Investigation into the effect of different concentrations of carbon dioxide on the rate of photosynthesis

Aim

To investigate into the effect of different carbon dioxide concentrations on the rate of photosynthesis.

Introduction

The investigation will be conducted using the method outlined in detail later on. In short, the water plant *Elodea* will be placed in a solution of altering hydrogencarbonate concentrations (0.02%, 0.04%, 0.06%, 0.08% and 0.1% as previous research has shown that concentrations above that start to damage the leaf.[1]) and the rate of photosynthesis will be measured by the volume of oxygen given off in a set amount of time, via a meniscus which is part of a photosynthometer apparatus set up.

Prediction

I predict that the rate of photosynthesis will increase as the concentration of carbon dioxide increases up to a certain point after which another factor limits the rate of photosynthesis e.g. light intensity or temperature.

Variables

-**The independent variable** is the concentration of carbon dioxide which will be manipulated to see what effect it has on the rate of photosynthesis.
-**The dependent variable** is the volume of oxygen given off in the set amount of time.
-**The fixed control** is the Elodea plant immersed in water with no added carbon dioxide in the form of hydrogen carbonate.
-**Potential confounding variable 1**: It is known that plants absorb certain wavelengths of light with differing efficiency, and that this also differs between plants. Thus the wavelength emitted from the light source must also be kept the same throughout the investigation, so it doesn't act as a separate independent variable and interfere with the design of the experiment.
-**Potential confounding variable 2**: Light intensity also has an effect on the rate of photosynthesis, so keeping the light source in the same spot for the duration of the experiment is also crucial, once again so this variable does not interfere with the aim of the study by producing results of questionable validity.
-**The range of concentrations** I will use is: 0.02%, 0.04%, 0.06%, 0.08% & 0.1%.
For each concentration, there will be three repeats to ensure that my results are as reliable as possible.

Method

1. Attach a capillary tube to the nozzle end of a 20cm³ syringe by means of rubber tubing. Push the end of the capillary tube to the tip of the nozzle of the syringe, and make sure that the rubber tubing provides an airtight seal.
2. Using a razor blade, cut three portions of *Elodea* stem, each from the top end of a different shoot.
3. Remove the plunger from the syringe. Introduce the plants into the barrel of the syringe, with their cut ends facing up, away from the nozzle.
4. Clamp the syringe vertically, nozzle downwards over a beaker.
5. Place a finger over the open end of the capillary tube. Fill the barrel of the syringe to the brim with tap water. Replace the plunger, catching any excess water in the beaker. Gently push in the plunger of the syringe until the top of the water in the barrel reaches the 20cm³ mark. No air should be trapped between plunger and water.

[1] 'Energy and Life', Cambridge University Press 1983

6. Clamp a lamp with the end of its 100W bulb exactly 8cm from the syringe. The distance is critical and must be exactly the same in each experiment. Turn light in the room off and shut blinds.
7. Switch lamp on. Very carefully raise the plunger of the syringe to pull the meniscus to a point near the top of the capillary. Mark the position of the meniscus. The set up should now look like the diagram below.

8. Measure the distance travelled by the meniscus during the next three minutes. Repeat this three times. Record results and average the distance the meniscus moved in each three minute interval.
9. Repeat steps 5 to 8 with the plant in the range of hydrogen carbonate concentrations mentioned. (The first experiment was the control.)

Justification

The method used was the most appropriate for my investigation as it allowed the precise control of all variables that may effect the dependent variable in the study. Prior to this study, two preliminary experiments were carried out. The first was on light intensity and the latter was on wavelength. In the former, a photosynthometer much like the one in the method described earlier was set up, with the independent variable being the distance of the light from the plant. In the latter, a light source emitting different wavelengths was placed a certain length from the set up, one of which had a 'shade' plant and one of which had a 'sun' plant. It was found that the higher the light intensity was, the more the rate of photosynthesis increased. For the wavelength experiment, it was found that the 'shade' plant was better adapted at absorbing green wavelengths and that the 'sun' plant was better adapted at absorbing wavelengths of red and blue. This justifies the strategy used to obtain results in my experiment as it eliminates the possibility of these two factors having an impact on the investigation. It does not matter so much in what way they affect the rate of photosynthesis, the important thing that the preliminary work highlighted was that they do affect it. Thus, as the light source will be kept at exactly 8cm from the plant at all times in the experiment, and the wavelength will be controlled for by using the same light source throughout (and switching off the light and shutting the blinds so that other light from e.g. the outside, light bulbs cannot impair the study, as it might be of a different wavelength to the light source used), my strategy is justified.

The reasons for the preliminary results are due to the splitting of water (photolysis) and the pigments found inside the chloroplast of pallaside cells in the leaves of plants. For the

preliminary light intensity experiment, the fact that the rate of photosynthesis increases as the light intensity is increased is explained in terms of the need to obtain extra electrons due to non-cyclic photophosphyrelation. In this light dependent stage of photosynthesis, as electrons become excited and used to make ATP, this leaves photosystems used to 'power' these electrons short of electrons. Thus water must be split in photosystem 2 into protons, electrons and oxygen so that the electrons that are lacking in the photosystems may be replenished. Consequently, if the light intensity is higher, it has more energy and will speed up these processes so that the photosystems have electrons available quicker, which speeds up the making of ATP, which is in turn responsible for providing the energy in the light independent reaction for reducing carbon dioxide to glucose. That is how an increase in light intensity increases the rate of photosynthesis. For the light wavelength experiment, differences in absorbance can be explained in terms of what pigments are present, for example the pigment chlorophyll a has a peak absorption of about 430 nm and carotenoids peak at 450 and 500 nm.

My prediction is justifiable in terms of diffusion. This is the net movement of molecules from an area of high concentration to an area of low concentration. It happens randomly due to the kinetic energy all molecules possess. Therefore, when carbon dioxide concentration is increased, this also increases the concentration gradient (it is steeper) between the carbon dioxide levels in the plant and immediately outside it. As a result, carbon dioxide will diffuse through the stomata on the leaves lower surface which are held open by guard cells. From there, they diffuse into the air spaces of the spongy mesophyll and eventually in the pallaside cells where they are used in the light independent stage of photosynthesis to make glucose. That is then the biological basis of how an increase in carbon dioxide concentration increases the rate of photosynthesis, making my prediction justified.