Investigation on How the Amount of Light Affects Photosynthesis

Aim

In this investigation I hope to find out how the amount of light affects photosynthesis.

Plan

Photosynthesis occurs only in the presence of light, and takes place in the chloroplasts of green plant cells. Photosynthesis can be defined as the production of simple sugars from carbon dioxide and water causing the release of sugar and oxygen. The fact that all plants need light in order to photosynthesise has been proven many times in experiments, and so it is possible to say that without light, the plant would die. I am saying this because in photosynthesis the carbon dioxide and water convert, using light energy, to form glucose and oxygen. Chlorophyll, which is the green pigment present in the chloroplasts, stores the carbon dioxide and the light energy allows the process to happen Before I start my plan I would like to indicate that all green plants make food by the process of photosynthesis. This can be summarised by the following equation:

Carbon Dioxide + Water $\Longrightarrow$ Glucose + Oxygen

$6CO_2$ (g) + $6H_2O$ (l) $\Longrightarrow$ $C_6H_{12}O_6$ (aq) + $6O_2$ (g)

The carbon dioxide comes from the respiration of plant cells and also forms the air and water around them. Chlorophyll, the green pigment present in the chloroplasts, is the catalyst for the process which absorbs the light. There are many factors, which affect the rate of photosynthesis, including light intensity, temperature and carbon dioxide concentration.

- Carbon dioxide concentration – This can affect the rate of photosynthesis, since if there is too little CO2, it can become the limiting factor, thus slowing down the capability of the experiment. In this case, as long as the experiment is done over a short period of time, the amount of carbon dioxide used up by the plant will not be sufficient enough to cause the carbon dioxide concentration to become the limiting factor.
- Water availability – water is also required in the photosynthesis reaction, and when it is lacking, the plants stomata close to prevent further water loss. This closing of the stomata cells also leads to little carbon dioxide being able to diffuse through. Clearly, in a water plant, like the pondweed, as long as the plant is fully submerged in water at all times, this will not be a problem.
- Temperature – Enzymes are used in the photosynthesis reactions of a plant. Therefore, temperature will increase the rate of photosynthesis, until a point at which the enzymes denature.
- Light intensity- Increasing the light intensity of the experiment will mean that there will be more oxygen bubbles produced.

The maximum rate of photosynthesis will be constrained by a limiting factor. 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 will therefore be necessary to control these factors throughout the experiment and not to let them affect

the integrity of my investigation into the effect of light intensity. As I am going to investigate on how the amount of light affects photosynthesis I am going to use a lamp and move it away from a beaker. To do this I am going to use a plant called Elodea (a Canadian pondweed) which produces bubbles of gas when it is photosynthesising. This gas is mainly oxygen. I am going to fill a beaker with tap water and add a pinch of sodium hydrogen Carbonate. Then I am going to cut a leafy shoot of pondweed approximately 5cm long, slide a paper clip onto the shoot just behind the tip and place the pondweed into the beaker. After that I am going to switch the lamp on and bring it close to the beaker about 10cm back. I will leave the apparatus for about 3 minutes and count the oxygen bubbles whic h come out from the pondweed. If the experiment works I am going to do repeats so that the results are accurate. I am then going to repeat the experiment but this time I am going to move the lamp back 20cm and then so on. To make this a fair test I am going to use the same pondweed over and over again, add the same amount of hydrogen carbonate and I am going to use the same amount of water. Also, to make it a fair test I am going to leave the experiment for the same amount of time. The experiment will work only if the light from the light bulb is absorbed through the pondweed. While doing this experiment I am going to have to be careful not to get any sodium hydrogen carbonate in my eyes and be careful not to put the beaker full of water near the switch of the light bulb.

Apparatus

Prediction

I predict that changing the intensity of the light will affect the process of photosynthesis. The reason to why I have said light intensity affects photosynthesis is because as light, and therefore energy, falls on the chloroplasts in a leaf, it is trapped by the chlorophyll, which then makes the energy available for chemical reactions in the plant. Thus, as the amount of sunlight, or in this case light from a bulb, falls on the plant, more energy is absorbed, so more energy is available for the chemical reactions, and so more photosynthesis takes place in a given time. Also, I predict that if the lamp is 30cm back then the light intensity will not be as strong as if it was 5cm away so then it will take a longer period of time for the sodium hydrogen carbonate to kick in and then less oxygen bubbles will appear from the pondweed. Furthermore, I predict that if the light intensity increases, the rate of photosynthesis will increase at a proportional rate until a certain level is reached, and the rate of increase will then go down. Eventually, a level will be reached where an increase in light intensity will

have no further effect on the rate of photosynthesis, as there will be another limiting factor, in this case probably temperature.

Preliminary experiment

To ensure that my plan is correct I am going to do a preliminary experiment. From the preliminary experiment I found out that in order for me to get the best possible and sufficient results I am going to have to change my plan. So, instead of moving the lamp back 10cm and etc. I have decided to go back every 5cm so that I get more accurate and sufficient results.

Analysis

	Number of bubbles in beaker			
Distance (cm)	Test 1	Test 2	Test 3	Average
5	186	185	187	186
10	156	175	131	154
15	160	162	158	160
20	154	152	153	153
25	140	139	140	140
30	130	134	137	134

Note: some numbers have been rounded up

As you can see from the table and the graph that there are is an anomalous result which does not look right and it is:

	Number of bubbles in beaker			
Distance (cm)	Test 1	Test 2	Test 3	Average
10	156	175	131	154

As I have run out of time I can not do this test again. However, I am going to look at this test again but from someone else's results and see whether this test came out the way it did because it was meant to happen like that or because it went wrong.

	Number of bubbles in beaker			
Distance (cm)	Test 1	Test 2	Test 3	Average
5	200	201	200	200
10	183	182	181	182
15	158	163	162	161
20	138	137	137	137
25	117	118	124	120
30	101	102	105	103

Note: some numbers have been rounded up

	Number of bubbles in beaker			
Distance (cm)	Test 1	Test 2	Test 3	Average
5	184	183	182	183
10	170	169	169	170
15	155	155	155	155
20	137	137	138	138
25	127	130	132	130
30	114	116	118	116

Note: some numbers have been rounded up

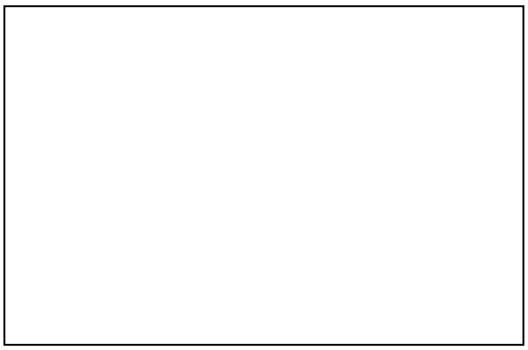
As you can see from the two tables that I was correct about that anomalous result being wrong. However because these two new tables follow a different pattern (as you can see from the graph) I am not going to be able to change the anomalous in my table. From the pattern on the graph you can see that these tables show that apart from the incorrect result, the rest of my results are fine and follow the same pattern. This was because of my plan as I made sure that all the measurements were correct. For example, I made sure that the lamp was away from the beaker at the measurement it should be.

Conclusion

During this investigation I found out that the further away you move the lamp the slower the process of photosynthesis occurs. This is due to the fact that the light energy from the bulb cannot reach the plant so then the glucose and oxygen will not be produced as quickly because Photosynthesis is the chemical process, which takes place in every green plant to produce food in the form of glucose. Plants use the suns energy to join together water and carbon molecules to make the glucose, which is sent around the plant to provide food. Cells in the root or stem can use the glucose to make energy, if the plant does not need to use all the glucose immediately then it is stored which is difficult because glucose is hard to store in water. Plants solve this problem by joining hundreds of glucose molecules together to make starch. Starch does not dissolve in water very well so it makes a better food store. Photosynthesis takes place mainly in leaves and depends on an important green pigment called chlorophyll, which is found in chloroplasts. To obtain the most sunlight as possible, leaves have a large surface area and the more sunlight the plant receives, the better it can photosynthesize. Chloroplasts are found in palisade cells in large numbers and to allow as much light to get in as possible, the cells are arranged like a fence. This helps the energy entering the surface of the leaf to travel a long way through the palisade cells. Glucose can provide energy or carbon, which can manufacture other molecules in the plant. Which can make new living matter and this is called biomass. So, this will not work because there would be no light energy to transfer the carbon dioxide + water into glucose and oxygen. Also, if there is no light energy to produce these goods then the plant cell will not be able to use the glucose and oxygen produced by photosynthesis to respire. But when the lamp is closer to the pondweed, then there is going to be more light energy for the plant to photosynthesize once it has photosynthesized, some of the glucose is turned into sucrose and used by the shoot and root tips to promote their growth. Before I did the experiment I made some predictions that changing the intensity of the light will affect the process of photosynthesis. This was absolutely correct as what I had thought would happen, did. Also, my graph backs my conclusion up 100%. This is because as you can see that it

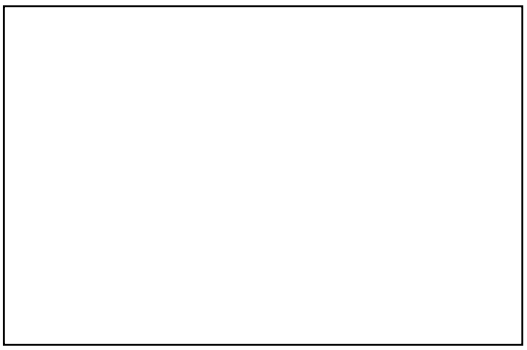
goes diagonally down, which is telling us that as you increase the distance between the lamp and the pondweed, the less photosynthesis occurs.

From this diagram you can see how photosynthesis works and what happens when you reduce the light intensity.



With a lot of light

You can see that the plant is darker and a richer green which tells us that it is getting enough light to photosynthesise.



with a little bit of light

You can see that the plant is a lighter green because it is not getting enough light which means it can not photosynthesise much.

Evaluation

I feel that this was a successful experiment. My results seem to indicate a clear pattern from which I was able to confidently draw a conclusion. This conclusion confirmed my prediction. The method that I used produced my results accurately and quickly enough to finish the experiment in the allotted time. My results were reliable, as the experiment was a fair test. I ensured that this was true by keeping all of the variables not involved in my experiment constant. I can say that no energy was deliberately put in or taken out of the contents of the beaker during the experiment. Although I feel that my experiment was overall good, I thought that there were many points at which the accuracy was not perfect. Firstly, the distance between the light sources and the Canadian Pondweed were not measured to a very high degree of accuracy, especially when you note the fact that the distance should have been measured exactly from the filament of the light bulb to the centre of the plant, and it is possible here to find an error. The second major inaccuracy was in measuring the volume of oxygen given off. We were just counting the bubbles as they came along and we did not know whether we missed one especially when they were coming fast. To improve this, it would be necessary to do the readings over a longer period of time, therefore increasing the volumes, and in turn reducing the errors. Another error would have been due to background light in the surrounding area. We tried to reduce this error by closing all blinds in the laboratory, but due to practical reasons, we could not all perform the experiment in a separate room, and we therefore experienced light pollution from other student's experiments. This would have had a very marginal effect on my results as a whole, but to eliminate this problem completely, it would have been necessary to perform the experiment in a totally dark room. To improve this experiment I could have used a light intensity measurer to the light intensity so I could have known how intense the light was. As I mentioned in my planning, carbon dioxide concentration could have been an error in the experiment, however, I feel that due to the short

period of time taken, there is very little chance that the concentration would ever have been as low as to have become the limiting factor. Again if I were to carry out the experiment over a longer time period, it would have been necessary to add sodium hydrogen carbonate to the water to increase the carbon dioxide concentrations. The last inaccuracy, though a small one, was in the time keeping. The main problem here was in when to begin the minute. If for one reading, the minute was started just after one bubble had been produced, and in another reading it was just before, this could have had a negative effect on the accuracy of my results. I therefore ensured that in each case I started the stopwatch just after a bubble had been produced, thus heightening the accuracy. Overall, I felt that due to the small volumes of oxygen involved, my experiment was not as accurate as it could have been, however I believe it was accurate enough to support and justify my hypotheses. Improvements could have been made as I have stated, mainly by simply increasing the time taken. However, due to practical time constraints in taking the readings for my investigation, and some consequential problems relating to time extension, I could not in fact make these adjustments. The other obvious way of increasing the reliability of my results would be to take many repeat readings and find an average. From my graph you can see that there is a fairly good correlation and also there are two obvious anomalies, telling us that something must have gone wrong during the experiment. This could have been because of the reasons stated above or because I might have counted too much or too less while the clock was running. Also, from my graph you can see that the results are correct as they follow the same pattern of other student's results. To extend my enquiries into the rate of photosynthesis, I could perhaps try to link in some of the other limiting factors to the same experiment, as well as investigating them in their own right. It could also be interesting to explore the effects of coloured lights on the rate of photosynthesis, which could lead to the question of whether or not other types of light, such as fluorescent lights or halogen lights, would have a different effect on the rate of photosynthesis.

Bibliography

AQA Science: Double Award Modular by Mary James.