

Exercise walk-through

# 22.1

## Photosynthesis and limiting factors

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International Baccalaureate · IB Diploma · Biology · HL

# 22.1 Photosynthesis and limiting factors

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Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_ **Total: 10 marks**

**KEY WORDS**    photosynthesis                      • limiting factor

# Objective

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Photosynthesis and limiting factors. Original classroom practice for IB HL; not an official IB paper.

## 1 Key knowledge and worked examples

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### ■ What would explain this observation?

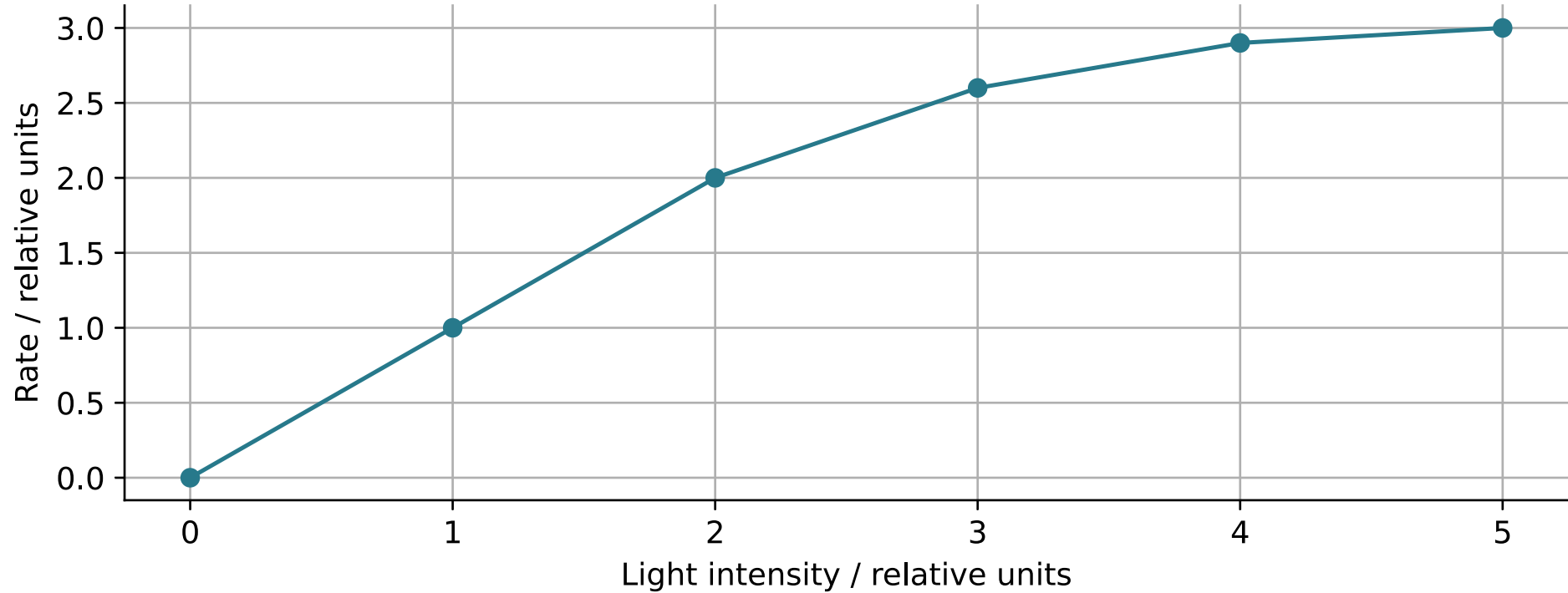
- A brighter lamp does not always produce more oxygen from pondweed. Another factor may limit the process when light is already sufficient.

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## ■ Build the model

- **Photosynthesis** transfers energy from light into chemical stores.
- Carbon dioxide and water form carbohydrate, releasing oxygen.
- Chlorophyll absorbs light; light intensity, temperature and carbon dioxide supply can affect rate.

- **limiting factor** : A factor whose shortage restricts rate.
- photosynthesis: Light-driven formation of carbohydrate.



## ■ Choose evidence that can test it

- Change only one factor when testing a limiting factor.
- At low light, extra light may increase rate.
- At a plateau, the changed factor is no longer the main limit in that range; the graph alone does not identify which other factor is limiting.

**In the lab:** Measure collected gas volume over a fixed time instead of assuming all bubbles have the same volume. Control temperature, plant size and carbon dioxide supply. Allow the plant to adjust before each reading and repeat.

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## ■ Work from known quantities

- Known: 6.0 cubic centimetres of gas are collected in 3.0 minutes.

- Use rate = volume/time.
- Rate =  $6.0/3.0 = 2.0$  cubic centimetres per minute.
- Bubble counts can be a rough proxy, but bubbles of different size make comparisons less reliable.

**Your turn:** 9.0 cubic centimetres of gas are collected in 3.0 minutes. Find the rate.

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■ **Check the conclusion and its limits**

- Moving a lamp changes light and may also change temperature.
- A photosynthesis experiment needs control of heating, not just a ruler.

**Not true:** All oxygen bubbles have exactly the same volume. Bubbles from pondweed vary in size and composition, so a bubble count is only a rough proxy for gas volume.

Measuring collected volume, as in the calculation above, is more reliable.

**Key:**

- Photosynthesis transfers energy from light into chemical stores.
- Change only one factor when testing a limiting factor.
- Watch for: moving a lamp changes light and may also change temperature.

■ **Write from a gas rate of 2.5 cubic centimetres per minute**

- 10.0 cubic centimetres of gas are collected in 4.0 minutes.

- Find the rate. At a plateau, the factor you changed is no longer the main limit.



## Exercises 2.1·2.3

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**2.1** A rate-light graph reaches a plateau. What follows? Choose one answer.

- **A** Another factor may now limit the rate
- **B** Light is still certainly the only limit
- **C** Photosynthesis has stopped

[1]

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**2.2** 9.0 cubic centimetres of gas are collected in 3.0 minutes. Find the rate. Show the relation, substitution and units. [2]

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**2.3** Decide whether this claim is true and justify: Bubbles from pondweed vary in size and composition, so a bubble count is only a rough proxy for gas volume. [2]

## Exercises 2.1-2.3

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**2.1** A rate-light graph reaches a plateau. What follows? Choose one answer.

- **A** Another factor may now limit the rate
- **B** Light is still certainly the only limit
- **C** Photosynthesis has stopped

[1]

**2.1 A** On the plateau, adding more light no longer raises the rate, so light is no longer the limiting factor; another factor such as carbon dioxide or temperature may now limit it. Photosynthesis has not stopped - the rate is constant, not zero.

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**2.2** 9.0 cubic centimetres of gas are collected in 3.0 minutes. Find the rate. Show the relation, substitution and units.

[2]

**2.2**  $\text{rate} = 9.0 / 3.0 = 3.0 \text{ cm}^3/\text{min}$ .

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**2.3** Decide whether this claim is true and justify: Bubbles from pondweed vary in size and composition, so a bubble count is only a rough proxy for gas volume.

[2]

**2.3** True. True. Bubbles from pondweed vary in size and composition, so a bubble count is only a rough proxy for gas volume. Measuring collected volume, as in the calculation above, is more reliable.

## Exercises 2.4·3.1

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**2.4** A factor whose shortage restricts rate: write the technical term. [1]

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**3.1** A fictional plant produces  $8 \text{ cm}^3$  in 4 min at low light and  $12 \text{ cm}^3$  in 4 min at high light. Explain the change, and why an unchanged rate after a further light increase would not identify the next limiting factor. [4]

## Exercises 2.4·3.1

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**2.4** A factor whose shortage restricts rate: write the technical term. [1]

**2.4** limiting factor. limiting factor means A factor whose shortage restricts rate.

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**3.1** A fictional plant produces  $8 \text{ cm}^3$  in 4 min at low light and  $12 \text{ cm}^3$  in 4 min at high light. Explain the change, and why an unchanged rate after a further light increase would not identify the next limiting factor. [4]

**3.1** Rates  $2$  and  $3 \text{ cm}^3/\text{min}$ , a 50% increase. A plateau suggests another limitation under those conditions, but does not identify it. Control temperature and carbon dioxide, allow equilibration and repeat.