

Light, dark and gas exchange in an aquatic plant

Investigate and describe the effect of light and dark conditions on gas exchange in an aquatic plant using hydrogencarbonate indicator solution

For Cambridge IGCSE Biology 0610 (and 0970, which has the same content). Teacher answers start on a new page.

Name

Date

Aim

To investigate how light and dark conditions affect the carbon dioxide concentration around an aquatic plant, using hydrogencarbonate indicator solution.

Background

An aquatic plant such as *Elodea* carries out **photosynthesis** and **respiration** at the same time. Photosynthesis takes in carbon dioxide and needs light. Respiration releases carbon dioxide and happens all the time, in the light and in the dark.

Hydrogencarbonate indicator solution changes colour with the concentration of carbon dioxide dissolved in it. It is **red** in equilibrium with the carbon dioxide in air, **yellow** when the carbon dioxide concentration is higher, and **purple** when it is lower.

In bright light the rate of photosynthesis is greater than the rate of respiration, so there is a net uptake of carbon dioxide. In the dark only respiration happens, so there is a net release of carbon dioxide.

Hypothesis

The indicator around *Elodea* in the light will turn purple and the indicator around *Elodea* in the dark will turn yellow, because photosynthesis needs light but respiration does not.

Variables

Independent	Light or dark conditions (tube wrapped in foil or not)
Dependent	The colour of the hydrogencarbonate indicator after 2 hours
Control	• Same volume of indicator (20 cm³) in each tube, red at the start • Same length and mass of <i>Elodea</i> in tubes 1 and 2 • Same temperature (use a water tank between the lamp and the tubes) • Same distance from the lamp for tubes 1 and 3 • Same time (2 hours)

Equipment

- 4 boiling tubes with bungs, in a rack
- Hydrogencarbonate indicator solution (red), about 100 cm³
- Fresh *Elodea*, two identical pieces about 4 cm long
- 25 cm³ measuring cylinder
- Forceps
- Aluminium foil
- Lamp, with a clamp stand
- Rectangular tank or large beaker of water as a heat shield
- Stop-clock

- Marker pen
- Eye protection

Risk assessment

Hazard	Risk	Precaution
Mains-powered lamp	The bulb gets hot and can burn skin. Water spilt near the lamp can cause a shock.	Do not touch the lamp. Keep water away from sockets and electrical equipment.
Hydrogencarbonate indicator solution	Low hazard but may irritate the eyes.	Wear eye protection and wash splashes off at once.
Glass boiling tubes	Cuts if broken.	Stand the tubes in a rack and push in bungs gently. Report any breakages to the teacher.
Pond plants	Pond water can contain microbes.	Wash your hands after handling the plants. Do not put the plants near your mouth.

Method

1. Put on eye protection. Label four boiling tubes 1 to 4 with a marker pen.
2. Use a measuring cylinder to put 20 cm³ of hydrogencarbonate indicator in each tube. Check that the indicator is red in all the tubes and record the colour.
3. Use forceps to put one piece of Elodea in tube 1 and an identical piece in tube 2. Push each piece down so that it is completely covered by the indicator.
4. Leave tubes 3 and 4 with no plant.
5. Put a bung in each tube at once, so that the tubes are airtight. Do not breathe into the tubes.
6. Wrap tubes 2 and 4 completely in aluminium foil so that no light can reach them.
7. Stand the four tubes in the rack at the same distance from the lamp, with the tank of water between the lamp and the tubes.
8. Switch on the lamp and start the stop-clock.
9. Leave the tubes for 2 hours.
10. After 2 hours, unwrap tubes 2 and 4 and immediately record the colour of the indicator in each tube.
11. Switch off the lamp, empty the tubes and wash your hands.

Results

Colour of the hydrogencarbonate indicator after 2 hours				
tube	conditions	colour at start	colour after 2 hours	change in carbon dioxide concentration
1	Elodea, light			
2	Elodea, dark			
3	No plant, light			
4	No plant, dark			

Exam questions 10 questions • 26 marks

1 State the colour of hydrogencarbonate indicator solution when the carbon dioxide concentration is (a) the same as in air, (b) higher than in air and (c) lower than in air. **[3 marks]**

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2 Tube 3 contained indicator but no plant and was left in the light. Explain why this tube was included. **[2 marks]**

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3 The indicator in the tube with Elodea in the light turned purple. Explain this result. **[3 marks]**

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4 The indicator in the tube with Elodea in the dark turned yellow. Explain this result. **[3 marks]**

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5 Give two variables that must be kept the same in tubes 1 and 2. **[2 marks]**

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6 Explain why bungs were put in the tubes. **[2 marks]**

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7 A student put a third piece of Elodea in dim light. The indicator stayed red. Explain this result. **[3 marks]**

8 A student says, 'Plants respire only in the dark.' Use the results to explain why this is not correct. **[2 marks]**

9 Suggest three ways in which the investigation could be improved. **[3 marks]**

10 A student wants to find out whether the colour change in the dark tube is caused by temperature. Describe how the student could show that it is not. **[3 marks]**

Teacher answers

Practical skill 7: Light, dark and gas exchange in an aquatic plant. The example results are practice data, not real measurements.

Example results

Example results (practice data), after 2 hours				
tube	conditions	colour at start	colour after 2 hours	change in carbon dioxide concentration
1	Elodea, light	Red	Purple	Decrease
2	Elodea, dark	Red	Yellow	Increase
3	No plant, light	Red	Red	None
4	No plant, dark	Red	Red	None

Conclusion

In the light the indicator turned purple, so the carbon dioxide concentration decreased: photosynthesis was faster than respiration and the plant took up more carbon dioxide than it released. In the dark the indicator turned yellow, so the carbon dioxide concentration increased: there was no photosynthesis but respiration continued and released carbon dioxide. The tubes without a plant stayed red in both the light and the dark, which shows that the colour changes were caused by the plant and not by the light, the foil or the air in the tube.

Errors and improvements

Error	Effect on the results	Improvement
Heat from the lamp warms the tubes.	Temperature affects the rates of photosynthesis and respiration, so the colour change is not due to light alone.	Place a water tank between the lamp and the tubes, or use an LED lamp.
Breathing into the tubes or leaving the bungs out adds carbon dioxide from the breath or air.	The indicator turns yellow when it should not.	Put the bungs in quickly and keep breath away from the tubes.
Pieces of Elodea of different size are used in the two tubes.	The rates of photosynthesis and respiration differ, so the tubes cannot be compared fairly.	Use pieces of the same mass and length from the same plant.
The colours are judged by eye.	Different people may record different colours, especially for small changes.	Compare each tube with standard colours or use a colorimeter.
The indicator is not red at the start.	A colour change could be wrongly interpreted.	Check the colour at the start and bubble air through the indicator to bring it to red before use.

Mark scheme

One mark for each point unless a maximum is given. Words in brackets are not needed for the mark.

1. [3]

- (a) red (1)
- (b) yellow (1)
- (c) purple (1)

2. [2]

- it is a control (1)
- to show that the colour change in the other tubes is caused by the plant, not by the light or the air (1)

3. [3]

- purple shows that the carbon dioxide concentration decreased (1)
- photosynthesis used carbon dioxide (1)
- rate of photosynthesis was greater than rate of respiration (1)

4. [3]

- no light so no photosynthesis (1)
- respiration continued and released carbon dioxide (1)
- so carbon dioxide concentration increased (1)

5. [2]

- size / mass of Elodea (1)
- volume of indicator (1)
- temperature / time / distance from lamp (1)
- Max 2

6. [2]

- so that carbon dioxide from the air could not enter the tubes / so that carbon dioxide could not escape (1)
- so that the colour changes are caused only by the plant (1)

7. [3]

- no net change in carbon dioxide concentration (1)
- rate of photosynthesis equals rate of respiration (1)
- carbon dioxide released by respiration is used in photosynthesis (1)

8. [2]

- plants respire all the time / in the light and dark (1)
- in the light, carbon dioxide from respiration is used for photosynthesis / photosynthesis is faster so net uptake (1)

9. [3]

- use a colorimeter / colour standards to measure the colour (1)
- repeat and compare results (1)
- use a heat shield / LED lamp (1)
- use more pieces of Elodea / test different light intensities (1)
- Max 3

10. [3]

- place a thermometer in each tube / measure temperature of the tubes at start and end (1)
- use a water tank / keep tubes at the same temperature (1)
- result: temperature did not change / same in all tubes, or tubes with no plant (control) stay red (1)

Exam tips

- Learn the three colours: yellow = more carbon dioxide than air, red = same as air, purple = less carbon dioxide than air.

- Explain each colour using both processes: photosynthesis uses carbon dioxide, respiration releases it. Say which is faster.
- Respiration happens in the light and the dark. It is a common mistake to say that plants only respire at night.
- Explain the controls: tubes with no plant show that the plant, not the light or the foil, caused the change.
- Do not breathe on the tubes. In evaluation answers, mention carbon dioxide from the air or breath.