29 MARCH 2003 SCIENCE INVESTIGATION RACHEL BEESLEY

INVESTIGATING THE LINK BETWEEN THE RATE OF PHOTOSYNTHESIS AND LIGHT INTENSITY

INTRODUCTION

The aim of my investigation is to see if different distances of light affect the rate at which a plant photosynthesises. To do this, I am going to conduct an experiment which will involve putting some pondweed into a test-tube of water and using a lamp to alter the light intensity. I will be able to measure how fast photosynthesis is taking place (the reaction rate) by counting the oxygen gas bubbles given off.

I predict that if the lamp is closer to the pond-weed, the reaction rate will be quicker and more oxygen gas bubbles will be produced. This is because sunlight is needed for photosynthesis to take place, so if more sunlight (or in the case of this investigation, light from a bulb) falls onto the plant, more energy is absorbed, meaning more energy is available for chemical reactions and so more photosynthesis takes place.

CONTROLLED VARIABLES

As well as light intensity there will be other factors that will affect the amount of oxygen gas bubbles given off. I will need to keep the following factors constant so they do not affect the results of my investigation.

- Carbon Dioxide:- carbon dioxide from the air is absorbed into the leaf by microscopic pores on the surface of the leaf, which are called stomata. The thin walls of the cells of the spongy mesophyll have a big, moist surface for gas exchange. On the gas exchange surface, the carbon dioxide dissolves in the water and diffuses to the chloroplasts, which is where photosynthesis happens. Oxygen, one of the products of photosynthesis, disperses out of the leaf along the same route, but in the opposite direction. If there is not enough carbon dioxide it can become the limiting factor and affect the rate of photosynthesis. However, as long as the experiment is done over a short period of time, the amount of carbon dioxide used up by the pondweed will not be enough to make C02 the limiting factor. If I was going to carry out my experiment over a long period of time, for example 24 hours, I could add a fixed amount of Sodium hydrogen carbonate to the water to make sure that there was an ample supply of carbon dioxide.

- Water:- water is also needed in the photosynthesis reaction, and if it is lacking, the plants' stomata close to prevent any extra water loss. This also means that less carbon dioxide can pass through them. However, in my experiment the pondweed will always be fully submerged in water so this will not be a problem.

- Chlorophyll:- plants need chlorophyll to photosynthesise because chlorophyll is the green substance which absorbs the sunlight energy to make starch and oxygen. If a leaf is bigger it will contain larger or more chloroplasts, so effectively there will be more chlorophyll.

- Temperature:- Enzymes are used in the photosynthesis reactions of a plant. Therefore, a higher temperature will increase the rate of photosynthesis until the enzymes denature, at about 45`C. If the temperature is too c old it becomes a limiting factor and the enzymes will stop working. The temperature can be kept fairly constant by conducting the experiment in one lesson when the air temperature shouldn't change enough to affect the temperature of the water.

- Plant:- Because every plant species has a different leaf structure, they photosynthesise at different rates. The rate of photosynthesis can also vary in plants of the same species because although they have the same leaf structure, the leaves can contain more or less chlorophyll to absorb sunlight than others. The size of the plant can also affect the rate of photosynthesis, because a bigger pl ant would mean a larger surface area for gas exchange. This variable is very simple to control, however; I will merely use the same piece of pondweed throughout the experiment .

DIAGRAM

METHOD

1. I will set up my equipment as shown in the diagram above. The amount of water in the test tube can vary, just as long as the pondweed is fully submerged.
2. I will then put the test tube into a test tube rack and place the ruler so that the "0" measurement is aligned with the edge of the test tube, and place the lamp so it is 10cm away from the test tube.
3. I will turn on the lamp and record the number of oxygen gas bubbles given off in 1 minute using a stopwatch.
4. I will repeat step 4 seven times, moving the lamp an extra 10cm away each time. Once I have recorded the number of oxygen gas bubbles at 70cm, I will repeat the whole process again for accuracy. If there are any anomalous results, I will repeat those and then take an average.

SAFETY

This particular experiment is very simple to perform and does not really need any safety precautions. It is not necessary to wear goggles, as there are no corrosive substances involved. To prevent any spillages I will ensure that the stools around my desk are pushed under the desk and out of anybody's way.

RESULTS TABLES

Distance of lamp from test tube	(1st set of results) No. of bubbles emitted per minute	(2nd set of results) No. of bubbles emitted per minute

Distance of lamp from test tube	Anomalous Results	Averages

CONCLUSION

From my table of results I can see that as I increased the distance of light, the fewer oxygen gas bubbles were given off, which reinforces my prediction that the closer the lamp was to the pondweed, the more bubbles would be given off. I included 5 columns in my table of results; the distance of light, the first set of results, the second set of results, the third set of results (any anomalous ones I repeated) and finally the calculated averages. From my second column I can see that the difference between the amount of bubbles emitted at 10cm and 20 cm is a lot larger in comparison to the rest. This is the main anomalous result, but I counted the difference between the amount of bubbles emitted at 30cm and 40cm as an anomaly as well., since that too has a larger difference than the other results. I repeated the experiment at 10cm and 40cm and recorded the new results in the third column because the others didn't fit the general pattern.
From my graph I can see that the amount of bubbles always decreases fairly steadily, but initially decreases quite rapidly. This again backs up my prediction. I can also clearly see the main anomalous result from looking at my graph, as it is nowhere near my line of best fit.

EVALUATION

Overall, my results were fairly accurate, apart from one or two anomalous results, so I think my conclusion has some value. My line of best fit was quite easy to plot; there was only the first point (10cm, 165 bubbles) that wasn't close to the line. If I had had more time, I would have repeated this result and possibly the result at 50cm (71 bubbles) a fourth time for higher accuracy.
Although I feel I performed the experiment quite well, there are a few errors which I would correct if I did the experiment again. Firstly, the distance between the lamp and the pondweed was not perfectly measured, especially considering that to make it completely fair, I would have had to measure the distance exactly from the filament of the bulb to the centre of the pondweed. Secondly, there was more light on the plant than just the light from my lamp. There was sunlight coming through the windows in the laboratory and extra light from other experiments that were being carried out around mine. To get rid of this problem entirely, I would have had to conduct my experiment in a separate, totally dark room, but for practical reasons this was not possible. Also, the heat generated by the lamp would have had an effect on the accuracy of my results, as I explained earlier. To keep this factor more constant, I could have switched off the lamp at intervals for one minute before I took another result. This would have given the bulb some time to cool off. Another way of keeping the temperature constant would have been to place a perspex block, if it had been available, between the lamp and the plant because that would have absorbed most of the heat and still allowed light energy to pass through.
The major flaw, however, was obviously counting the bubbles given off. At 10cm, the bubbles discharged so quickly that it was very hard to give an absolutely accurate number. The only way I can think of improving this error is to use some sort of mechanical device that would give a more correct number. However, I do think that overall my method and experiment were alright because the trend of my graph supports my prediction.
If I were to extend this investigation further I could I could substitute light intensity with some of the other limiting factors, such as temperature or different types of plant, for example Canadian pondweed, which is very effective. I could also investigate if different types of light, such as coloured, fluorescent or halogen lights, have a different effect on the rate at which a plant photosynthesises.