Exercise walk-through

Photosynthesis ▪ 6.1

eXercise

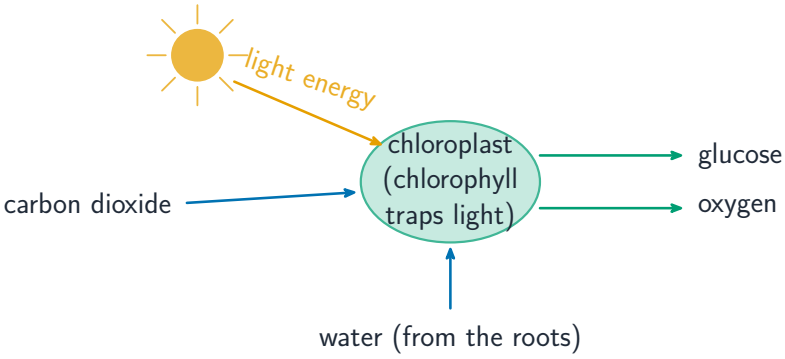
You must be able to

- write the word (and balanced) equation for photosynthesis
- state the uses of glucose and the roles of nitrate and magnesium ions
- describe how light, CO_2 and temperature affect the rate

Method — Equation and rate

- glucose → starch (store), cellulose (walls), respiration, sucrose (transport).
- nitrate → amino acids; magnesium → chlorophyll.

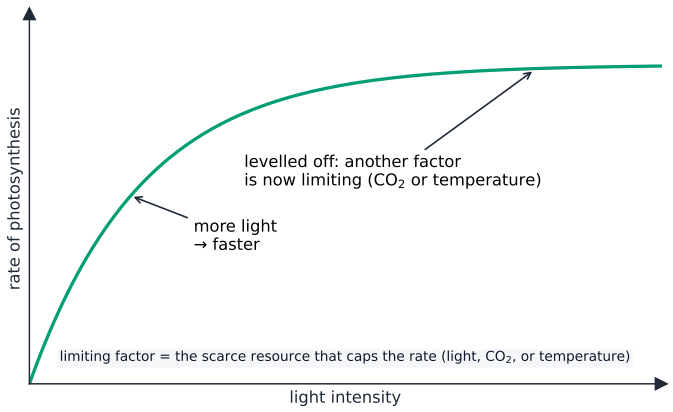
Method — Equation and rate



carbon dioxide + water $\rightarrow$ glucose + oxygen

A chloroplast: CO_2 + water + light $\rightarrow$ glucose + oxygen

Method — Equation and rate



Rate vs light intensity, levelling off

Method — The equation, the factors, and reading the graph

$$\text{carbon dioxide} + \text{water} \xrightarrow[\text{chlorophyll}]{\text{light}} \text{glucose} + \text{oxygen}$$

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

Chlorophyll is not a reactant: it absorbs the light energy and transfers it to the reaction, which is why it is written over the arrow.

A limiting factor 限制因素 is the factor in shortest supply, which holds the rate back. Three matter: **light intensity**, **carbon dioxide concentration** and **temperature**.

Reading a rate graph, which the exam asks every year. Where the line **rises**, the factor on the *x*-axis is limiting: more of it gives more photosynthesis. Where the line **levels off**, that factor is no longer limiting, so something else is — for a light-intensity graph, usually carbon dioxide concentration or temperature. If the line **falls** at high

Method — The equation, the factors, and reading the graph

temperature, the reason is different in kind: the enzymes have been **denatured**, so their active sites no longer fit the substrate.

What the plant does with the glucose: respiration, to release energy; converted to starch for storage; converted to cellulose for cell walls; converted to sucrose for transport in the phloem; used with nitrate ions to make amino acids and then proteins.

Mineral ions. Nitrate ions are needed to make amino acids and so proteins; without them growth is stunted and older leaves turn yellow. **Magnesium ions** are needed to make chlorophyll; without them the leaves turn yellow between the veins.

Worked example. A graph shows the rate of photosynthesis against carbon dioxide concentration at 20 °C and at 30 °C. Both level off, but the 30 °C line levels off higher. Explain. At low concentrations the rate rises because carbon dioxide is the limiting factor. Both level off when carbon dioxide is no longer limiting. The 30 °C line levels

Method — The equation, the factors, and reading the graph

off at a higher rate because the enzymes controlling photosynthesis work faster at the higher temperature, so temperature was the factor limiting the 20 °C line.

Practice 2.1 ▪ 2 marks

Write the word equation for photosynthesis.

Solution 2.1

Worked steps

carbon dioxide + water → glucose + oxygen M1 A1 *reactants*, *products*.

Practice 2.2 ▪ 1 mark

State the role of magnesium ions in a plant.

Solution 2.2

Method: The equation, the factors, and reading the graph

Worked steps

needed to make chlorophyll B1.

Practice 2.3 ▪ 2 marks

Explain why a plant lacking nitrate ions grows poorly.

Solution 2.3

Method: The equation, the factors, and reading the graph

Worked steps

Nitrate ions are needed to make amino acids and so proteins B1; without proteins the plant cannot build new cells, so growth is stunted and the older leaves turn yellow B1.

Practice 2.4 ▪ 1 mark

State what is meant by a limiting factor.

Solution 2.4

Worked steps

The factor in shortest supply, which holds back the rate of the reaction B1.

Practice 2.5 ▪ 2 marks

Give the balanced symbol equation for photosynthesis.

Solution 2.5

Worked steps

$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$ **M1** **A1** *for the correct formulae, for balancing.*

Exam-style 3.1 ▪ 1 mark

Photosynthesis can only take place where there is light and:

A nitrate

B chlorophyll

C oxygen

D protein

Solution 3.1

Method: The equation, the factors, and reading the graph

A nitrate

B chlorophyll ✓

C oxygen

D protein

Worked steps

B. Photosynthesis needs chlorophyll (and light).

Exam-style 3.2 ▪ 2 marks

A graph shows photosynthesis rate rising with light intensity, then levelling off.
(a) Explain why the rate levels off at high light intensity.
(b) Name one other factor that could then be limiting.

Solution 3.2

Method: The equation, the factors, and reading the graph

Worked steps

(a) another factor is now limiting **M1**; e.g. CO_2 concentration or temperature is in short supply **A1**.
(b) carbon dioxide concentration (or temperature) **B1**.

Exam-style 3.3 ▪ 2 marks

State two uses a plant makes of the glucose produced in photosynthesis.

Solution 3.3

Method: The equation, the factors, and reading the graph

Worked steps

any two of: stored as starch; made into cellulose; used in respiration; converted to sucrose for transport B1 B1.

Exam-style 3.4 ▪ 2 marks

A student measures the rate of photosynthesis of pondweed by counting the bubbles of gas released each minute at different light intensities, at two temperatures.

(a) Name the gas being collected, and explain why counting its bubbles measures the rate of photosynthesis.

(b) At low light intensity both lines rise steeply and lie on top of each other. Explain what this shows.

(c) At high light intensity the 25 °C line levels off higher than the 15 °C line. Explain why.

(d) The student repeats the experiment at 45 °C and the rate is very low. Explain this result.

(e) Suggest two variables the student must keep constant for the comparison to be valid.

(f) Estimate what would happen to the rate if the student added sodium hydrogencarbonate solution, which releases carbon dioxide, at high light intensity.

Solution 3.4

Method: The equation, the factors, and reading the graph

Worked steps

(a) Oxygen B1; it is a product of photosynthesis, so the faster the bubbles are released, the faster photosynthesis is happening B1.
(b) Light intensity is the limiting factor at this point B1, so increasing it increases the rate, and temperature makes no difference because it is not limiting here B1.
(c) Above a certain intensity light is no longer the limiting factor, so both lines level off B1; at 25 °C the enzymes controlling photosynthesis work faster than at 15 °C B1, so the rate at which the plant can use the light is higher, and temperature was limiting the 15 °C line B1.

Solution 3.4

(d) The enzymes have been denatured by the high temperature **B1**; their active sites have changed shape so the substrate no longer fits, and the reaction almost stops **B1**.
(e) Any two of: the distance of the lamp, or light intensity when it is not the variable; the concentration of carbon dioxide; the species and mass of pondweed; the volume of water; the time counted **B2**.
(f) The rate would increase **B1**, because at high light intensity carbon dioxide is the limiting factor, and supplying more of it removes that limit **B1**.