HOW LIGHT INTENSITY AFFECTS THE RATE OF PHOTOSYNTHESIS.

Photosynthesis is the process in which plants make their own food using light. To make the food they also require Carbon Dioxide, Chlorophyll and water. This can be shown in an equation:

Carbon Dioxide + Water $\xrightarrow[\text{Chlorophyll}]{\text{light}}$ Glucose + Oxygen.

The balanced word equation for this is:

$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$

The plant takes in light energy from the sun, using the palisade cells, which are situated in the leaf. The cells contain Chlorophyll, which is the green substance inside the leaf, and also chloroplasts, which trap the sun's energy. This then reacts with the water. The plant uses light energy to separate 1 hydrogen atom from the water. This gives the OH – ion, which is hydroxyl, and the H+ ion that is hydrogen. These are then unsatisfied bonds so they join together to form 2 water molecules, 1 oxygen and 4 hydrogen molecules. (The hydrogen ions are turned into glucose), this means that the more light there is, the more water is split and hence there is more oxygen. This is all part of the light stage. The light stage involves this splitting of water and also the production of ATP, this is a source of energy which is later used in the dark stage. The light stage traps the sunlight and converts it into chemical energy. Oxygen produced in the light stage is evolved as oxygen gas, and the hydrogen reduces the carbon dioxide to carbohydrate. ATP is formed in the light stage and is used as energy for the dark stage, the reduction of carbon dioxide into carbohydrates takes place in a number of steps, each

controlled by an enzyme. Melvin Calvin has proved these steps by illuminating the chlorophyll in the plant in the presence of carbon dioxide and allowing it to photosynthesise for a certain period of time. It is then killed with boiled alcohol (ethanol). This inactivates the enzymes and stops the reactions. This chain of reactions is known as the Calvin cycle. It produces starch and amino acids. For amino acids to be produced nitrates are required. Nitrates are needed to make proteins and if there is a shortage it leads to yellow older leaves and stunted growth. The root hair cells in the roots can absorb this mineral. The amino acids are then converted into ammonium ions.

Water is needed by the plant to photosynthesise; it diffuses from the soil, into the root hair cells via osmosis. It can then be transported to the growing regions of the plant by the xylem cells.

Carbon dioxide is another product used in photosynthesis, it diffuses from the atmosphere into the plant by the stomata, which are situated in the plant's leaves and controlled by the guard cells. They control the size of the stomata, enabling it to open and close, the plant needs to do this because although the stomata needs to open in order to take in carbon dioxide, the plant loses water through transpiration whilst the stomata is open and so the guard cells prevent the plant becoming flaccid and they prevent wilting and dehydration.

The products of photosynthesis are glucose and oxygen. The oxygen is released into the atmosphere for use by humans and animals. The glucose produced is released via respiration, it can be converted inot starch -which is an insoluble carbohydrate and can be stored by the cells without causing large amounts of water to accumulate. Glucose is also converted into cellulose for the cell wall, it can be changed into proteins along with other nutrients and also nitrates, and the proteins are used for growth and making enzymes. Glucose can be changed into lipids (fats and oils) for storage in seeds.

There are certain factors which affect the rate of photosynthesis, these are temperature, light intensity and carbon dioxide concentration, in my experiment I will be investigating how light intensity affects the rate of photosynthesis in a piece of pondweed.

Prediction.

My prediction is that changing the light intensity will affect the rate of photosynthesis to a certain extent but then other factors such as temperature and carbon dioxide concentration will begin to have an effect.

I think this because I know that the effect of temperature, carbon dioxide concentration and temperature are all limiting factors, and at one particular time only one of these can be the limiting factor and after a certain length of time, the other 2 factors will begin to have an effect on the rate of photosynthesis.

Apparatus.

Lamp, meter ruler, pondweed, stopwatch, beaker, boiling tube, stirring rod, sodium hydrogen carbonate, spatula.

Diagram.

Method.

1) Collect your apparatus, plug in the lamp and lay it flat on the bench. Place the metre ruler next to it.
2) Half fill the boiling tube with water and add the piece of pondweed, place the boiling tube in a beaker of water. Add a spatula of sodium hydrogen carbonate to the boiling tube.
3) Place the beaker on 0cm, switch the lamp on and wait until tiny bubbles appear. When this occurs begin timing the experiment for 1 minute, record your results.
4) Move the beaker to 5cm and repeat the experiment. Keep moving the beaker up 5 cm each time.

   Use the stirring rod to stir the water in the beaker throughout the experiment so that the heat is evenly spread.

5) When you have a full table of results, repeat the whole experiment again so that your experiment is more accurate and work out the average.

To make sure my experiment is a fair test I will keep certain things the same, I will do the experiment twice to make sure it is accurate, I will only have 1 variable throughout the experiment, this will be the distance of the light source. The temperature will be approximately 23 degrees (room temp.) because more oxygen will be produced. I will use the same piece of pondweed, the same lamp and the same amount of water each time.

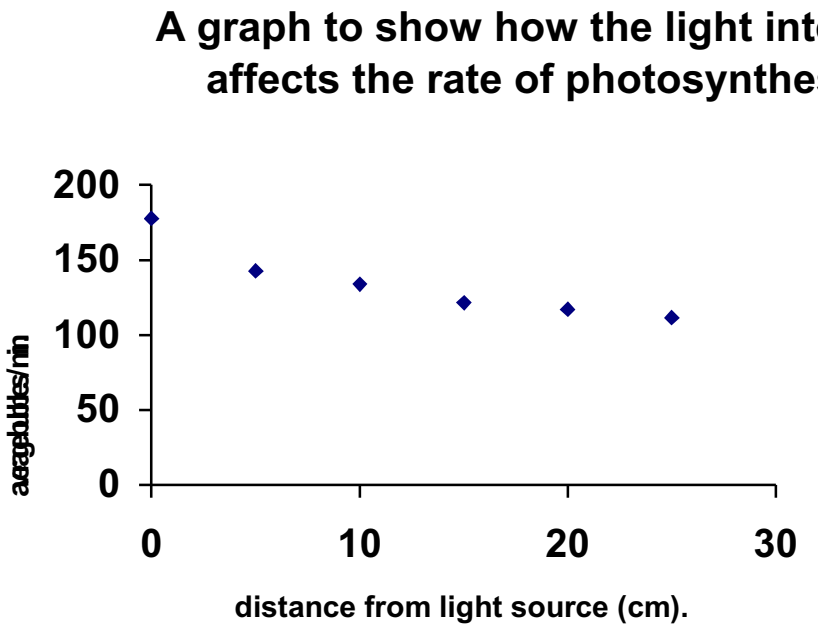
I will be changing the light intensity in my experiment, as this is what my investigation is based on. I will do this by moving the pondweed further away each time.

In my investigation I will measure how many bubbles of oxygen are given off in one minute. I should see a decrease in the amount of bubbles as I decrease the light intensity.

The experiment is quite a safe one however; I will have to ensure the water doesn't come into contact with the electric socket.

Results.

Distance from light source (cm).	Amount of bubbles 1st time. (Per min.)	Amount of bubbles 2nd time. (Per min.)	Average amount of bubbles. (Per min.)
0	185	170	177.5
5	144	141	142.5
10	134	134	134
15	130	113	121.5
20	125	109	117
25	120	103	111.5



Conclusion.

My results show me that as the light intensity increases, the rate of photosynthesis steadily increases; I know this because there are more bubbles being given off. This is the prediction I made earlier.

There are certain patterns in my results such as at the beginning of the experiment my results decreased quite dramatically, as the light intensity decreased further, the rate of photosynthesis decreased – but not as much.

From my results I can conclude that the rate of photosynthesis increases as the light intensity increases. I have found this by taking 2 results – I then added them together and divided by 2, which gave me an average. This made it more reliable.

From my results I have used another graph and drawn dotted lines up to the curve to find the results I should have according to the curved line. These are also shown in a table, doing this will let me to see what my results should be and if I have any errors in my experiment.

Distance from light (cm).	Amount of bubbles / min.
5	152
10	136
15	122
20	116
25	112

My results show light affects the rate of photosynthesis and I can relate my results to scientific knowledge that I explained earlier. The more light energy there is the more ATP there is

and more oxygen is produced as a result. This backs up my results, which are; light intensity affects the rate of reaction.

My results more or less match my prediction – my graph shows that as I predicted, the light intensity affects the rate of photosynthesis. This means that the 2 are proportional to each other.

Evaluation.

I think my experiment was done quite well because we kept the same variable throughout the whole thing, we changed the light intensity by the same amount each time and we did each experiment for exactly 1 minute. This ensured it was a fair test; we also made sure our experiment was carried out safely.

Most of my results were accurate and fitted the line of best fit, however 1 point was slightly out – this was the 5 cm result. There are many things this could be down to, such as human error with the stopwatch. If the experiment was done for a little less or more time than the others, this could account for the error. Also, a little way into the experiment we noticed that the bubbles were coming from different parts of the pondweed – this means we may have been counting bubbles from a different part of the plant for that particular result. As the experiment took a while to get going, we did it in a few different lessons, so the pondweed might not have had as long in the light as the other experiments. In the beginning I planned to use the same piece of pondweed each time and the same length but as we used different lessons it is possible that the pondweed was a different piece and a different size. As the plant bubbled very quickly near the start, it is possible that I did not manage to count all of the bubbles or I could have miscounted. These could all cause 1 result to be out.

I could make my experiment better by making sure I used the same piece of pondweed each time, the same size, the same light – incase the 1 bulb was stronger than the other, the same amount of water each time. I could also repeat my experiment a few more times using different lengths to get more results and hence a more accurate graph.

I think my experiment was good enough to give the conclusion that light intensity affects the rate of photosynthesis because my experiment was as fair as possible and I didn't make many errors. My graph also proves this because it is a curved line, which shows the light intensity, and rate of photosynthesis are proportional to one another.

There are some other experiments I could carry out to extend my investigation such as, investigating the other limiting factors (carbon dioxide concentration and temperature) which affect photosynthesis rate. I could also extend the light intensity experiment by using different types of lights such as fluorescent or halogen lights. I could also investigate how different coloured pigments absorb the light more, for example black absorbs light and white reflects it, and chlorophyll is a green substance so maybe a green pigment would affect the rate of photosynthesis.

Biology coursework

Light intensity investigation

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