Exercise walk-through

Investigation of limiting factors ▪ 13.2

eXercise

You must be able to

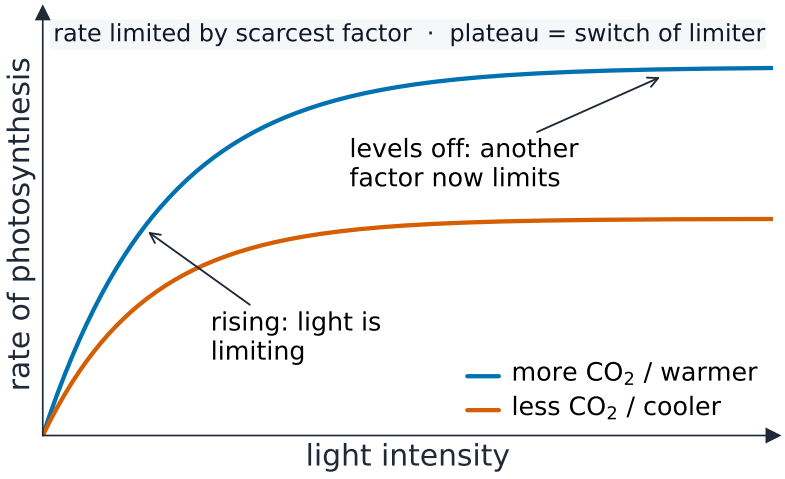
- explain the effects of light intensity, carbon dioxide concentration and temperature on rate
- read a rate graph to identify which factor is limiting
- describe investigations using redox indicators and whole aquatic plants

Method — Limiting factors

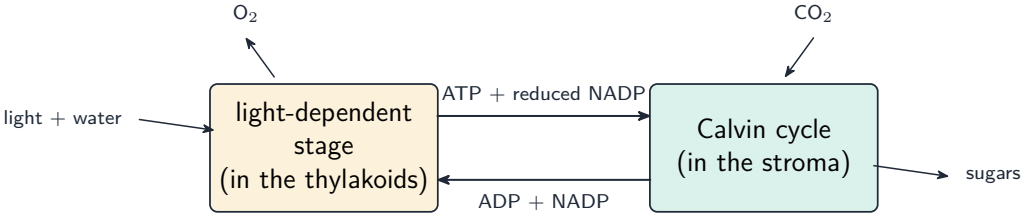
A **limiting factor** 限制因素 is the one in shortest supply that holds back the rate.

- raising **light intensity** speeds the rate until another factor becomes limiting.
- raising **CO concentration** speeds the rate until another factor becomes limiting.
- raising **temperature** speeds the rate to an optimum; too high and the enzymes denature.

Method — Limiting factors



Method — Limiting factors



Limiting factors act on the two stages of photosynthesis

Method — Investigations

- a redox **indicator 指示剂** (DCPIP or methylene blue) with a chloroplast suspension loses colour as the light-dependent stage works — time the colour loss at different light intensities or wavelengths.
- with a whole **aquatic plant 水生植物** (e.g. *Elodea*), count the oxygen bubbles per minute, or collect the gas, under different conditions. Use a control and repeat for reliability.

Practice 2.1 ▪ 3 marks

Name **three** factors that can limit the rate of photosynthesis.

Solution 2.1

Method: Limiting factors

Worked steps

light intensity; carbon dioxide concentration; temperature **B1** *each*.

Practice 2.2 ▪ 1 mark

State how you could measure the rate of photosynthesis of pondweed.

Solution 2.2

Method: Limiting factors

Worked steps

count the oxygen bubbles given off per minute (or collect/measure the volume of oxygen) B1.

Exam-style 3.1 ▪ 1 mark

On a rate-against-light-intensity graph, the curve rises then levels off. At the levelled-off part, the limiting factor is:

A light intensity

B something other than light (e.g. CO_2 or temperature)

C the amount of chlorophyll only

D oxygen concentration

Solution 3.1

Method: Limiting factors

A light intensity

B something other than light (e.g. CO or temperature) ✓

C the amount of chlorophyll only

D oxygen concentration

Worked steps

B. When the curve levels off, light is no longer limiting — another factor is.

Exam-style 3.2 ▪ 1 mark

Why does the rate of photosynthesis fall at very high temperatures?

A too much CO dissolves

B the enzymes denature

C light cannot reach the leaf

D water freezes

Solution 3.2

Method: Limiting factors

A too much CO dissolves

B the enzymes denature ✓

C light cannot reach the leaf

D water freezes

Worked steps

B. Above the optimum the enzymes denature, so the rate falls.

Exam-style 3.3 ▪ 2 marks

A student counts oxygen bubbles from pondweed at different distances from a lamp.
(a) Explain why moving the lamp closer increases the bubble rate (up to a point).
(b) State **two** variables the student must control to make this a fair test.

Solution 3.3

Method: Investigations

Worked steps

(a) moving the lamp closer raises the light intensity **M1**, so more light energy is available for the light-dependent stage, increasing the rate **A1**.
(b) any two: temperature; CO concentration; same piece of pondweed; same time counted **B1** *each*.

Exam-style 3.4 ▪ 3 marks

Explain how a redox indicator such as DCPIP can be used to measure the rate of the light-dependent stage.

Solution 3.4

Method: Investigations

Worked steps

add DCPIP to an illuminated chloroplast suspension B1; the dye is reduced by the light-dependent stage and loses its blue colour B1; time how long the colour takes to disappear at each condition — faster loss means a faster rate B1.