

Where the substances come from and go

- Carbon dioxide diffuses from the air into the leaf through the **stomata**.
- Water is absorbed from the soil by root hair cells and carried up to the leaves in the **xylem**.
- Oxygen diffuses out of the leaf through the stomata, or is used by the plant's own cells for respiration.
- Glucose is used by the plant straight away or turned into other substances, such as starch for storage.



What a leaf takes in and gives out while it photosynthesises.

- Photosynthesis only happens in the light, but plant cells respire all the time. In bright light photosynthesis is faster than respiration, so overall the plant takes in carbon dioxide and gives out oxygen. In the dark it only respires, so it gives out carbon dioxide. Grade 7+ only

Testing a leaf for starch

- A leaf turns the glucose it makes into **starch** for storage. Iodine solution turns from orange-brown to **blue-black** where starch is present.
- Starch forms only where the leaf had light, chlorophyll and carbon dioxide. A covered part (no light), a white part of a variegated leaf (no chlorophyll) or a leaf kept without carbon dioxide stays orange-brown.
- To explain a result, give the whole chain: no light (or no chlorophyll, or no carbon dioxide) → no photosynthesis → no glucose made → no starch.

How to answer each type of question

Recall: complete the equation or give a formula

1 to 3 marks | Grade 3

1. Learn the word equation as a sentence: carbon dioxide and water make glucose and oxygen.
2. Use names in a word equation and formulae only when a formula is asked for.
3. Check the formula carefully: glucose is $C_6H_{12}O_6$, not $C_6H_{12}O_2$.

Example. (a) Complete the word equation for photosynthesis.
..... + water → ..... + oxygen
(b) Give the chemical formula of water.

Model answer.

(a) carbon dioxide (1); glucose (1)
(b) H_2O (1)

Explain why photosynthesis is endothermic

2 marks | Grade 5

1. Say that energy is taken in from the environment (surroundings).
2. Say how it gets there: it is transferred to the chloroplasts by light.

Example. A student wrote: 'Photosynthesis gives out energy to the plant.'
The student is wrong. Explain why photosynthesis is described as an endothermic reaction.

Model answer. Energy is taken in / transferred from the environment (1) to the chloroplasts by light (1).

Explain the results of a starch test on a leaf

3 marks | Grade 6

1. Spot what was different between the parts of the leaf: light or chlorophyll.
2. Link each part in a chain: light and chlorophyll → photosynthesis → glucose → starch.
3. Finish with the test: starch turns iodine blue-black; no starch means it stays orange-brown.

Example. A plant was kept in the dark for two days. A strip of foil was then fixed across one of its leaves and the plant was put in bright light for 6 hours. The leaf was tested with iodine solution.
The part under the foil stayed orange-brown. The rest of the leaf turned blue-black.
Explain these results.

Model answer. The part under the foil received no light, so it could not photosynthesise (1). The uncovered part photosynthesised and made glucose (1). The glucose was converted into starch, which turns iodine solution blue-black (1).

Explain gas exchange by a plant in the light and the dark 3 marks **Grade 7**

1. Remember that plant cells respire all the time, releasing carbon dioxide.
2. Photosynthesis, which takes in carbon dioxide, only happens in the light.
3. Compare the two rates: in bright light photosynthesis is faster than respiration.

Example. A plant gives out carbon dioxide at night but takes in carbon dioxide on a sunny day. Explain why.

Model answer. The plant's cells respire all the time, which releases carbon dioxide (1). At night there is no light, so there is no photosynthesis to use the carbon dioxide (1). On a sunny day the rate of photosynthesis is greater than the rate of respiration, so more carbon dioxide is taken in than is released (1).

Don’t lose marks

- Writing that photosynthesis happens 'in the chlorophyll'. It happens in the chloroplasts; chlorophyll is the pigment that absorbs light.
- Writing light as a reactant on the left of the equation. Light is not a substance: it transfers the energy, so write it above the arrow.
- Calling photosynthesis exothermic, or saying it 'makes energy'. Energy is never made: it is transferred to the chloroplasts by light.
- Saying plants get their food from the soil. Plants make their own glucose; the soil supplies only water and mineral ions.
- Saying plants photosynthesise instead of respiring. Plants respire all the time, day and night, and photosynthesise only when there is light.

More tips

Memory tricks

- Endo = in: in photosynthesis energy goes in, carried by light.
- Chloroplast and chlorophyll both start with 'chloro' (green): the chloroplast is the organelle, chlorophyll is the green pigment inside it.
- Glucose formula pattern: 6 carbon, 12 hydrogen, 6 oxygen (6-12-6).
- Respiration is photosynthesis in reverse: swap the two sides of the word equation to get glucose + oxygen → carbon dioxide + water.
- Check the balanced equation by counting atoms: 6 C, 12 H and 18 O on each side.

Exam technique

- For 'endothermic' questions, use both key phrases: 'energy transferred from the environment' and 'to the chloroplasts by light'.
- Write 'carbon dioxide' in full rather than a half-remembered formula. If you do use formulae, check every subscript.
- In experiments with starch tests or indicators, write the whole chain: light → photosynthesis → glucose made (and carbon dioxide used) → the result you see.
- If a question asks for a word equation, give names only; do not mix names and formulae.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

Write the word equation for photosynthesis

carbon dioxide + water → glucose + oxygen, with light written above the arrow.

Grade 3

State where photosynthesis takes place

In the chloroplasts of plant and algal cells, where chlorophyll absorbs light.

Grade 4

Recognise the formulae of the four substances

Carbon dioxide is CO_2, water is H_2O, glucose is $C_6H_{12}O_6$ and oxygen is O_2.

Grade 5

Explain why photosynthesis is endothermic

Energy is transferred from the environment to the chloroplasts by light, so the reaction takes in energy.

Grade 5

State where the reactants come from

Carbon dioxide diffuses into the leaf from the air through the stomata; water is absorbed by the roots and carried up in the xylem.

Grade 6

Explain the results of a leaf starch test

Only parts of a leaf that had light and chlorophyll made glucose, which was stored as starch and turns iodine solution blue-black.

Grade 7

Explain plant gas exchange in light and dark

Plant cells respire all the time, so a plant gives out carbon dioxide in the dark but takes it in overall when photosynthesis is faster than respiration.

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