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Biology Coursework

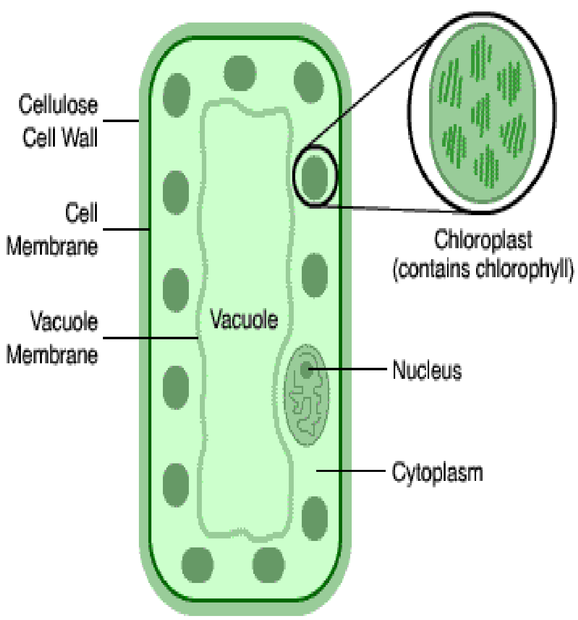
Aim:

To investigate the effect of light intensity on photosynthesis.

Introduction:

This investigation seeks to find a relationship between light intensity and the rate of photosynthesis.
Photosynthesis is a chemical reaction occurring in the leaves of green plants. Using the energy from sunlight, it changes carbon dioxide and water into glucose and oxygen, to be used as energy by the plant.

Photosynthesis happens in the mesophyll cells of leaves. There are two kinds of mesophyll cells - palisade mesophyll and spongy mesophyll. The mesophyll cells contain tiny bodies called chloroplasts, which contain a green chemical called chlorophyll. This chemical is used to catch the light energy needed in photosynthesis



A Plant Cell

Plants can absorb and use light as an energy source, because plants contain the green pigment, known as chlorophyll, which allows the energy in sunlight to work chemical reactions. The chlorophyll is contained in chloroplasts, and these work as 'Energy Transducers' that convert light energy into chemical energy.

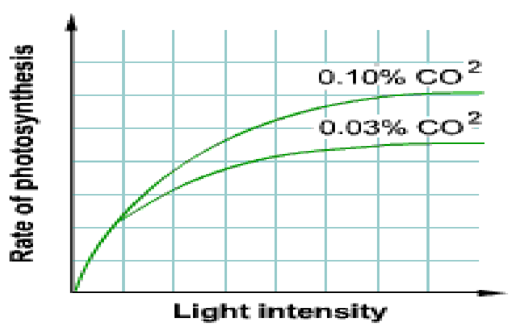
Photosynthesis also needs certain conditions to operate in the optimum way these include:

- Chlorophyll
- Carbon dioxide (from the air)
- Water (from the soil)
- Sunlight energy (any light will do except green light)

There are also certain factors that limit photosynthesis, these include:

- **Light**

Sometimes light is a limiting factor. A plant may have lots of water and carbon dioxide, but it will not photosynthesise very fast if there is not enough light; increasing the light intensity will make photosynthesis faster.



- **Carbon dioxide**

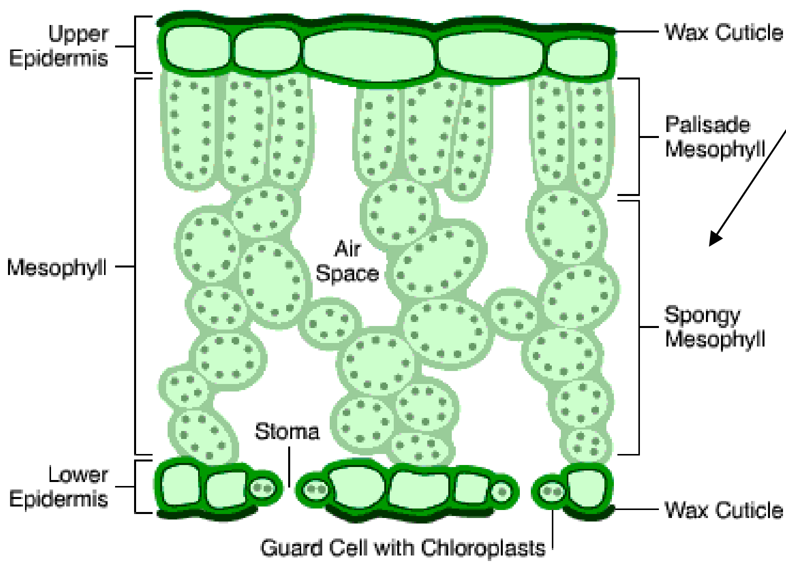
Sometimes the level of carbon dioxide is limiting. There ma y be plenty of light but the plant cannot photosynthesise because it has run out of carbon dioxide.

- **Temperature**

Temperature can be a limiting factor too. The rate of photosynthesis will be limited if it is too cold for the enzymes to work properly.

The chlorophyll is found in abundance in the leaves of the plant. In order to photosynthesise efficiently a leaf needs a method for exchange of exchange of gases between the leaf and its surroundings, a way of delivering water to the leaf, a system for the removal of glucose so that it can be transported to the other parts of the plant and as an efficient means of absorbing light energy.

The Structure of a Leaf



The rate of photosynthesis can be estimated by measuring how much carbon dioxide a plant absorbs during the process. This is done by using a radioactively labelled form of carbon dioxide (CO). This labelled form is absorbed by the leaf cells and converted into labelled carbohydrates in exactly the same way as ‘ normal’ carbon dioxide. A Geiger counter is used to detect how much radioactive material has been taken in by the plant- and this shows the rate of photosynthesis. This method is called tracing photosynthesis and is used to provide information about the other compounds plants make during photosynthesis or how plants transport food substances from one place to another.

Apparatus:

Boiling Tube full with tap water
Canadian Pond Weed
Light, with a 50-watt bulb
2x Metre Rulers

Diagram:

Method:

Firstly we collected our apparatus and assembled them.
We had decided upon 7 lengths on which to test whether the theory is correct, these were: 5cm, 10cm, 15cm, 20cm, 25cm, 30cm, and 35cm.
We decided to take results over a period of five minutes, and take the number of bubbles of oxygen produced each minute from the Canadian pondweed.
We recorded these results and then found the average number of bubbles per minute.
These results were then plotted onto a graph.

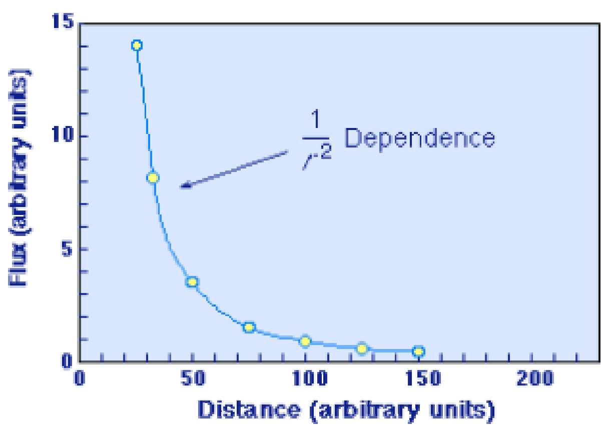
Fair Test:

To ensure that the experiment is a fair test we will keep the following constant:
The water temperature
Use the same bulb and lamp
The species of the plant
The number of leaves on the plant.

We will also keep the same person recording the results and the same to call out the results.

Prediction:

I feel that the light intensity will have a great effect of the rate of photosynthesis. I think we will find that the larger the light intensity, the faster the rate of photosynthesis.
We could also use the Inverse Square Law to help us predict the outcome of our experiment:



The equation for this law is:

$$\frac{I_1}{I_2} = \frac{d_2^2}{d_1^2}$$

The inverse square law states that for every time the distance doubles, the intensity of the light will half.

Preliminary Work:

For our preliminary work we decided upon the lamp di stances we were going to use for our main experiment. We did some tests that helped us in our decision.

Length: 10cm

Minutes	Bubbles
1	10
2	12

Length: 20cm

Minutes	Bubbles
1	7
2	14

Length: 30cm

Minutes	Bubbles
1	4
2	9

Length: 40cm

Minutes	Bubbles
1	3
2	6

Length: 50cm

Minutes	Bubbles
1	2
2	5

Length: 60cm

Minutes	Bubbles
1	2
2	3

These results showed us that the optimum distances were between 10cm and 30cm. However we decided to give a bit of leeway - and therefore included 5cm either way.
This gave us the lengths of:

5cm, 10cm, 15cm, 20cm, 25cm, 30cm, and 35cm.

Results:

Measurement 1- 5cm

Minutes	Bubbles
1	17
2	28
3	36
4	46
5	53

Mean number of bubbles: 9

Measurement 2- 10cm

Minutes	Bubbles
1	13
2	17
3	22
4	26
5	32

Mean number of bubbles:4.5

Measurement 3- 15cm

Minutes	Bubbles
1	17
2	17
3	17

4	23
5	25

Mean number of bubbles: 4

<u>Measurement 4- 20cm</u>

Minutes	Bubbles
1	10
2	18
3	21
4	28
5	34

Mean number of bubbles: 9

<u>Measurement 5- 25cm</u>

Minutes	Bubbles
1	0
2	3
3	4
4	6
5	7

Mean number of bubbles: 2.5

<u>Measurement 6- 30cm</u>

Minutes	Bubbles
1	3
2	7
3	10
4	13
5	14

Mean number of bubbles: 3.5

<u>Measurement 7- 35cm</u>

Minutes	Bubbles
1	5
2	5
3	6
4	6

5	6

Mean number of bubbles: 2

Average number of bubbles per minute

Distance (cm)	**Rate (bubbles per minute)**
5	9
10	4.5
15	4
20	9
25	2.5
30	3.5
35	2

To find out the average number of bubbles per minute:

Example:

Measurement 2- 10cm

Minutes	Bubbles
1	13
2	17
3	22
4	26
5	32

The difference between 1 and 2 is **4**
The difference between 2 and 3 is **4**
The difference between 3 and 4 is **4**
The difference between 4 and 5 is **6**

Analysis:

Our experiment does show that light intensity does have an effect on the rate of photosynthesis. However we did come across some errors in our experiment and these were shown up in our graph.

The main source of error in any kind of scientific experiment is human error. It is a simple fact that whenever humans conduct an experiment or any kind of investigation there will always be some sort of error involved with the outcome and the results.
In this experiment the main sources of human error were involved with the reading of the bubbles per minute. Since we were using our eyes, it is highly likely that we could have missed a bubble. This would have changed the average rate, which therefore could have changed the outcome of this experiment. It is important to note that since we were conducting the experiment, the results we collected are probably not accurate.

One factor that we could not control, given the resources we were supplied with was the light that was coming in through the windows and the possibility of extra light coming from other groups light bulbs. This could mean that more light was reaching the plant-and therefore the rate of photosynthesis would be higher. However next time we conduct the experiment we could black out all windows- or better in a windowless room- with no other surrounding light sources. This would help to make sure that the light intensity is kept at a constant rate.

Another factor that could have affected our experiment was temperature. The experiment was not done in a thermostatically controlled room, and therefore it is likely that the temperature was not kept constant. This would have affected the rate of enzyme activity, and since a ten -Celsius rise in temperature can cause a doubling in the rate of enzyme activity, it is more than likely that the temperature was a major error source in our experiment.

The graph that was drawn from our results was curved, as expected. There were, however, some errors shown- that were off the line of best fit.

Overall I feel that our prediction was correct as the larger the light intensity was, the higher the rate of photosynthesis. The conclusion of this experiment is that light intensity is the most important factor in the process of photosynthesis.

Evaluation:

Our experiment was successful as our prediction was correct, and we got the results we expected. There were some points that were anomalous (off the line of best fit), and they were errors, which were made when recording the results. The anomalous results found in this experiment were:

Anomalous results found in the graph *Distance vs. Rate*

1. Distance- 20cm: Rate- 9 Bubbles per minute
2. Distance- 25cm: Rate- 2.5 Bubbles per minute
3. Distance- 30cm: Rate- 3.5 Bubbles per minute

The evidence that could show why these results were anomalous is that all the results where gathered and recorded by humans, not computers. The main sources of error in this experiment were human errors and the way in which we recorded the results.

To correct these errors we could have used more specialist equiptment, such as lasers to control the clocks, computers to record the results. To obliterate the possibility of any surrounding light getting in and interfering with the experiment we could have done the experiment in a dark room with only our light bulb, away from any other light sources. This would have made our results more accurate.

Perhaps there were some errors that we could not have prevented such as temperature change in the room (e.g. the sun going behind a cloud). This could have affected our results and possibly given us errors. Working in a thermostatically controlled room could change this.

The other main errors which we encountered in the experiment were other light sources affecting the light intensity and the time taken for the plant to adapt to intensity change. Maybe we should have allowed the plant time to change so that the results we were getting would have been more accurate.

If I could do the experiment again, I would have two people recording the results, and then take the average of the two results. This would help to find the source of error easier. I feel we have enough data to form a firm conclusion and that it would not be necessary to conduct more tests. If I had access to any equiptment, I would try to make the whole experiment, computerised and have no human involvement. This would ob literate the main source of error in any experiment or investigation, which is human error. Without human error, our experiment would have been 100% accurate and correct, without any flaws or mishaps. This would help to get rid of error and give us a better, fairer set of results.

There are other experiments that we could test our prediction on, and see if it works in all scenarios. Another investigation that could be done is similar to the one tested in this experiment, but on a more natural level. This time we would take two of the same plant and plant them in two different environments: a wooded one and an open one. We could then test them each day for a month to see how much glucose each had produced (this would be done by taking a sample of leaf fro m the plant). This would show us how light intensity affects photosynthesis in nature.

Diagram:

This experiment would show us how photosynthesis and light intensity work in nature, and this would give us a more natural, realistic set of results that could be used to back up the primary experiment.