Gaseous exchange in leaves

NAME ___________________________________ DATE __________________

A stoma is **a** pore, found in the leaf and stem **epidermis** that is used for **gas exchange.** The stomata can open and close. The **guard cells** surrounding each stoma have banana shape parts. In the light, water enters the guard cells by **osmosis** from the surrounding epidermis cells. This causes the guard cells to become **turgid** and swell. They bend outward, opening up the stoma. In the dark, the guard cells lose water again, they become **flaccid** and the stoma closes. No one knows for sure how this change is brought about, but it seems to be linked to the fact that the guard cells are the only cells in the lower epidermis that contain chloroplasts. In the light, the guard cells use energy to accumulate solutes in their vacuoles, causing water to be drawn in by osmosis.

Air containing carbon dioxide and oxygen enters the plant through these openings where it is used in photosynthesis and respiration, respectively. Oxygen produced by photosynthesis in the **spongy layer** cells (parenchyma cells) of the leaf interior exits through these same openings. Also, water vapour is released into the atmosphere through these pores in a process called **transpiration**. Carbon dioxide, a key reactant in photosynthesis, is present in the atmosphere at a concentration of about 384 ppm. Most plants require the stomata to be open during daytime. The problem is that the air spaces in the leaf are saturated with water vapour, which exits the leaf through the stomata (this is known as transpiration). Therefore, plants cannot gain carbon dioxide without simultaneously losing water vapour.

One way to determine the degree of stomatal opening in a leaf is by measuring leaf **gas exchange**. A leaf is enclosed in a sealed chamber and air is driven through the chamber. By measuring the concentrations of carbon dioxide and water vapour in the air before and after it flows through the chamber, one can calculate the rate of carbon gain (photosynthesis) and water loss (transpiration) by the leaf.

This experiment depends on the use of hydrogencarbonate indicator, a pH indicator, containing the dyes cresol red and thymol blue in a solution of sodium hydrogencarbonate. This pH indicator is in equilibrium with atmospheric carbon dioxide, i.e. its orange colour when you receive it indicates the acidity of the atmosphere due to carbon dioxide. Carbon dioxide is an acid gas. Increase in acidity (fall in pH) turns the indicator yellow while decrease in acidity (rise in pH) turns it first red and eventually purple.

Materials

- plant leaves - 3 test-tubes and rubber bungs - 1 test-tube rack
- bench lamp (in the absence of sunlight)
- piece of aluminium foil, about 120 x 140 mm
- spirit marker - pair forceps - 10 cm^3 graduated cylinder
- hydrogencarbonate indicator

Procedures

1. Wash three test-tubes in tap-water. Rinse them with distilled water and finally rinse them with the bicarbonate indicator itself.
2. Label the tubes 1-3.
3. Use a graduated cylinder to place 2 cm^3 hydrogencarbonate indicator in each tube.
4. Close each tube with a rubber bung.
5. Roll the leaf longitudinally, its upper surface outwards and slide it into tube 1 so that it is held against the wall of the test-tube and does not touch the indicator solution (Fig. 1)
6. Repeat this procedure with tube 2.
7. Do not put a leaf in tube 3.
8. Cover tube 1 with aluminium foil to exclude light and place the three tubes a few centimetres away from a bench lamp (or in direct sunlight if possible). Switch on the lamp and leave the apparatus for 40 minutes.
9. At the end of 40 minutes, hold all three test-tubes against a white background to compare the colours of the indicator solutions and record these colours in your table.

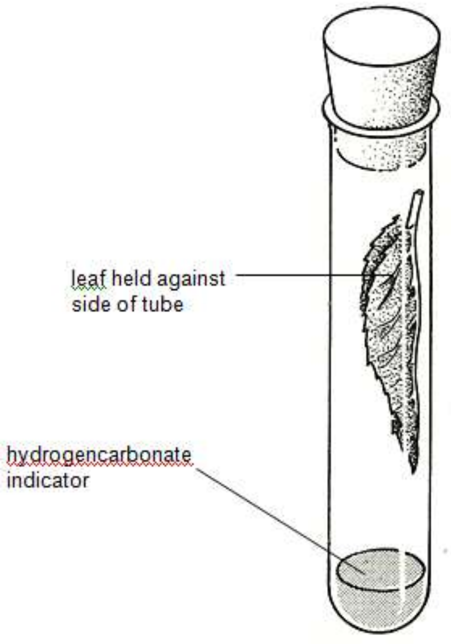

Fig. 1

Tube	Conditions	Colour of indicator	Change in pH
1	Leaf in darkness		
2	Leaf in light		
3	No leaf		

Discussion

Read the introductory paragraphs to the experiment once again.

1. Although the hydrogencarbonate indicator solution is a pH indicator, i.e. its colour depends on its acidity; this experiment assumes that its changes of colour depend entirely on changes in the carbon dioxide content of the air. Explain why this is a reasonable assumption.

2. (a) What change in pH is suggested by the indicator becoming more yellow?

(b) What change in the composition of the air in the test-tube is most likely to cause such a change of pH?

3. (a) What change in pH is suggested by the indicator becoming more red or purple?

(b) What change in the composition of the air in the test-tube is most likely to cause such a change in pH?

4. What was the purpose of setting up tube 3?

5. What effect did the presence or absence of light have on the concentration of carbon dioxide in tubes 1 and 2?

6. If you know something about the processes in leaves which lead to gaseous exchange, explain the difference in results in test-tubes 1 and 2.