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HOW DOES LIGHT AFFECT THE RATE OF PHOTOSYNTHESIS
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INTRODUCTION

Photosynthesis is the process that produces food in plants. The 'food' it produces is glucose. In order for photosynthesis take place you need a green plant sunlight and water. The carbon dioxide enters the leaf through the leaves, and the water goes through the roots of the plant. The water and carbon dioxide is mixed in the chloroplast, which is where the light is trapped. The mixture of carbon dioxide and water make the substance glucose which is sugar. The mixture of the two also gives off oxygen. Green plants use the light energy from the sun to combine carbon dioxide and water to make food. Light energy is converted into chemical energy and is stored in the food. The light used in photosynthesis is absorbed by a green pigment called chlorophyll. The three features that leaves have to make photosynthesis an efficient process are thinness, flatness and a large surface area to catch lots of sunlight. The leaf also has palisade cells are near the top of the leaf and are also packed wit chloroplasts. The guard cells on the leaf control the movement of gases into and out of the leaf. The four things needed for photosynthesis are:

Light – This comes from the sun
Chlorophyll – the green substance which is found in chloroplasts,
Carbon dioxide – enters the leaf from the surrounding air,
Water – comes from the soil, up the stem and into the leaf.

The formula for photosynthesis is:

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

The rate of photosynthesis is affected by several factors. They are the amount of available carbon dioxide and water. Only 0.03% of the surrounding air around is CO_2. The third and final factor is the temperature. Chlorophyll works best when it's warm but not too hot, as they then denature. Enzymes denature when the temperature reaches approximately 40°C. There were quite a few people involved in the discovery of making photosynthesis known. One of the main people involved in the discovery was Melvin Calvin and also one of his assistants A. A. Benson. They were the first to realise that Carbon 14 couldn't solve the mystery of photosynthesis. Calvin and Benson began doing experiments. They created a cycle to explain photosynthesis to others. The process was named the Calvin cycle. In 1961 Melvin Calvin won the Nobel Prize for chemistry. Other people were involved in the discovery of photosynthesis.

A person who went by the name of Philip Hauge Abelsone made replicas of some of the proteins found in oxygen. An English Biochemist John B. S. Haldane made an excellent point and when he said *"that if life was responsible for the oxygen in the atmosphere, photosynthesis ought to have started when there was no oxygen in it and carbon dioxide was present instead*." R. Emerson and W. Arnold illuminated plant cells with extremely short flashes of light. An English Botanist called Stephen Hales had the idea that if plants can give off gases then this means that they could also take in gases. Rudolf Fittig discovered that there were six carbo n atoms, twelve Hydrogen atoms, and six Oxygen atoms in glucose. Other people who helped make photosynthesis known are Joseph Bienaime Caventou and Pierre Joseph Pelletier. These people secluded the green substance and named it chlorophyll after the Greek name for 'green leaf'. A German biochemist named C. Benda used a dye system and named the cytoplasm and mitochondria. Daniel Arnon was able carry through the complete and photosynthetic reaction working with disrupted spinach cells. For this project I will be looking at how light affects the rate of photosynthesis. Does light increase the rate of photosynthesis? Or does light decrease the rate of photosynthesis? I set up some apparatus to find out the answer to these questions. Here's what I came up with.

EQUIPMENT LIST

Funnel – The pond weed will be placed in the funnel and the funnel will be placed in the water bath

Water Bath – This is where the water will be placed

Thermometer – This will measure the temperature of the water

Measuring Cylinder – This will measure the quantity of oxygen given off

Lamp – This will shine light on the pond weed

Ruler – This will measure how far the lamp is from the water bath

Pond Weed – This will be used to measure the rate of photosynthesis

METHOD

INPUT VARIABLES

The light intensity will be changed by increasing and decreasing the distance of the lamp from the water bath.

OUTPUT VARIABLES

The rate of photosynthesis will be determined by the volume of oxygen produced which will be measured by the volume of water displaced from a measuring cylinder.

CONTROL VARIABLES

The light is easily absorbed by the chlorophyll pigment in the leaf. Chlorophyll easily absorbs red and blue light. It does not however absorb yellow or green light but instead reflects them. This decreases the quantity of light absorbed and therefore the rate of photosynthesis which takes place. This means that the same lamp, with the same power light bulb must be used throughout the whole of the experiment.

First I will fill a water bath full of water. Other equipment that will be placed in the water bath include a thermometer, a funnel (containing pond weed)

Attach the funnel to a measuring cylinder using a rubber hose for the gas to be collected.

Place a lamp at 0cm from the water bath.

At the same time I will switch the lamp on and begin the timer on the stop watch.

After 10 minutes I will stop the clock, turn the lamp off, and record the results of how much gas has been collected.

I will repeat the above 3 times and work out the average results.

Next I will move the lamp back 10cm using a ruler to measure the distance accurately.

Afterwards I will run the experiment again 3 times and work out the average.

I will continue to repeat the experiment until I have reached 100cm.

The results that will be collected are going to be recorded in a table . The table will look like this:

DISTANCE FROM LAMP (CM)	OXYGEN COLLECTED (CM) 1ST	OXYGEN COLLECTED (CM) 2ND	OXYGEN COLLECTED (CM) 3RD	OXYGEN COLLECTED AVERAGE (CM)
0				
10				
20				
30				
40				
50				
60				
70				
80				
90				
100				

FAIR TEST

To ensure that only light intensity is affecting the rate of photosynthesis I will keep constant the following factors each time I repeat the experiment.

The amount of pond weed:

If there is more pond weed after the first recording and less pond weed after the second recording then the results will be imprecise. To keep the same amount of pond weed used at all times, I will use a top hand balance.

The temperature of the water:

Chlorophyll works like an enzyme because it works best when it's warm but not too hot. The rate of photosynthesis is determined on how hot the chlorophyll is.

The amount of time that has passed when I record the results:

The quantity of gas accumulated will vary a great deal if the results are recorded after dissimilar times. To keep the amount of time that has passed the same, I will use a stop watch.

The power of the light bulb on the lamp:

During the process photosynthesis light alo ng with chlorophyll is used form glucose and oxygen. Glucose provides the energy needed for the plant, so light is an essential factor which aff ects the rate of photosynthesis. So it's important that the power of th e light bulb remains the same otherwise the results will be inaccurate.

PREDICTION

For this experiment I predict that the further the lamp is from the water bath then the slower the rate of photosynthesis that will take place. I predict this because even if all the other elements are present for photosynthesis, they would be of no use without light energy. Glucose is the entire reason why photosynthesis takes place because it produ ces food for the plant. In green plants, light energy is used to combine carbon dioxide and water to form glucose which the plant uses as a source of food . Therefore the less light there is, then the slower the rate of photosynthesis takes place. Eventually a point is going to be reached where the closer the lamp is to the water bath then no difference is going to be made on the rate of photosynthesis.

RESULTS

DISTANCE FROM LAMP (CM)	OXYGEN COLLECTED (CM) 1ST	OXYGEN COLLECTED (CM) 2ND	OXYGEN COLLECTED (CM) 3RD	OXYGEN COLLECTED AVERAGE (CM)
0	34	29	37	33.30
10	39	33	29	33.60
20	27	37	37	33.60
30	35	32	29	32.00
40	22	31	30	27.60
50	22	25	22	23.00
60	24	26	24	24.70
70	18	16	18	17.30
80	17	14	16	15.60
90	11	13	13	12.30
100	10	11	10	10.30

CONCLUSION

My graph proved my prediction to be right. The further the lamp was from the water bath the slower the rate of photosynthesis took place. My graph shows that the closest the lamp was to the water ba th was also the quickest rate of photosynthesis that took place. My first three results were a straight line. When the results were recorded at 0cm, 10cm, and 20cm it was all in a straight line. This means that the rate of photosynthesis did not have an affect once the lamp was any closer than 20cm. As the graph progresses further the rate of photosynthesis is was decreasing. The graph shows that 100cm which was the furthest the lamp was from the water bath was when the rate of photosynthesis took place at its slowest.

My graph started with the lamp closest to the water bath, and that was when photosynthesis took place at the fastest rate. Furthermore, the slowest rate at which photosynthesis took place was when the lamp was the furthest from the water bath. The reason why this happened was because light is a key factor which is needed in the process of photosynthesis. In the process of photosynthesis li ght energy is used to form glucose which the plant uses as a food source. Chlorophyll uses light energy to carry out photosynthesis. The speed at which photosynthesis takes place depends on how intense the light energy . Chlorophyll only absorbs the red and blue ends of the visible light spectrum, but not the green light in the middle which is reflected back . This is why the plant looks green.

On my graph the first three results are practically level. This shows that the rate of photosynth esis does not increase once the lamp is closer than 20cm to the water bath. This is because the available water and carbon dioxide has been used at its maximum rate.

EVALUATION

In my opinion I consider my experiment to be fairly accurate as everything went to plan and furthermore all the equipment I used worked well throughout the experiment. The results that were recorde d turned out as I expected, and matched my prediction. However I recorded an anomalous result when the lamp was 60cm away from the water bath. I had no problems with the equipment, and they all worked well. I consider the equipment I used to be very suitab le and very much relevant for this experiment.

I would also say my results would be very reliable as the graph look to be in a good state. To improve my graph further I could have used the points where the rate of photosynthesis took place at its quickest. I would then repeat the experiment but with smaller intervals to see when the rate of photosynthesis was at its quickest to record more accurate results.

I then could have gone on to use smaller intervals to find out when the rate of photosynthesis did n ot increase further more so I could have recorded a more accurate result.

There are a few things which I could have done to make my results more precise. One would be by using an electric water bath. By using an electric water bath, I could have kept the t emperature of the water the same at all times. When the temperature of the water decreases the electric

water bath turns on and increases the temperature of the water until it reaches the required temperature. When the required temperature is reached the electric water bath is turned off. The electric water bath can also solve the problem of the extra heat which is created by the lamp.

To record a more accurate graph I could have changed the intervals on the distance scale. Instead of going up in 10cms I could have gone up in 5cms.

When I setup the apparatus I used a measuring cylinder to collect the oxygen. Instead of using a measuring cylinder I could have used a gas syringe. A measuring cylinder measures in cm which is very efficient for collecting gas. A gas syringe is designed to measure gas and therefore will record far more accurate results. A gas syringe measures in cm^3 which is what gas is measured in and as a result is much mor e suitable for this experiment.

An additional way to improve to my exp eriment would have been to perform the experiment in the dark as the rate of photosynthesis wouldn't have been contaminated with other sources of light. This would further improve the reliability of my results.

In addition to my previous improvement, I wou ld also keep the distance from the lamp to the water bath the same throughout the whole experiment but would also use a light filter. I would use a light filter because to vary the amount of light that gets through to the wate r bath using smaller intervals i.e. use a filter that only lets 5% of the light through, 10%, 15% etc.

Taking into account all the improvements I would have made to this experiment I would predict that the more light there is then the quicker the rate of photosynthesis will take place . This is the same prediction as my previous experiment however my suggested opinions will improve the accuracy and reliability of my results.