

Gas exchange in flowering plants

Revision notes · Diffusion of carbon dioxide and oxygen in leaves, stomata, net gas exchange by day and night, and the hydrogen-carbonate indicator practical.

For Pearson Edexcel International GCSE Biology 4BI1 and Science (Double Award) 4SD0. **Biology only** is not in the Double Award and is only examined on Paper 2.

Gas exchange in flowering plants Spec 2.40B, 2.41B, 2.43B-2.45B, 2.70

Gas exchange, diffusion and stomata Spec 2.40B, 2.41B, 2.43B, 2.70

Waste products of metabolism

Metabolism is all the chemical reactions in a cell. Two of its products are waste products in a plant.

Carbon dioxide is a waste product of respiration. **Oxygen** is a waste product of photosynthesis. Both leave the plant from the leaves by diffusion through the **stomata**.

Biology only

Diffusion in gas exchange

Biology only

Diffusion is the net movement of particles from a region of higher concentration to a region of lower concentration, down a concentration gradient. Gases move into and out of leaves by diffusion, so no energy is needed to move them.

Biology only

Plants use and make both gases. Gas exchange of carbon dioxide and oxygen therefore depends on two processes at the same time.

Biology only

Gas exchange in relation to respiration and photosynthesis

Process	Takes in	Gives out	When it happens
Respiration	Oxygen	Carbon dioxide	All the time, in light and dark
Photosynthesis	Carbon dioxide	Oxygen	Only when there is light

Biology only

Gases reach the mesophyll cells through the stomata and the air spaces inside the leaf. How the structure of the leaf is adapted for gas exchange is covered in Leaf structure and adaptations.

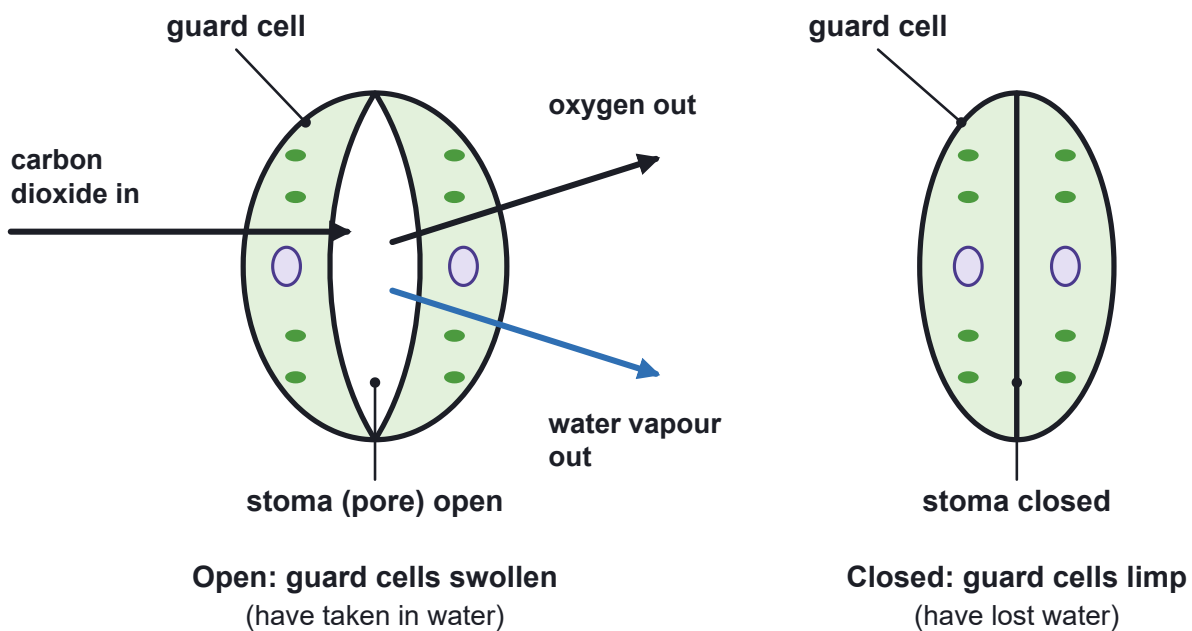
Biology only

The role of stomata

Biology only

A stoma is a pore in the leaf surface. It is surrounded by two **guard cells**. When the guard cells take in water they swell and the stoma opens. When they lose water they become limp and the stoma closes. Carbon dioxide enters and oxygen leaves through open stomata. Water vapour is also lost through them, so the plant closes its stomata when it loses too much water.

Biology only



Guard cells that take in water swell and **open** the stoma; guard cells that lose water go limp and **close** it.

Biology only

Exam tip: In the day, carbon dioxide diffuses into the leaf because photosynthesis uses it up, so its concentration inside the leaf is lower than in the air.

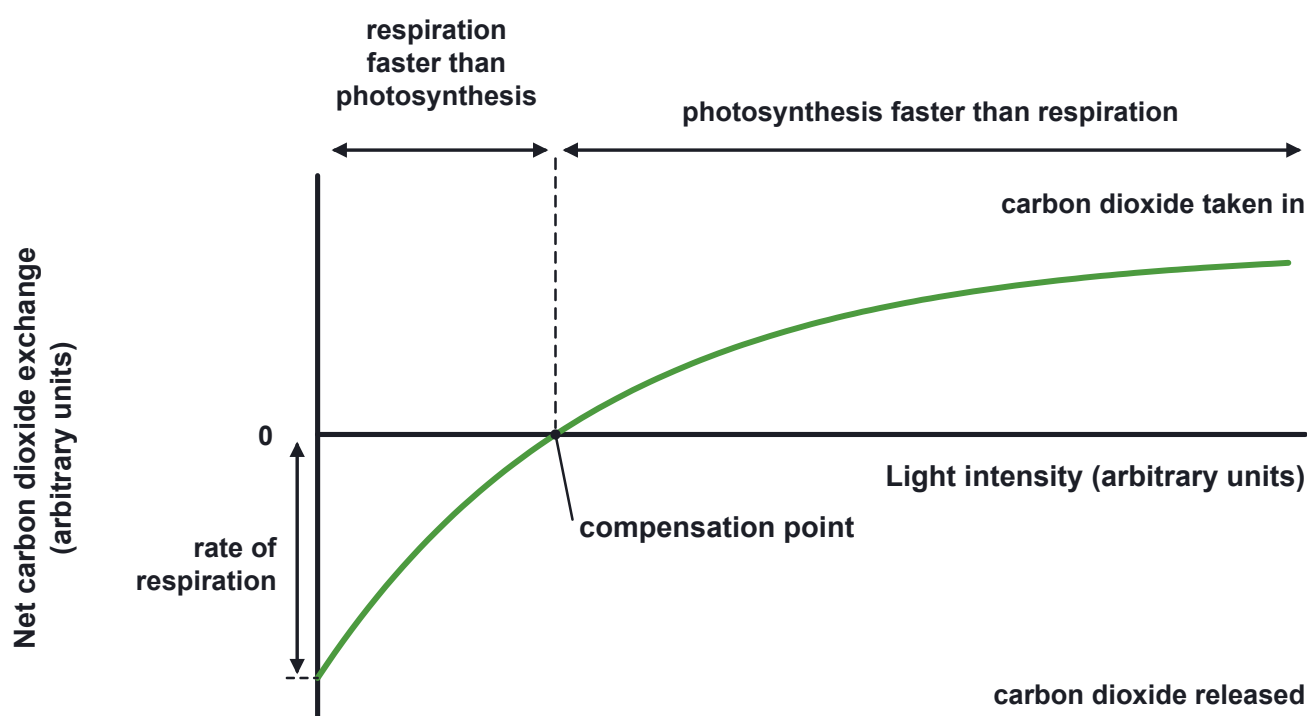
Net gas exchange by day and night Spec 2.44B Biology only

A plant respire **all the time**. It photosynthesises **only when there is light**. This means that the **net** exchange of carbon dioxide and oxygen with the air changes with the light intensity.

Net gas exchange at different light intensities			
Light	Rate of photosynthesis compared with respiration	Net exchange of carbon dioxide	Net exchange of oxygen
Darkness (night)	No photosynthesis, only respiration	Carbon dioxide released	Oxygen taken in
Dim light	Photosynthesis slower than respiration	Carbon dioxide released	Oxygen taken in
Compensation point	Photosynthesis equals respiration	None	None
Bright light (day)	Photosynthesis faster than respiration	Carbon dioxide taken in	Oxygen released

At the **compensation point** the carbon dioxide made in respiration is used up by photosynthesis, and the oxygen made in photosynthesis is used up by respiration. No gas moves in or out overall, but both processes are still happening.

As light intensity rises, the rate of photosynthesis rises while the rate of respiration stays about the same. A graph of net carbon dioxide uptake against light intensity therefore starts below zero (carbon dioxide released), crosses zero at the compensation point, then rises above zero.



Below the **compensation point** the plant releases carbon dioxide; above it, the plant takes carbon dioxide in.

Exam tip: Never say that plants only respire at night. They respire all the time. In the day the carbon dioxide from respiration is simply hidden by faster photosynthesis.

Practical: light and net gas exchange Spec 2.45B Biology only

Hydrogen-carbonate indicator changes colour as the carbon dioxide concentration of the air around it changes. It turns **yellow** when carbon dioxide rises and **purple** when carbon dioxide falls. You can use it to see whether a leaf takes in or releases carbon dioxide in different light intensities.

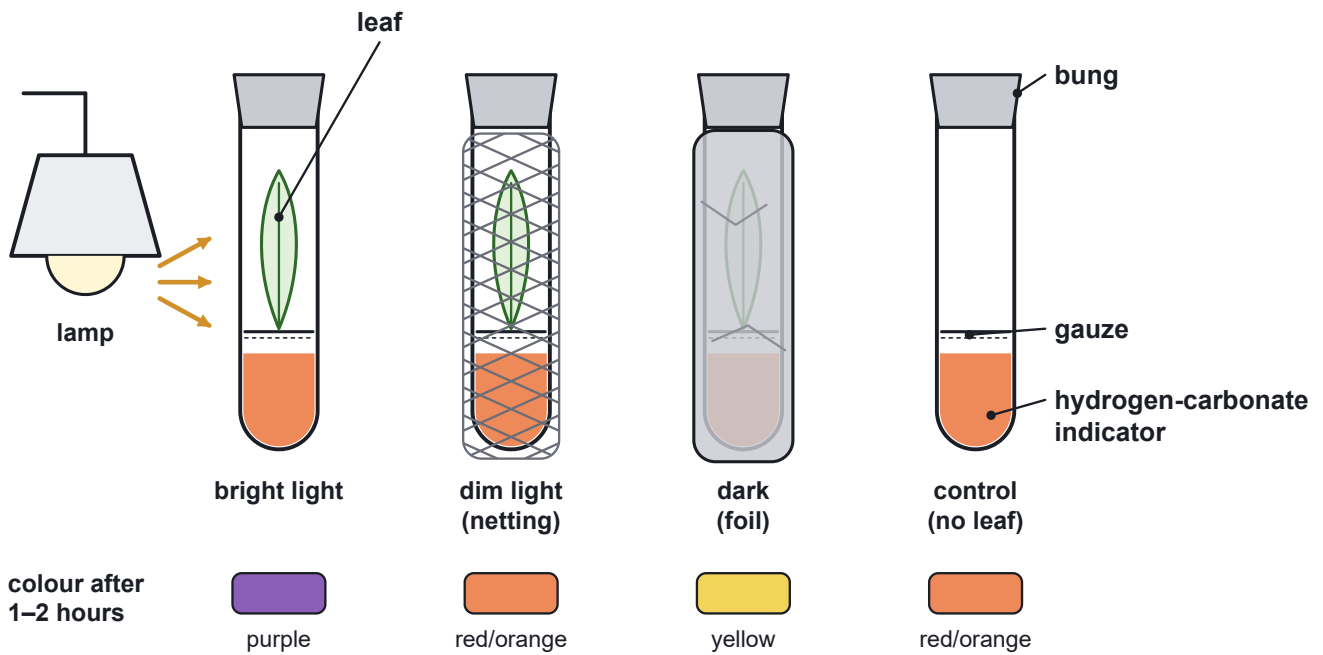
Colours of hydrogen-carbonate indicator	
Colour	Carbon dioxide concentration
Red/orange (starting colour)	Same as in normal air
Yellow	Higher than normal air (carbon dioxide has been added)
Purple	Lower than normal air (carbon dioxide has been removed)

1. Put the same volume of hydrogen-carbonate indicator into four boiling tubes.
2. Put a similar leaf (same size and mass) into three of the tubes, held above the indicator on gauze or a wire so it does not touch the liquid. Leave the fourth tube with no leaf as a control.
3. Seal each tube with a bung.
4. Place the first tube in bright light. Place the second in dim light (wrapped in one layer of gauze or netting). Wrap the third completely in foil so it is in darkness.
5. Leave all the tubes for the same time, for example one to two hours, at the same distance from the lamp. Do not breathe into the tubes, as this adds carbon dioxide.
6. Record the colour of the indicator in each tube.

Expected results		
Tube	Colour after the time	Explanation
Bright light	Purple	Photosynthesis faster than respiration, so net uptake of carbon dioxide
Dim light	Stays red/orange	Photosynthesis about equal to respiration, so no net change
Dark (foil)	Yellow	Only respiration, so net release of carbon dioxide
No leaf (control)	Stays red/orange	Shows the colour change is caused by the leaf

Variables in the investigation	
Type of variable	Example
Independent variable	Light intensity (bright, dim, dark)
Dependent variable	Colour of the hydrogen-carbonate indicator
Control variables	Size and mass of leaf, volume of indicator, time, temperature, distance from the lamp

Practical: Put a water tank (heat shield) between the lamp and the tubes so that heat from the lamp does not change the temperature. The lamp gets hot, so do not touch it. The dim light result depends on the light level: the indicator may turn slightly yellow or slightly purple.



Key

- purple: carbon dioxide lower than in normal air
- red/orange: carbon dioxide same as in normal air
- yellow: carbon dioxide higher than in normal air

Bright light: the indicator turns **purple** (carbon dioxide taken in). Dark: it turns **yellow** (carbon dioxide released).

Quick check

- Biology only** Name the process by which gases move into and out of a leaf.
- Biology only** What do guard cells do?
- Which gas is a waste product of photosynthesis and leaves through the stomata?
- Biology only** What is happening at the compensation point?
- Biology only** What colour does hydrogen-carbonate indicator turn when carbon dioxide is added?

Quick check answers

Gas exchange in flowering plants

1. Diffusion.
2. They open and close the stoma.
3. Oxygen.
4. The rate of photosynthesis equals the rate of respiration, so there is no net gas exchange.
5. Yellow.