

## PLANNING

### Introduction:

Photosynthesis is the process plants use to make their food. This occurs when plants take in sunlight energy and water (intake by the roots from the soil – especially when it has rained) and carbon dioxide. The energy from the sun is absorbed and then stored by the chlorophyll to make the carbon dioxide and water react together to make glucose and oxygen. The word formula is:

**Carbon dioxide + water → glucose + oxygen**

And the chemical formula is:



This is what we will be experimenting on:

The rate of photosynthesis according to how much light (intensity) is applied from various distances. To measure this, we will be counting bubbles and taking readings.

### Aim:

My aim is to investigate the effect of changing light intensity on the rate of photosynthesis and to show that oxygen is produced during photosynthesis. (We will be measuring this by counting the bubbles produced after a set amount of time.)

### Apparatus list

- 1 piece of weed (elodea)
- 0.25g of NaHCO<sub>3</sub> (sodium hydrogen carbonate)
- 250ml of H<sub>2</sub>O (water)
- a graduated measuring cylinder
- a lamp (caution: HOT!)
- a razor
- tin foil/black paper
- a stop clock
- a metre ruler
- a paperclip

### Prediction:

When there is more light applied to the selected plant instead of a whole group of plant, the individual plant can use more energy. The more energy there is, the more can be used to make the carbon dioxide and water react together to produce glucose and oxygen; therefore the whole process speeds up when the light intensity is higher. The light intensity depends on the distance between the plant and the light source. So if the light source is, for example 20cm away from the plant, the light intensity will be higher than if the light source was 30cm away

*from the plant, because the distance between the two is shorter (i.e. they are closer together). However we can only measure this by the oxygen bubbles given off (a waste product of the process of photosynthesis because the glucose is used as the plant's food), so this means that we will have to measure the oxygen underwater so we can count the bubbles. The chemical and word equation already show that oxygen is produced during photosynthesis.*

*Therefore, I predict that the closer the light source is to the plant, the higher the level of light intensity will be so the process of photosynthesis will be faster (as there will be more energy reserved for the one plant), so there will be more bubbles produced.*

### **Method:**

*Firstly, I will get out all of my apparatus as in the apparatus list, and set it up as shown in the diagram, so as to be ready to start immediately.*

*I will put some black paper around most of the graduated measuring cylinder to leave enough room for the light to get through to the weed, sealing it onto the cylinder with cellotape. Following that, I will measure out 250ml of water and put it into the cylinder, and then I will measure out 0.25g of sodium hydrogen carbonate ( $\text{NaHCO}_2$ ) and stir it into the water in the cylinder, giving it a 0.2% solution (known volume). I will then choose a young, green, leafy piece of elodea (weed) and cut it away from the rest of the plant at the base of the selected weed's stem (where it is attached to the main stalk), and covering the cut end with my thumb, I will quickly put the paperclip on the end of the weed and immediately transfer it to the solution in the cylinder (paperclip-end down). Using a metre ruler, I will put the lamp at a set distance away from the cylinder (equilibration), recording the distances (there will be 5 different distances), noting down the distance (cm) and recording the number of bubbles produced after 5 minutes at each set distance, and then going back to get repeats to make my results as accurate and reliable as possible and also to be able to calculate an average for each distance (light intensity).*

*Depending on whether my experiment goes according to plan and if I have enough time, I will repeat the experiment but changing the volume of  $\text{NaHCO}_2$  to make it a 0.4% solution. I will be using an identical method.*

*I will record my results in a table and then use this table to make various graphs to try to extract a trend/pattern so as to be able to analyse, conclude and evaluate accurately. Altogether, I will be recording 10 readings (15 readings if I do go ahead with the repeat).*

*After I have completed the experiment, I will clear away my equipment safely and neatly. I will have to wear an overall to protect my clothes and also a pair of goggles so as to protect my eyes in case the solution splashes anywhere.*

### **Fair testing:**

*The following will be kept constant to make the test a fair one:*

- 1. The equipment e.g. cups, thermometers and so on, so as to make sure that the conditions, amounts and factors such as temperature are kept the same.*
- 2. The room temperature (\*C) so excess heat from outside does not stimulate the rate of photosynthesis, speeding it up.*

*The volume of water; the elodea; the pH of the solution; the amount of the NaHCO<sub>3</sub> (except for when I may be doing my repeat, using a 0.4% solution, but this does not affect the 0.2% solution as I will have completed that test before I start the 0.4% solution), and the temperature of the room. We can open windows to try and level the temperature of heat from the lights unbalances it. These are our constants.*

*The light from the bulb being applied to the weed will be the independent variable, as I will be manipulating it.*

*Also, the black paper around the cylinder will be controlling how much light is let into the cylinder.*

**N.B - variables:**

- Factors like timing (i.e. when we will take the readings and how long for) are our **independent variables** – this being the type of factor we will change step-by-step, deliberately.*
- Our readings (results) are the **dependant variables** – the size or amount of this depends on the first reading.*
- All of the other variables will be our **constants** – they will be kept under control.*

## OBTAINING

### Preliminary experiments:

*Experiments I have done before this experiment include testing a leaf to see if light is necessary for photosynthesis and testing a leaf to see if carbon dioxide is needed for photosynthesis. The first was done by leaving a leaf in a cupboard to de-starch it and then cover it with a strip of black paper or foil with some sort of shape cut out of it and then leave it the path of sunlight for a few days and then test it for starch. The latter was done by de-starching a plant and put a leaf on one side of the plant in an air-tight test tube with a small amount of distilled water in it and another leaf in an air-tight test tube with the same amount of potassium hydroxide solution and leave the plant in a sunny area for a few days and then test it for starch.*

*When I was doing the first reading for the 0.2% solution, there were no problems with the experiment – it went exactly according to plan and there is no need to change any of the Planning section or the method, which I am pleased about.*

### Results:

Distance from elodea (cm)	Reading 1 (0.2% vol)			Reading 2 (0.4% vol)	
	1 <sup>st</sup> Reading	2 <sup>nd</sup> Reading	Average no. bubbles p/min	1 <sup>st</sup> Reading	Average no. bubbles p/min
10	372	396	76.8	399	79.8
20	274	257	53.1	262	52.4
30	228	219	44.7	209	41.8
40	185	177	36.2	159	31.8
50	150	148	29.8	135	27

*The readings in the above table show the amount of bubbles after 5 minutes.*

*From this table I was able to calculate the light intensity, which would be to divide 1 by the distance squared and then say for example the distance is 10cm, it would be 0.01 so, to write that in standard form would be  $100 \times 10^{-3}$  so that would be the light intensity for the light applied at a distance of 10cm away from the elodea. This will help me to plot a graph showing light intensity at different distances.*

To show this for all 5 distances, I have decided to put it in a table to show light intensity.

Distance	$\frac{1}{d^2}$	Light intensity $\frac{1}{d^2}$
10	0.01	100 x 10
20	0.0025	25 x 10
30	0.0011	11 x 10
40	0.000625	6.25 x 10
50	0.0004	4 x 10

**Graph(s):**

See graph paper.

**Observing:**

At the beginning, the average number of bubbles per minute for the 0.2% solution did not differ greatly from that of the 0.4% solution (76.8 and 79) and therefore the end result being 29.8 and 27. This is probably why, visually, the graphs look similar, because all of the graphs look extremely similar with trend, pattern and size. My graphs show the drop in the number of bubbles in proportion to the drop in light intensity.

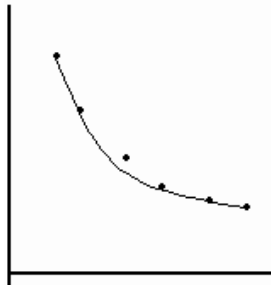
$\frac{1}{d^2}$  means 1 divided by the [distance squared]. This makes it easier to plot on a graph and it enables us to show the answer in standard form (e.g.  $6.25 \times 10^{-5}$ ) which is far more readable than 0.000625. In observation, in the table above, the number that has to be multiplied by 10 goes from 100 to 11, and then to 4. This also shows that as the amount of concentrated light moves further away, the number of oxygen bubbles produced (representing the rate of photosynthesis) decreases to show that for the process of photosynthesis to work quickly, light is a necessity.

## ANALYSING AND CONCLUDING

### Analysis:

Looking over my graphs, I can see a few anomalous results, which are not that far off the mark, however there is one particular result which is far away from the line: it is on the graph which shows the 2<sup>nd</sup> reading of the 0.2% solution at 20cm distance. I am displeased with that as I am inclined to think that some major error was made, however, it could just be simple like a timing error (i.e. I looked at the stopclock a bit late or a bit early), or maybe I miscounted the bubbles.

All the graphs have the same kind of shape.



This indicates that the results are reliable seeing as they all have the same shape and no more than one anomalous result per graph. For example, if some of the graphs had curves the same as or similar to the above graph, and some differentiated completely or at least noticeably, then I would know that I had gone seriously wrong somewhere with the method or the solution volume or some other factor in the experiment. Thankfully, my plant worked extremely reliably so I can depend on that for good results. In my table (pg.4), it shows that as the lamp is moved further away, the numbers of bubbles decrease. The shape of the curve shows that at first the number of bubbles is very high, then, as you move the lamp away, it curves down. After that, at about 40cm, the difference of the number of bubbles is far smaller than at the beginning. This suggests that when the light source (lamp) is moved from 40 – 50cm away from the plant, the light intensity is not used as much because the plant starts to use its reserved energy rather than rely on the light source as much but it still uses as much light as it can get and the process of photosynthesis evens out, which is shown by the straighter part of the curved line at the end. This backs up my prediction: that the higher the light intensity (i.e. the closer the light source is to the plant), then the faster the rate of photosynthesis, proving that:

- a) light is a necessity for photosynthesis to occur
- b) oxygen is produced during photosynthesis.

### Conclusion:

To conclude, my experiment has gone really successfully and I appreciate my

*plant working well, otherwise I would have had to start again with another plant, which would have given me less time to do my experiment.*

*My results table shows a considerable drop between the number of bubbles at each set distance and in the averages for each, that is also shown in the curve on my graphs. This shows that my experiment went according to plan and I am happy that there were no faults as such in my method. The two issues that needed to be proved (as that was the purpose of the experiment) were that oxygen is produced during photosynthesis and that light is needed for photosynthesis to occur. This first was proved by the oxygen bubbles I counted, and the second was proved by the amount of oxygen bubbles decreasing as the light source was moved further away from the elodea. This proves that my prediction was correct.*

*However, my results for the 1<sup>st</sup> and 2<sup>nd</sup> readings of the 0.2% solution and of the 0.4% solution do not differ a lot which makes me think that maybe something like the volume of the solution was not entirely accurate because I think that a 0.2% change in the volume of the solution (which is in fact, doubling the amount of NaHCO<sub>2</sub>) should have some evident effect on the amount of bubbles produced, either slowing down the process of photosynthesis or speeding it up. My results, unfortunately tell me that the extra NaHCO<sub>2</sub> had little to no effect (or evident effect) on the rate of photosynthesis. I cannot be sure what caused this, how or why, but I can put it down to the following: change in room temperature, a 'faulty' plant or a possible mistake I may have made whilst measuring the NaHCO<sub>2</sub>, however I am sure I measured everything out correctly or I would have realised at the time. However, it did not affect the most important part of my experiment: with the 0.2% solution, which I am happy to say went extremely well.*

## EVALUATION

### Fair testing?

*The experiment was conducted safely and fairly. The apparatus I used was safe and worked efficiently and I used the same equipment throughout the experiment. I tried to keep the room temperature the same by opening the windows to let out the excess heat. This is because there was a significant rise in room temperature because of the heat given off by my light and also from the lights being used around me for other people's experiments. I kept the timing for the amount of time before and after each reading for each distance was taken (after 5 minutes for each distance – there were 5 different distances). This was to ensure that I had as few anomalous results as possible and to make that results easy to analyse, conclude and draw up in a table and on various graphs.*

### Accurate and reliable results?

*I think that a large proportion of my results are accurate, therefore are reliable but the anomalous results suggest that somewhere I have gone wrong with timing or maybe I miscounted the bubbles at some point e.g. at 30cm on the 1<sup>st</sup> reading of the 0.2% solution. However, the number of bubbles could have increased at some point more dramatically because of a rise in temperature on the outside (room temperature) causing the rate of photosynthesis to become unbalanced.*

*I cannot see any anomalous results that are really far off the mark other than that of the reading for 20cm on the 2<sup>nd</sup> reading of the 0.2% solution. This indicates that my results are reliable.*

*The experiment was difficult to complete because there was so much to do and find out and I think I probably could have spent hours doing more of it because no matter how much or how little you did, there was always something else you could do (e.g. change the temperature of the solution, the pH of the solution, the concentration - % - of the solution and so on), and I would have liked to be able to experiment a bit more, given the time.*

*Possibilities for other experiments include using the concept and basics of this experiment but changing the NaHCO<sub>2</sub> to something other like potassium hydroxide solution perhaps. Maybe we could use a plant under conditions in which we could measure the amount of carbon dioxide (CO<sub>2</sub>) taken in and the amount of oxygen given off and compare the two to see what kind of difference there is and why.*