

Investigating Photosynthesis

Aims: The aim of our investigation is to find out how the amount of light, that is light intensity, affects the rate of photosynthesis.

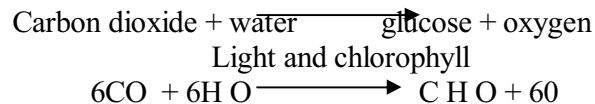
Background information: What variables are involved.

Dependant variable: Light intensity, distance, lamp and plant.

Key factors to control:

- temperature
- number of leaves
- presence of chlorophyll
- time

Preliminary practical work:



- Photosynthesis is when green plants produce glucose from sunlight.
- Light energy, water, chlorophyll, glucose and carbon dioxide are needed for photosynthesis to take place.
- Sunlight, chlorophyll, water and carbon dioxide are needed during photosynthesis.
- Sodium hydrogencarbonate increases the levels of carbon dioxide in a plant.
- It does matter if all the leaves are of different sizes because then the experiment will not be fair and therefore results will not be reliable.
- We can assume that each leaf is approximately the same size because there is no need to measure each leaf exactly, an estimate would be more preferable within the width of the leaf. Each leaf should have similar sizes to be approximate.
- The amount of light on a plant may be a limiting factor that means that it is something which is less in the plant and reducing. Not enough light slows down the rate of photosynthesis.
- The amount of carbon dioxide in the water may be a limiting factor because there is too little of it, it could be decreasing. Too little carbon dioxide also slows the rate of photosynthesis. If carbon dioxide is a limiting factor then either temperature or light intensity may also be a limiting factor.
- If a lamp is moved to be twice as far away from a plant, then the amount of light reaching the plant would be limiting and the rate of photosynthesis will be limiting and slowing down and there would be a decrease in the rate.
- A lamp produces heat as well as light.
- Heat will affect the rate of photosynthesis because it will affect the results/experiment by interfering. The water may warm up and the Elodea will warm up causing anomalous results. The Elodea will warm up; the enzymes in the Elodea will warm up. If enzymes become too hot, they become denatured, they cannot work and the rate of photosynthesis will then stop.

Apparatus:

I need pond water because Elodea grows in pond water. If Elodea is put in tap water, then the chlorine in tap water might kill the enzymes. I need a beaker because I can put the Elodea and the water into the beaker and I can do my experiment by counting the number of bubbles and the beaker helps me do this and help keep the contents in the beaker. It can help keep the water to act as a water bath for a heat shield for my experiment, which can help reduce anomalous results. I will need a stopclock because I can use this to count the bubbles each minute whilst doing my experiment accurately. I will obviously need Elodea crispera to carry out the experiment successfully using a pondweed to find how light intensity affects photosynthesis. I will use sodium hydrogencarbonate to increase the rate of photosynthesis and the carbon dioxide level the plant is receiving. I will use a spatula to use the sodium hydrogencarbonate on the spatula using an equal amount for a fair test. I will need the boiling tube to hold the Elodea crispera in that so I can carry out the experiment. Thermometer will be needed to take readings of the water and recording the temperature, but always making sure that the temperature does not exceed above 40 and making sure it is even for a fair test, such as up to 40 . I will use a 200W lamp to use as the amount of light the plant is receiving and which is fair for the experiment to be successfully be carried out. A light shield will be used to protect other sources of light entering the Elodea within which my experiment can be altered. I will use a water bath- to act as a heat shield to ensure that the temperature is kept constant.

Prediction:

I predict that as the light level is raised the rate of photosynthesis increases steadily but only up to a certain point, but beyond that, it won't make any difference because then it'll be either the temperature or the carbon dioxide level that is the limiting factor. Also with carbon dioxide it will only increase the rate of photosynthesis up to a point. If light and carbon dioxide were in plentiful supply then the factor limiting photosynthesis would be temperature. Finally if temperature gets too high it will destroy the chlorophyll enzymes.

The rate of photosynthesis is affected by the amount of light energy to perform photosynthesis. It can only do it as fast as the light energy is arriving. Chlorophyll actually 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.

It's affected by the amount of carbon dioxide. Carbon dioxide and water are raw materials. Water is not in short supply in a plant but only 0.03% of the air around is carbon dioxide, so it's quite scarce.

The temperature also affects it. Chlorophyll is like an enzyme so it works best when it's warm but not too hot. **Chlorophyll is NOT like an enzyme, but the mechanism of photosynthesis is controlled by enzymes.**

Four factors affect photosynthesis they are light- the more light there is, the faster the rate of photosynthesis. Water- too little water makes the photosynthesis slow down. Temperature- the optimum temperature is around 30 . Photosynthesis still works fine up to about 40 . But once you get much above 40 it slows down dramatically. Carbon dioxide- if paraffin is burnt in a greenhouse the carbon dioxide levels increase and so does the rate of photosynthesis- that increases growth. Here are three important graphs for the rate of photosynthesis. At any time one or other of the above three factors will be the limiting factor which is keeping the photosynthesis down at the rate it is on the next page:

Preliminary practical work:

- * I will be aware that the inverse square law when doubling the distance between the plant and lamp will reduce the amount of gas produced by one quarter.
- * trebling the distance between the lamp and the plant reduces light intensity received by the plant by one ninth. **There is no need to make a qualitative prediction – they hardly ever apply to living processes because of their complexity.**

Distances will be 10, 15, 20, 25, and 30cm

Inverse square law represents as:

$$L \propto 1/d^2$$

L = light intensity

D = distance between lamp and plant.

Graphs can be plotted of the amount of gas produced against light intensity. This assumes that the plant is not affected by any light other than that whose distance is being altered. Law assumes that the plant is not affected by any light other than that whose distance is being altered.

- ☞ To shield my set-up from the effects of light from other sources, I would use a heat shield that will not affect my results. **The heat shield shields the apparatus from HEAT. How are you going to shield it from ambient room lighting, so that only the lamp illuminates it?**
- ☞ The most appropriate length of plant/number of leaves that produce measurable amount of gas in a time that allows repeats is 0.5cm of the leaf and about 10 leaves approximately.
- ☞ I will use an appropriate design of heat shield to prevent the heat from the lamp entering the pondweed. I will use a water bath- to act as a heat shield.
- ☞ The most appropriate way of measuring the amount of gas produced is to count the bubbles of gas being released by the pondweed that is easier.

Here is a diagram of the set-up of the preliminary work:

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You must have ACTUAL results from your preliminary experiment, not predicted ones. What information does your preliminary experiment provide that can be used in your full experiment? What EXACTLY was the purpose of the preliminary work?

Distance (cm)	Light intensity (lux)	Predicted results
10cm	80	
20cm	76	60
30cm	70	
40cm	66	57
50cm	63	

Background light recorded by sensor 2 = **40 lux**

Here is a graph that has been plotted with the preliminary practical work I did with the sensors.
This is the evidence I have obtained:

Here is a diagram of the set-up of my experiment:

Method:

The variables involved are light intensity, temperature, carbon dioxide, environment and availability of water.

The effect of each variable is that light intensity can change the way the Elodea is photosynthesising, it depends on the amount of light energy that is being emitted.

Temperature affects the water and sometimes decreases the rate of photosynthesis as a limiting factor and if it is high it can destroy enzymes. If there is too little carbon dioxide than it could decrease photosynthesis and affect my experiment. The environment has to be kept the same throughout the experiment or it can dramatically change my results, which will result in anomalous results when performing the experiment. For example all in one day. The availability of water is obviously available and cannot limit, although if enough water is not used successfully in the experiment then it could affect my results considerably.

The variables that need to be kept the same are the temperature, number of leaves, presence of chlorophyll and time.

This is my method of how I will carry out my experiment:

For a fair test, I will make sure the distance from the lamp and beaker is constant for each try. I will make sure the light intensity is accurate and will not limit carbon dioxide or temperature. I will making sure the pondweed gets enough carbon dioxide by adding sodium hydrogencarbonate and make sure my results are reliable by doing 3 try's. I will make sure the leaves are all the same sizes or approximately the same. The size will be of 0.5cm, length will be 2cm and the area of the leaf will be 1cm. By limiting heat that will affect any results I will put a heat shield. To allow my experiment to have enough light I will increase the rate of photosynthesis. But making sure the temperature is just right, up to 40 that are neutral for the plant. But at this point the enzymes will be destroyed, if this becomes a limiting factor than the water will be warmed up. I will ensure the temperature is kept constant by using a water bath as a heat shield. I will check my thermometer regularly to ensure that the temperature of water bathing the pondweed does not fall below 35 or above 40 . I will check if heat is affecting the rate of photosynthesis because it could affect the temperature of the water and warm up the Elodea. I will measure the distance from the lamp and Elodea accurately, each minute the distance will be altered and 3 tries will be experimented on, to document my results reliably. I will cut exactly 10cm of pondweed for my experiment. I will measure the amount of bubbles per minute. I can measure the amount of gas being given off by using a piece of equipment that can measure the amount of gas given off, this method is slightly complicated and not simple instead of the method of counting the number of bubbles given off.

I can make sure that my measuring is accurate by using my preliminary work and using the inverse square law by calculating what my results should exactly be, making a prediction of my results for both the preliminary practical work done and my experiment. This can ensure that results are reliable and by performing fair tests and making sure factors will not limit in my experiment and nothing will affect my results e.g.- heat may allow anomalous results to occur. I can stop heat affecting any results by using a water bath as a heat shield. I will use a metre rule to measure the distance between the light and plant when carrying out the experiment each minute the light intensity will be decreased each time the distance is moved, (each minute material to use as a light shield for unwanted light will be used to).

Safety precautions that could be taken can be making sure sodium hydrogencarbonate will not be inhaled because it is a minimal hazard. Make sure with

a lamp, to beware of an electric shock, especially if hands are wet. If splashed with water, a hot main lamp may explode. Also ensure good hygiene by hand washing.

- ⇒ Add, to 200cm of 'pond' water in a beaker, one spatula - full of sodium hydrogencarbonate.
- ⇒ Fill a boiling tube with this 'pond' water.
- ⇒ Cut a sprig of *Elodea crispera*, 5cm long.
- ⇒ Wrap the strip of lead round the top of the sprig.
- ⇒ Place the sprig, cut end uppermost, into the boiling tube full of 'pond' water.
- ⇒ Place the boiling tube in a beaker of water- this will act as a heat shield.
- ⇒ Place the thermometer in the water in the beaker. Record the temperature.
- ⇒ Allow the plant to begin to produce a steady stream of bubbles
- ⇒ Shield the set-up from unwanted light.
- ⇒ Set up the 200W lamp at the *furthest* distance investigated. Measure the distance.
- ⇒ Allow the plant time to adjust to the new conditions.
- ⇒ Count the number of bubbles produced in a known period that will be every 5 minutes.
- ⇒ Measure and record the temperature of the water in the beaker regularly.
- ⇒ Repeat these measurements into 3 trys.
- ⇒ I will repeat the steps for a range of closer distances.

PLANNING 7/8. This could be improved to 8 with proper use of a preliminary experiment as described above. Make sure that you mention shielding the apparatus from room lighting.

Here are my results that I set up in a table with the average results: Obtaining evidence:

I have included a range of observations and measurements of at least 5 and have recorded the temperature regularly. The observations and measurements have been recorded clearly and accurately for safe and fair test:

Distance (cm)	NO of bubbles (1 min)	1 st try	2 nd try	3 rd try	Average NO of bubbles
5	32	9	10	13	10
10	37	7	9	12	9
15	26	6	8	11	8
20	20	5	9	6	7
25	16	4	7	5	5
30	12	3	5	4	4

OBTAINING EVIDENCE - 8/8 No alterations needed

Analysing Evidence and Drawing Conclusions:

Here is a graph of the number of bubbles and Average number of bubbles on the next page to show that I have drawn conclusions consistent with the evidence from my result table/chart and by using scientific knowledge:

The scientific knowledge and understanding I can apply to the conclusions that I have drawn is that the more the lamp distance from the Elodea, the increase of bubbles of gas produced. This is because the amount of light energy being received by the Elodea is plentiful and the rate of photosynthesis increases. If light energy is limiting then the rate of photosynthesis slows down intensively. I moved the lamp 5 cm each minute and then counted the bubbles. As I moved the lamp away from the Elodea, the rate of photosynthesis limited. As shown in my graph/conclusion the results varied and as the distance increased my results decreased which meant the number of bubbles decreased as well. The scientific knowledge is that plants need light to carry out photosynthesis and produce bubbles of gas, but if light is limiting,

then the rate of photosynthesis is also limiting which allows the rate of bubbles to slow down and then less oxygen bubbles is produced. Light is needed for photosynthesis to occur, without it photosynthesis cannot happen as light intensity can produce the oxygen bubbles that occur in the experiment, these bubbles reduce when the amount of light reaching the plant is moved away, which I demonstrated in my experiment.

The results support my original prediction in the way that as the light intensity decreased, the rate of the bubbles also decreased. The results show a decline in the number of bubbles as the distance increases as the graph shows; the line of best fit shows negative correlation. The results support my original prediction, as the distance of 5cm on the 1st try was 9 bubbles, as the distance increased by 5, the number of bubbles decreased by one, which also showed a pattern, every time on the 1st try the bubbles decreased by, this was obviously because there was a limiting factor of light reaching the plant when the distance was increased by 5. The results for the 2nd try also undermine my original prediction because, the number of bubbles also decrease by one here when the distance increases by 5, although for 20cm the number of bubbles increase to one as 9 which proves that it was an anomalous result, despite this may have not supported my prediction as there may have been a factor that I may have not controlled, the next two results are fine, they certainly do support my prediction because the number of bubbles does not decrease by one but by 2 for 25cm and 30cm, 7 and 5 bubbles. Also a result that does undermine my original prediction dramatically is on try 3, which for the first 3 results it decrease by 1 bubbles, although for the next 3 results from 11 bubbles it decrease to 6 which was a dramatically change, it then reduces to one from 6, 5, 4 bubbles, this certainly under mines my original prediction.

My original prediction mentioned that as the light level is raised, the rate of photosynthesis increases steadily but only up to a certain point which my graph shows but in the opposite as the light levels decreased the rate of the photosynthesis decreases steadily as well. When bubbles are produced it shows that photosynthesis is occurring. My results do show areas where something may have been declining or limiting such as on my 1st try at 30cm I had a result of 3 bubbles at that distance which is incredibly low and quite peculiar but this proves that it was an anomalous result that a factor is limiting such as temperature or carbon dioxide. **This sentence is difficult to follow – I am not sure what you mean.** Although temperature was recorded from time to time and sodium hydrogencarbonate was also added before the experiment for a fair test and reliable results. Anomalous results occurred because the experiment may have been affected by heat or light from another source which is interrupting the experiment and allowing anomalous results such as a low decrease in the number of bubbles between 5cm and 10cm, or even on the 1st try only 1 bubble decreased from 25cm and 30cm which was 4 bubbles and when the distance increased the number of bubbles decreased by 1 which was entirely anomalous.

ANALYSING RESULTS. I cannot give a mark for this skill without seeing the graph that you will draw. I would estimate 7/8 if your graph is O.K. You do not really explain the EXTENT that the conclusion supports the prediction, which is necessary for 8 marks.

Evaluating Evidence:

The accuracy of my measurements and observations were mostly reliable and accurate there were a few results that were off the graph and anomalous which showed those same results was accurate but some were clear. I also made accurate observations such as when counting the number of bubbles to make sure no bubbles

are missed when counting I carefully made sure every bubble was counted each minute, also by recording these results immediately on a tally chart. Any anomalous results such as one on the 2nd try which was on 20cm it was 9 bubbles from 8, the number of bubbles increased to one, when from my prediction I mentioned that the number of bubbles will decrease, as the distance increase by 5, although this bubble increased by one. I suggest this happened because an absolute fair test may have not been considered and an extra bubble may have been measured, or a miscalculation in the number of bubbles read. I would have not suggested that there was a limiting factor because the number of bubbles increased or a key factors that was not controlled. Another strange/anomalous result was one that I mentioned such as on try 3 there was a result of 11 bubbles, then the number of bubbles reduced to 6, which shows that this result was an enormous change, this could be because of a limiting factor such as carbon dioxide, **In as given experimental set up, factors are either limiting or they are not. The limiting factors would not change during the course of the experiment.** not even of the solution may have been added, despite this for my measurements I had decided for a fair test that for each try I add a spatula full of sodium carbonate so I have a fair test, this occurred although it may have affected this result, there are other factors that could have caused this such as the temperature may have allowed a reduction of the results from 11 bubbles to 6. These limiting factors may have allowed this huge reduction of the bubbles in try 3. I made accurate measurements when I was measuring the distance between the lamp and Elodea and also measured the time extremely accurately, each minute it had to be done. I measured the amount of leaves on the pondweed and the size of each leaf approximately. I measured the amount of bubbles that were produced each minute accurately and mostly dependable. If I had missed any it proved that I had not performed a fair test. I measured the gas fairly accurately; ensuring my experiment was fair.

The evidence is sufficient to support a firm conclusion as the results are extremely clear and accurate, also the preliminary work that I did was supportive for my actual results, for the distances I did for this work, I predicted the results using the formula of reducing the light intensity by a quarter, I predicted these results only for 20cm and 50cm, I was unable to work out the others because it was the only way to work out the two predicted results. My predicted results were accurate and fair, although as it shows on my graph that it was falling from 90 lux to 60 lux, this was because there was extra light arriving at the plant which was the background light of 40 lux. The suitability of my results were good **What do you mean by this? Can you JUSTIFY this opinion?** which also supported my prediction and allowed me to show what was occurring with my results and how light intensity was affecting the plant, the sufficient evidence showed that the plant was losing bubbles as the distance increased, I interpreted this from my results graph and table and all the sufficient evidence that I processed clearly showed me what was happening in my experiment and with scientific knowledge I was able to prove the evidence that I had retrieved was correct and mostly reliable.

The improvements I would make to allow my results to be even more accurate, fair and much more reliable, but trying to avoid anomalous results when obtaining evidence and analysing evidence then I would suggest that the water bath the pondweed was actually in should have been changed each time a new try was being introduced, **Why? Explain** to enable an even more fairer test and enabling no anomalous results to occur in the end, I would do this when obtaining the results. I would also make sure I measure the bubbles even more accurately **How?** to ensure that good, reliable results are obtained clearly. Finally, I would also ensure that the

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light received by the plant is moved from the plant accurately with a metre rule, despite this I did carry out this accurately during the experiment, but I would like to ensure that my results were clearly accurate and even more reliable than before, so no anomalies occur at all when obtaining the evidence. I would check that I do a much more of a fairer experiment, make sure my timing is accurate when counting the number of bubbles. **Evaluation should discuss experimental design, not assess how well you did the experiment!** The reliability of my results were accurately taken into account, all results were reliable to discover a pattern. **Explain what evidence you have that the results were reliable.** The conclusions that I have drawn show how the distance affects the light intensity emitting on the Elodea. From this I could interpret an easy pattern. The conclusions drawn show clearly how a pattern has been developed and concludes the results made and therefore is reliable. The further work to provide additional evidence for the conclusion would be to investigate further distances in 10's each time, not in 5's as I did in this investigation. So I could investigate how the length can vary in every 5cm and 10cm, I could investigate the difference between the distances, to find out how the different lengths of different sizes affect the amount of light intensity the plant is receiving or the rate of photosynthesis. **This is very difficult to follow - what on earth do you mean???** I could also extend the enquiry by investigating how the amount of carbon dioxide affects the rate of photosynthesis. **This is not extending the enquiry – this is doing a different experiment.** This would enable me to see how factors that are needed for photosynthesis would vary, such as light intensity that is investigated; I could investigate the amount of carbon dioxide. Chlorophyll is a substance that is needed for photosynthesis to occur, I could test the amount of chlorophyll a plant has received, or received, it depends on the amount of sunlight that the plant is actually receiving.

You have missed an obvious source of inaccuracy – when counting bubbles, the bubbles may not all be the same size.

EVALUATION 3 or 4/6. Your evaluation is tends to 'waffle'. You make statements but do not justify them with evidence from your results – see my comments.