Investigate The Influence Of Carbon Dioxide On The Rate Of Photosynthesis

Biology – Leaving Cert

Experiments

Materials/Equipment

Fresh Elodea

Metre Stick

Sodium hydrogencarbonate solutions of various concentrations eg. 0.02% - 1%

2 Thermometers

5 Boiling tubes

Scissors

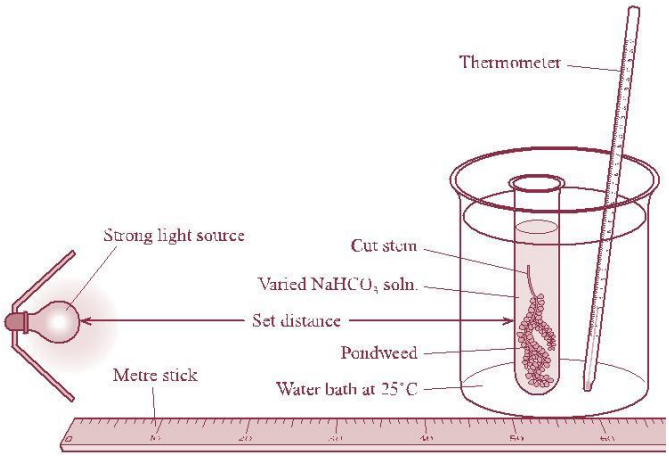
Large beaker of water at 25˚C

Forceps

Test-tube rack

Funnel

Strong light source



Procedure

1. Familiarise yourself with all procedures before starting.
2. Fill each boiling tube with a different concentration of sodium hydrogencarbonate, label and place in the water bath. Leave to warm to 25 °C.
3. Obtain a fresh shoot of *Elodea.*
4. Cut the stem at an angle. Remove several leaves from around the cut end of the stem.
5. Switch on the light source.
6. Put the plant into the boiling tube with the lowest concentration of sodium hydrogencarbonate e.g. 0.02%, cut end pointing upwards and stand this boiling tube in the beaker as shown
   in the diagram.
7. Place this boiling tube at a measured distance from the light source e.g. 15 cm.
8. Allow the plant to adjust for at least 5 minutes and observe bubbles being released from the cut end of the stem.
9. Count and record the number of bubbles released per minute. Repeat twice.
10. Calculate and record the average number of bubbles released per minute.
11. Using the same piece of pondweed repeat steps 7 to 11 with the other concentrations of sodium hydrogencarbonate.
12. A graph should be drawn of the rate of bubble production against sodium hydrogencarbonate concentration. Put the sodium hydrogencarbonate concentration on the horizontal axis.

Note:

During this experiment only one factor (carbon dioxide concentration) should be varied – light intensity and temperature must be kept constant.

To keep the light intensity constant, keep the boiling tube at a constant distance from the light source.

To keep the temperature constant use a water bath at 25 °C.

Result

$NaHCO_3$ concentration	Trial 1 (No. of bubbles/min)	Trial 2 (No. of bubbles/min)	Trial 3 (No. of bubbles/min)	Average (No. of bubbles/min)

Conclusion/Comment

Skill Attainment

Investigate The Influence Of Carbon Dioxide On The Rate Of Photosynthesis

Following instructions
Familiarise yourself with all procedures before starting
Follow instructions step by step
Listen to the teacher's instructions

Correct manipulation of apparatus
Carefully use the scissors to cut the end of the plant
Place the plant in the boiling tube, cut end pointing upwards
Use the metre stick to measure the distance of the plant from the light source Use the thermometer
Use the timer

Observation
Observe bubbles being released
After allowing the plant to adjust, observe a steady stream of bubbles
Observe the number of bubbles being released per minute at each of the given concentrations

Recording
Write up the procedure
Record each concentration used
Record the number of bubbles being released per minute at each of the given concentrations Record the average number of bubbles being released per minute at each of the given concentrations
Draw a graph with labelled axes

Interpretation
Draw reasonable conclusions from your observations and results

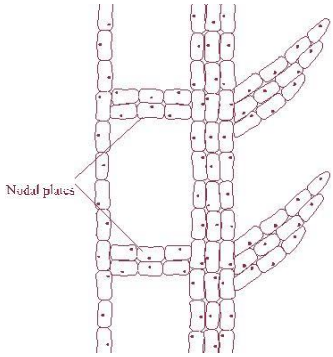
Application
Become aware of any other application(s) of what you learned in this activity

Organisation
Exercise caution for your personal safety and for the safety of others
Work in an organised and efficient manner
Label as appropriate
Work as part of a group or team
Clean up after the practical activity

Background information

Elodea spp.

Elodea is a hydrophyte, a plant adapted to living in water. One important adaptation of freshwater aquatic plants is the formation of aerenchyma. This is parenchyma tissue with large intercellular air spaces that help to keep the plant buoyant.



L.S. Elodea Stem

Elodea has a large proportion of the stem occupied by these structured airspaces, which are separated from one another by nodal plates. These 'cross' plates prevent free movement of large bubbles of gas. When the oxygen is produced in the leaves during photosynthesis it diffuses into the air spaces and accumulates there. This is easier than diffusing into the surrounding water.

Oxygen can form up to 33% of this trapped air. Eventually the pressure becomes so great that bubbles of gas are forced out of the cut end of the stem when the plant is actively photosynthesising.

Factors affecting the rate of photosynthesis

There are certain factors which affect the rate of photosynthesis e.g. light intensity, temperature, and carbon dioxide concentration. The maximum rate of photosynthesis will be constrained by a limiting factor – any factor that is in short supply. This factor will prevent the rate of photosynthesis from rising above a certain level, even if the other conditions needed for photosynthesis are improved. It is therefore necessary to control these factors throughout the experiment and to keep them constant so as not to let them affect the integrity of the investigation.

(i) Light intensity

Increasing the light intensity will increase the rate of photosynthesis provided there is sufficient carbon dioxide available and provided the temperature is warm enough to allow the reactions to occur. Light intensity is proportional to the inverse of the square of the distance from the lamp ($1/d^2$) rather than just the distance because it depends on the area of the beam of light falling on the plant. The further the distance from the lamp the greater the area being lit by it.

(ii) Carbon dioxide concentration

Provided the other factors are available in sufficient quantities, increasing the concentration of carbon dioxide will increase the rate of photosynthesis until the plant is photosynthesising at its maximum rate (it has become saturated). If there is too little carbon dioxide, it can become the limiting factor, thus impeding the viability of the investigation. However, as long as the investigation is completed in a short period of time, the amount of carbon dioxide used up by the plant will not be sufficient to cause the carbon dioxide concentration to become the limiting factor.

(iii) Temperature

Enzymes are required for photosynthesis. Therefore, increasing the temperature will increase the rate of photosynthesis, until a point at which the enzyme activity decreases or the enzymes become denatured. Thus the experiment is carried out at a constant optimum temperature for the plant enzymes i.e. 25 °C.

Advance preparation

- Collect *Elodea* and pondwater from a pond or canal or purchase from a 'fish tank' suppliers or garden centre.
- Try out the experiment beforehand to determine
  (i) the distance(s) suited to the light source
  (ii) the concentration of sodium hydrogencarbonate to get a steady (but not too fast) stream of bubbles.
- Make up sodium hydrogencarbonate solutions (if doing the 'carbon dioxide concentration' investigation).
- Set the water bath at 25 °C and check the temperature with a thermometer.

Helpful hints

- Ensure that the *Elodea* is fresh and well illuminated before the experiment. If the plant has to be stored, leave it in an aquarium and bubble air through it.
- Use a very bright light e.g. that from a projector or a daylight bulb (can be purchased from art material suppliers or some garden centres). If you use a Halogen lamp make sure to place an open glass container of water in front of it in order to absorb some of the heat emitted.
- Try out a few different sprigs of *Elodea* to see which one is bubbling best and then use this one for the investigation.
- If the bubbles stop, or do not start, cut the stem again and lightly crush between your fingers. This seems to allow the bubbles out past the nodal plate (see the diagram in background information). If bubbles are too fast, a pinch with the forceps sometimes helps to slow them down.
- Keep the pondweed down at the bottom of the boiling tube. It is easier to count the bubbles travelling through a long column of water or solution. If the pondweed tends to float, it can be weighed down with a paper clip.
- *Cabomba* is an excellent aquatic plant to use in place of *Elodea*, it is available from suppliers of tropical fish.
- *Scenedesmus*, a green alga, may be immobilised and used with hydrogencarbonate indicator and a colorimeter.
- A conical flask can be substituted for the beaker as this will keep the boiling tube steadier, making it easier to move along the bench.
- The experiment seems to work best in May and September as the plant is photosynthesising more actively.
- A solution of 0.2% sodium hydrogencarbonate can be used instead of pondwater. Tapwater can be used if dechlorinated.
- Count the bubbles for 15 seconds and multiply by 4 to get the number of bubbles per minute.
- When moving the *Elodea* from tube to tube, do it gently so as not to damage the plant. If there is a risk of damage, leave the *Elodea* in one tube, pour off the sodium hydrogen-carbonate solution just tested and refill with a solution of a higher concentration.
- When the student is drawing the graph using the formula $1/d^2$, multiply by 1000 to

make the figures easier to handle i.e. use $1000/d^2$ as the light intensity.