

Rate of photosynthesis

4.4.1.2 · Biology · revision notes

The factors that affect the rate of photosynthesis, the idea of a limiting factor, and the required practical on light intensity. Expect graphs, calculations and practical questions, including 6-mark method answers.

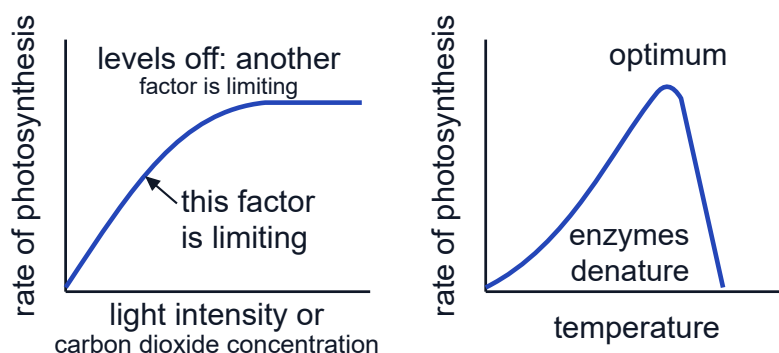
Key facts

- Factors: temperature, light intensity, carbon dioxide concentration, amount of chlorophyll
- Rate = volume of oxygen (or number of bubbles) $\div$ time
- Sodium hydrogencarbonate solution supplies carbon dioxide in the pondweed practical
- Limiting factor = the factor in shortest supply, which stops the rate increasing
- Too hot: enzymes denature, so the rate falls

Notes

Factors and limiting factors

- Four factors affect the rate of photosynthesis: **temperature**, **light intensity**, **carbon dioxide concentration** and the **amount of chlorophyll**.
- A **limiting factor** is the one in shortest supply. It holds the rate back: increasing it increases the rate, but increasing the other factors does not.
- Light intensity and carbon dioxide: the rate rises as the factor increases, then levels off when a different factor becomes limiting.
- Temperature: photosynthesis is controlled by enzymes, so the rate rises up to an optimum and then falls steeply as the enzymes denature.

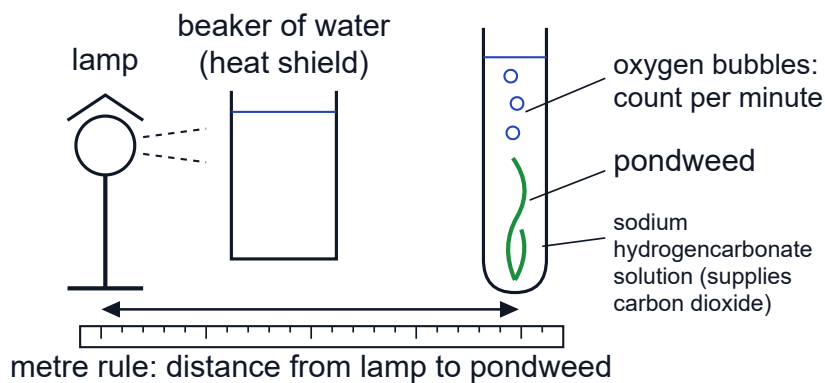


Left: the rate levels off when another factor limits it. Right: past the optimum, enzymes denature.

- Chlorophyll absorbs the light, so leaves with less chlorophyll (for example, leaves damaged by tobacco mosaic virus) photosynthesise more slowly.

Required practical: light intensity and pondweed

- Put pondweed in a boiling tube of dilute sodium hydrogencarbonate solution, which supplies carbon dioxide.
- Place a lamp 10 cm away, measured with a metre rule, and leave the pondweed a few minutes to adjust.
- Count the oxygen bubbles released in one minute, or collect the gas in an upturned measuring cylinder for a set time.
- Repeat at 20, 30, 40 and 50 cm, three times at each distance, and calculate means.
- Control the temperature (LED lamp, or a beaker of water as a heat shield), the carbon dioxide concentration and the piece of pondweed. Darken the room so the lamp is the only light.
- Rate of photosynthesis = volume of oxygen (or number of bubbles) ÷ time.



Move the lamp to change the distance, and count the bubbles each time.

How to answer each type of question

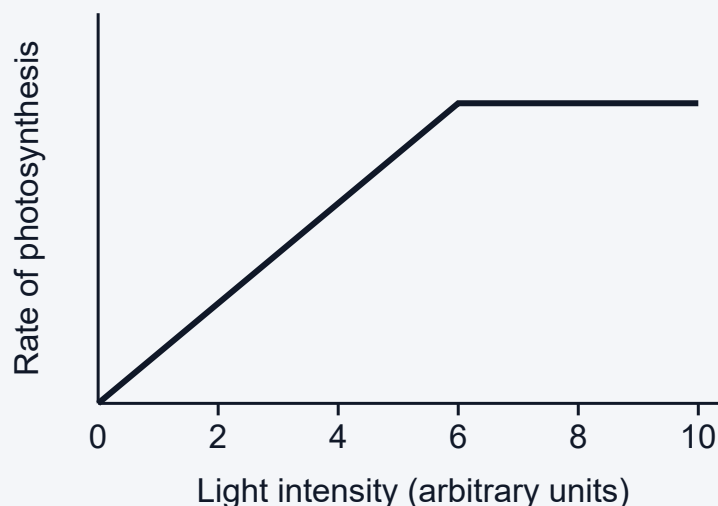
Describe and explain a rate graph with one factor

2 to 3 marks

Grade 5

1. Describe the rising part, then the flat part, quoting values from the graph.
2. Explain the rising part: the factor on the x-axis is limiting.
3. Explain the flat part: name another factor that is now limiting.

Example. The graph shows how the rate of photosynthesis of a plant changes with light intensity.



Explain the shape of the graph.

Model answer. From 0 to 6 units, light intensity is the limiting factor (1), so increasing it increases the rate of photosynthesis (1). Above 6 units another factor, such as carbon dioxide concentration or temperature, is limiting, so the rate stops increasing (1).

Don't lose marks

- ✗ Writing 'more light, so the plant grows more' without saying that light is the limiting factor and the rate of photosynthesis increases.
- ✗ Explaining a flat part of a graph with 'the plant is at its maximum'. Name another factor that is now limiting, such as carbon dioxide concentration or temperature.
- ✗ Saying high temperatures 'kill' the enzymes. Say the enzymes are denatured.
- ✗ In the practical, forgetting that a hot lamp warms the water, so temperature changes as well as light intensity.

More tips

Memory tricks

- Limiting factor = the weakest link: improve it and the rate rises; improve anything else and nothing changes.
- Graph rule: rising line → the x-axis factor is limiting; flat line → something else is limiting.
- Sense check: moving the lamp further away must give a lower light intensity and a lower (or equal) rate.
- The temperature curve has the same shape as an enzyme activity curve (rise, peak at the optimum, steep fall) because enzymes control photosynthesis.

Exam technique

- When asked which factor is limiting, name one factor and back it up with evidence from the graph or table.
- In 6-mark method answers, cover what you change, what you measure, at least two control variables and repeats. Write the steps in order.
- Use the full terms: 'light intensity', not just 'light', and 'carbon dioxide concentration', not 'more air'.

What each grade needs

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

Grade 3

Name the factors affecting photosynthesis rate

Temperature, light intensity, carbon dioxide concentration and the amount of chlorophyll.

Grade 4

Explain what a limiting factor is

The factor in shortest supply, which stops the rate of photosynthesis increasing; raising it raises the rate.

Grade 4

Describe the light intensity required practical

Put pondweed at different distances from a lamp and count the oxygen bubbles, or measure the volume of oxygen, in a set time.

Grade 5

Explain the effect of temperature

The rate rises up to an optimum temperature, then falls quickly because the enzymes that control photosynthesis denature.

Grade 5

Explain a one-factor rate graph

Where the line rises the factor on the x-axis is limiting; where it levels off another factor has become limiting.

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