Exercise walk-through

4.1 Photosynthesis and limiting factors (4.4.1, RP6)

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Photosynthesis

- **Photosynthesis** happens in the **chloroplasts** of plant cells and algae.
- Green **chlorophyll** absorbs light energy, which is used to turn carbon dioxide and water into **glucose**, with oxygen as a by-product.

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

Photosynthesis (2)

- Photosynthesis is an **endothermic** reaction: energy is transferred from the surroundings, as light, to the **chloroplasts**.
- **Worked example 1.** Three leaves on a plant were treated for two days: leaf A was covered with black paper, leaf B was sealed in a clear plastic bag with a chemical that absorbs carbon dioxide, and leaf C was left uncovered.

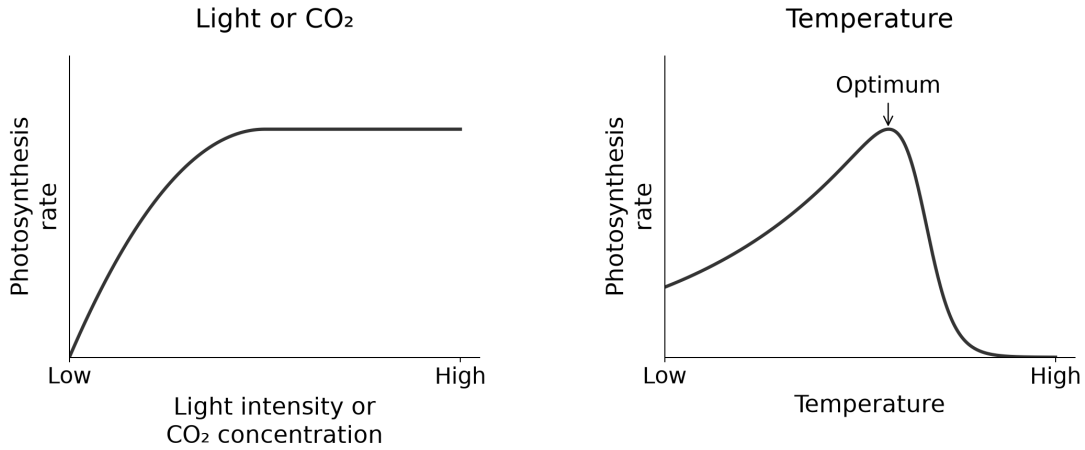
$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

The rate of photosynthesis

- **light intensity** , because light supplies the energy;
- carbon dioxide concentration, because carbon dioxide is a reactant;
- temperature, because photosynthesis is controlled by enzymes;
- the amount of **chlorophyll**, because chlorophyll absorbs the light.

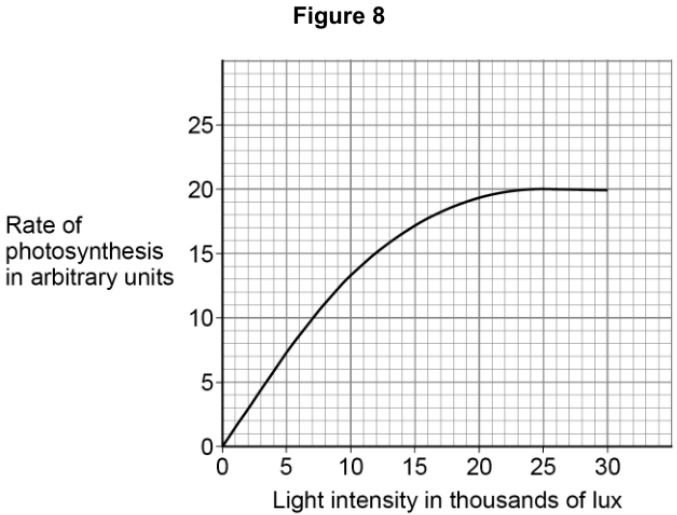
$$\text{light intensity} \propto \frac{1}{\text{distance}^2}$$

Figure: The rate of photosynthesis



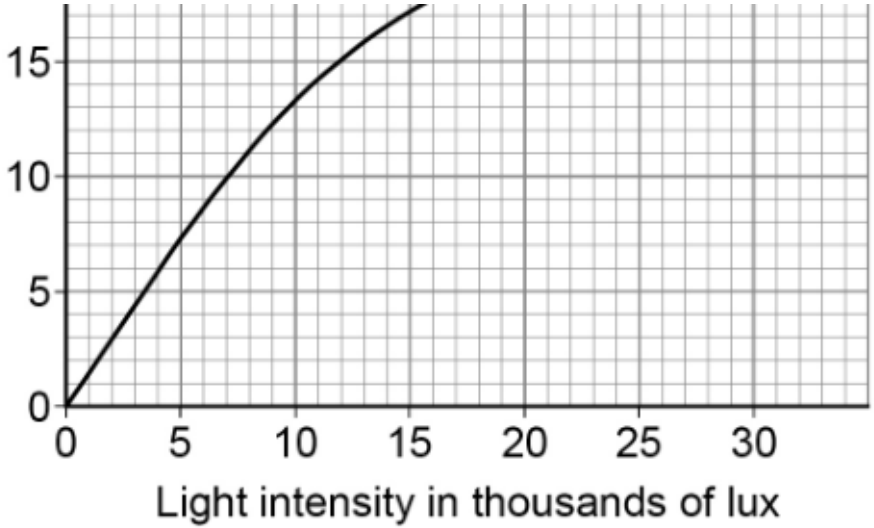
- Rate rises with **light intensity** or carbon dioxide until another factor limits it; with temperature it rises to an **optimum**, then falls as enzymes **denature**
- Read the axes and units first.

Figure: The rate of photosynthesis (2)



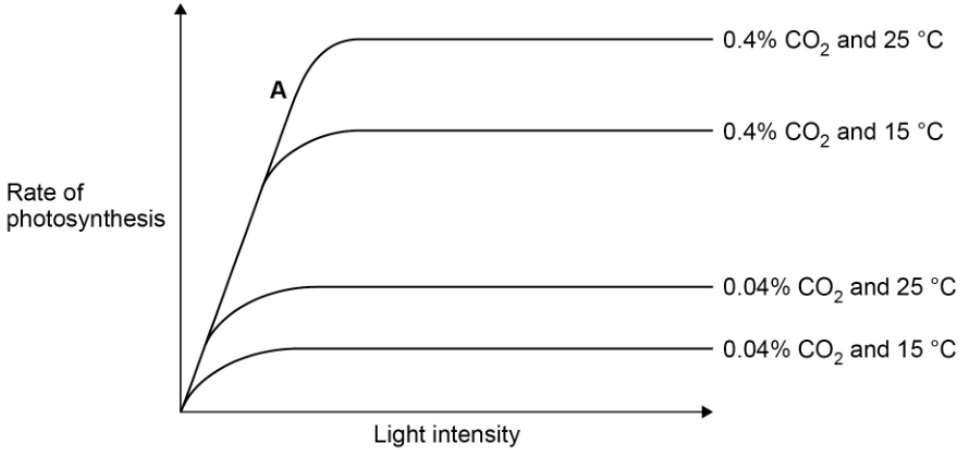
- Rate of photosynthesis against **light intensity** in thousands of lux (AQA GCSE Biology Paper 1H, June 2023, Figure 8)
- Read the axes and units first.

Figure: The rate of photosynthesis (3)



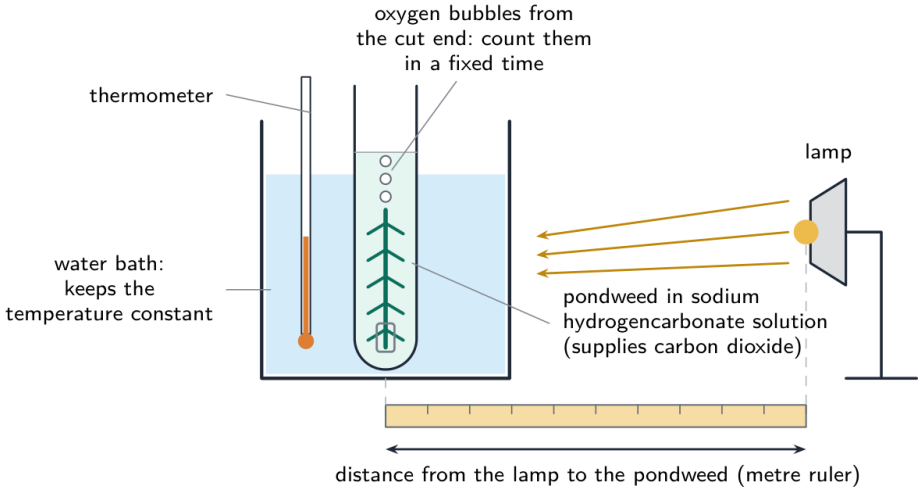
- The straight part of the same graph, enlarged
- Read the axes and units first.

Figure: The rate of photosynthesis (4)



- Rate of photosynthesis against **light intensity** at two temperatures and two carbon dioxide concentrations (AQA GCSE Biology Paper 1H, June 2024, Figure 7)
- Read the axes and units first.

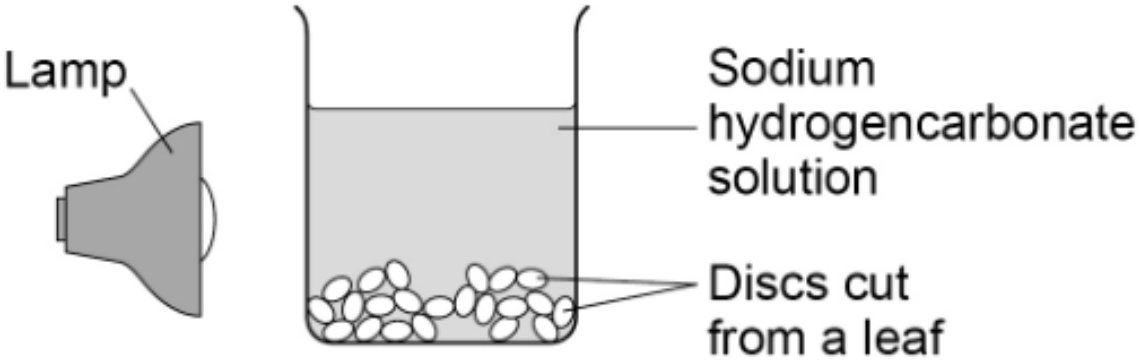
Figure: The rate of photosynthesis (5)



- Counting oxygen bubbles from **pondweed** at a measured distance from a lamp (not to scale)
- Match each part of the diagram to the text.

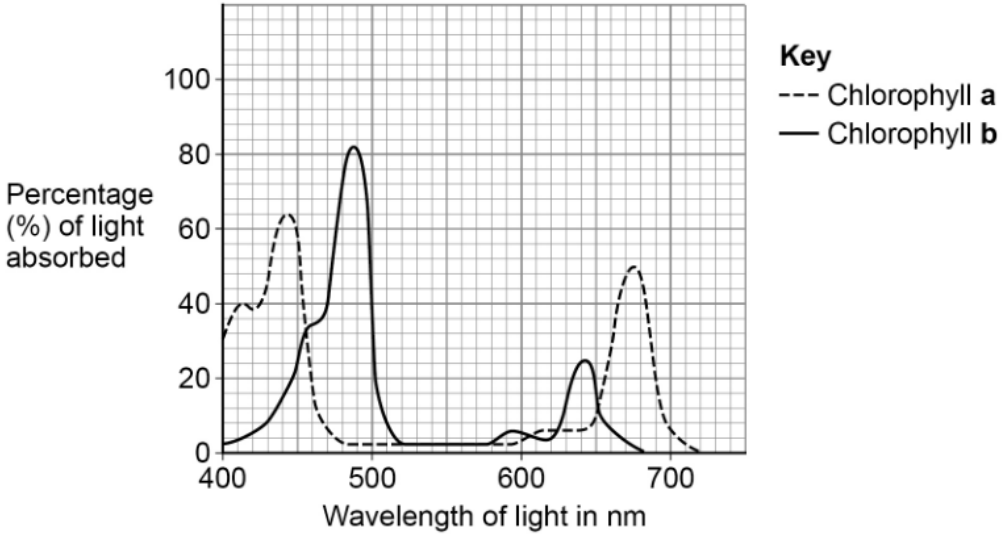
Figure: The rate of photosynthesis (6)

Figure 9



- Leaf discs in **sodium hydrogencarbonate** solution under coloured light (AQA GCSE Biology Paper 1H, June 2023, Figure 9)
- Match each part of the diagram to the text.

Figure: The rate of photosynthesis (7)



- Light absorbed by **chlorophyll** a and chlorophyll b at different wavelengths (AQA GCSE Biology Paper 1H, June 2023, Figure 10)
- Read the axes and units first.

How plants use glucose

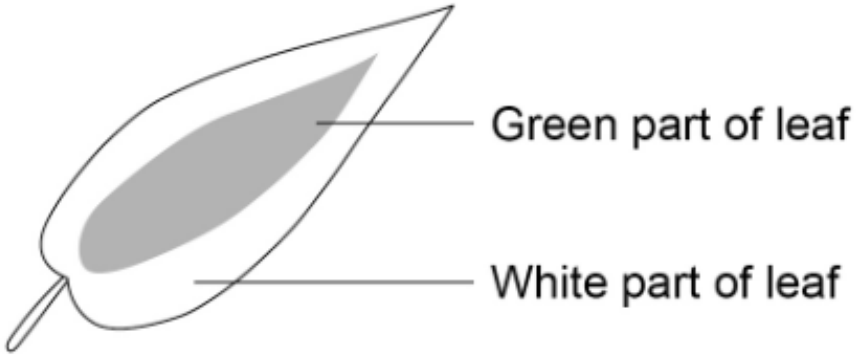
- for respiration, to release energy;
- to make **starch**, which is insoluble, for storage;
- to make fats and oils for storage, especially in seeds;

How plants use glucose (2)

- to make **cellulose** , which strengthens cell walls;
- to make **amino acids** , which are built into proteins. This also needs **nitrate ions** absorbed from the soil.

Figure: How plants use glucose

Figure 6



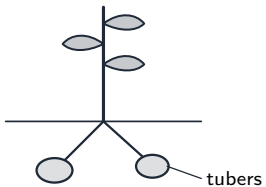
- A variegated leaf: the grey part is green and the white part has no **chlorophyll** (AQA GCSE Biology Paper 1H, June 2024, Figure 6)
- Match each part of the diagram to the text.

Exercises 2.1·2.2

2.1 Complete the word equation for photosynthesis. [2]

$$\square + \text{water} \xrightarrow{\text{light}} \text{glucose} + \square$$

2.2 Give **two** ways a plant uses the glucose it makes. [2]



Exercises 2.1·2.2

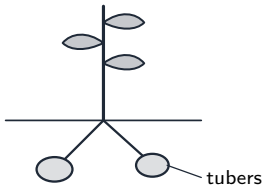
2.1 Complete the word equation for photosynthesis. [2]

$$\square + \text{water} \xrightarrow{\text{light}} \text{glucose} + \square$$

2.1

- carbon dioxide; oxygen

2.2 Give **two** ways a plant uses the glucose it makes. [2]

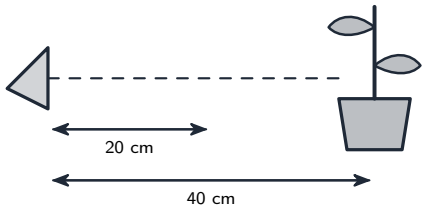


2.2

- any two: respiration; stored as starch; makes cellulose for cell walls; makes fats or oils; makes amino acids (proteins)

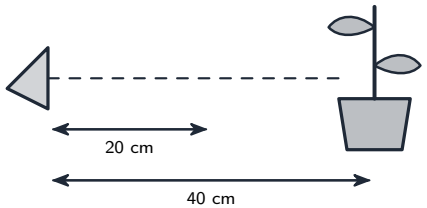
Exercise 2.3

2.3 A lamp is moved from 20 cm to 40 cm away from a plant. By what factor does the light intensity change? [2]



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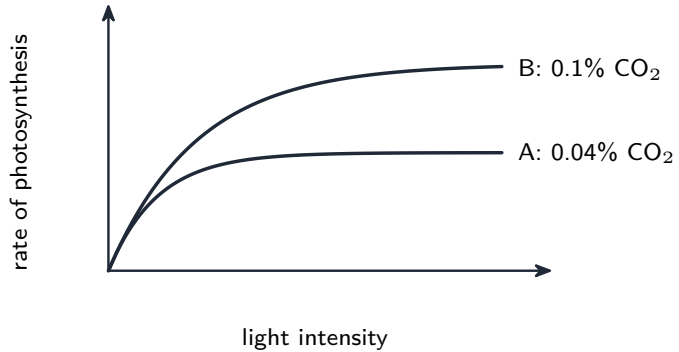


2.3

- the distance doubles; intensity $\propto \frac{1}{d^2}$; it falls to $\mathbf{\frac{1}{4}}$

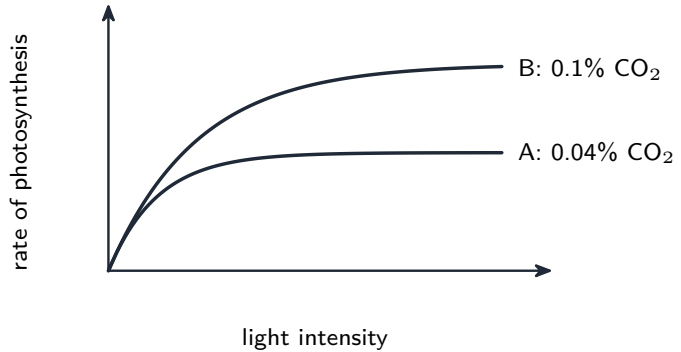
Exercise 3.1

3.1 The graph shows the rate of photosynthesis at different light intensities, at two carbon dioxide concentrations. Explain the shape of line A. [3]



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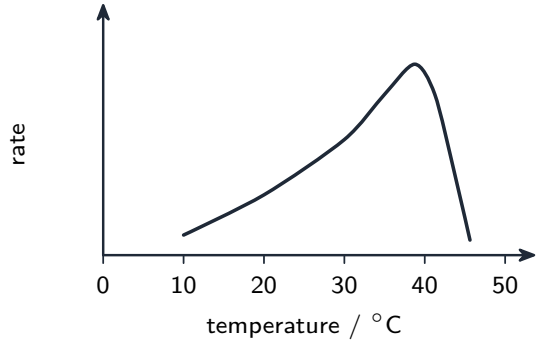


3.1

- at first the rate rises with light intensity: light is limiting
- then the line levels off: more light has no effect
- another factor limits the rate, e.g. carbon dioxide (line B is higher)

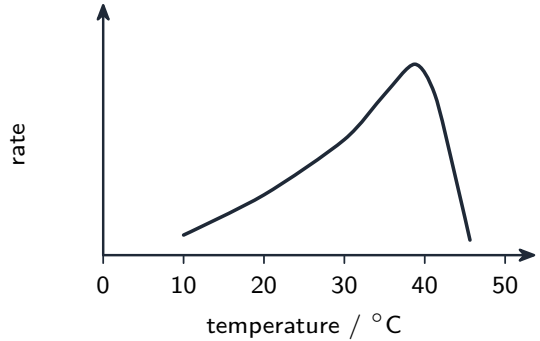
Exercise 3.2

3.2 The rate of photosynthesis increases from 10 °C to 35 °C, then falls quickly above 40 °C. Explain why. [3]



Exercise 3.2

3.2 The rate of photosynthesis increases from 10 °C to 35 °C, then falls quickly above 40 °C. Explain why. [3]



3.2

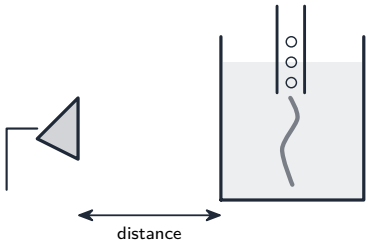
- photosynthesis is controlled by enzymes
- warmer molecules move faster and collide more often, so the rate rises
- above about 40 °C the enzymes are denatured, so the rate falls

Exercise 3.3 (a)

3.3 A student counts the bubbles of oxygen given off by pondweed with a lamp at different distances.

distance / cm	**10**	**20**	**30**	**40**	**50**
bubbles per minute	60	32	15	8	5

(a) Calculate the relative light intensity at 20 cm. Use intensity $= \frac{10\,000}{d^2}$. [2]

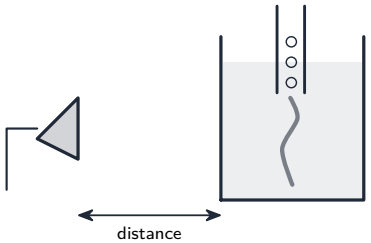


Exercise 3.3 (a)

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(a) Calculate the relative light intensity at 20 cm. Use intensity $= \frac{10\,000}{d^2}$. [2]



(a) $\frac{10\,000}{20^2} = \frac{10\,000}{400} = \mathbf{25}$

Exercise 3.3 (b)

3.3 A student counts the bubbles of oxygen given off by pondweed with a lamp at different distances.

distance / cm	**10**	**20**	**30**	**40**	**50**
bubbles per minute	60	32	15	8	5

(b) Describe the pattern in the results and explain it. [3]

Exercise 3.3 (b)

3.3 A student counts the bubbles of oxygen given off by pondweed with a lamp at different distances.

distance / cm	**10**	**20**	**30**	**40**	**50**
bubbles per minute	60	32	15	8	5

(b) Describe the pattern in the results and explain it. [3]

(b) the further away the lamp, the fewer bubbles; the light intensity falls as the distance increases (inverse square law); light is the limiting factor, so less photosynthesis and less oxygen

Exercise 3.3 (c)

3.3 A student counts the bubbles of oxygen given off by pondweed with a lamp at different distances.

distance / cm	**10**	**20**	**30**	**40**	**50**
bubbles per minute	60	32	15	8	5

(c) Give **two** variables the student should control. Explain why one of them matters. [2]

Exercise 3.3 (c)

3.3 A student counts the bubbles of oxygen given off by pondweed with a lamp at different distances.

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(c) Give **two** variables the student should control. Explain why one of them matters. [2]

(c) any two: temperature; carbon dioxide concentration; the same piece of pondweed; a reason, e.g. temperature changes enzyme activity

Exercise 3.3 (d)

3.3 A student counts the bubbles of oxygen given off by pondweed with a lamp at different distances.

distance / cm	**10**	**20**	**30**	**40**	**50**
bubbles per minute	60	32	15	8	5

(d) A farmer grows tomatoes in a greenhouse. Explain how the farmer can increase the yield, and why the farmer must think about cost. [6]

Exercise 3.3 (d)

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(d) points to include:

- heaters keep the temperature near the best for the enzymes
- lamps give more light for longer each day
- burning paraffin adds carbon dioxide
- more photosynthesis gives more glucose for growth, so more tomatoes
- raising one factor helps only until another limits the rate; the extra yield must be worth more than the cost

Levels: **5–6** a full, logical answer with correct biology and correct terms; **3–4** several correct points, partly linked; **1–2** one or two relevant points.