Factors That Affect Photosynthesis

Aim: To investigate a factor that affects the rate of photosynthesis.

Outline: A piece of pondweed will be cut and placed into a beaker containing water and sodium hydrogen carbonate. A lamp will be shined on to the pond weed and the amount of bubbles released from the plant will be counted. The lamp will be adjusted to different distances from the plant to try and obtain different results.

Photosynthesis Equation:

$6CO_2 + 6H_2O$ light energy & chlorophyll $C_6H_{12}O_6 + 6O_2$

Variables:
Experimental Variable- Light intensity is to be the variable explored in this investigation. Increasing or decreasing the distance from the light source to the plant can vary light intensity.

Fixed Variables-
Light Wavelength (color)- Light energy is absorbed by pigments in the leaf such as chlorophyll. Chlorophyll easily absorbs blue light, in the 400 -450 nm range, and also easily absorbs red light in the 650-700 nm range. Chlorophyll does not absorb green light or yellow light effectively but tends to reflect them, decreasing the amount of light absorbed and decreasing the rate of photosynthesis. Why the rate of photosynthesis increases or decreased from the amount of light energy absorbed is what is being investigated in this experiment. The light color can be fixed by using the same lamp throughout the experiment.
Carbon Dioxide- CO_2 concentration can affect the rate of photosynthesis since the more CO_2 in the air, the more CO_2 that can diffuse into the leaf. This variable can be fixed by adding a fixed amount of sodium hydrogen carbonate to the beaker and plant. The experiment should also be completed in one session and under two hours so the plant does not use up a significant percentage of the CO_2.
Water- Water is required in the photosynthetic reaction. When plants lack water, their stomata close to prevent further water loss. At the same time, closing the stomata cells doesn't allow CO_2 to diffuse into the leaf. Water is also therefore, linked to the carbon dioxide factor. Water can be kept a constant by keeping the same amount of water in the beaker.
Temperature- Enzymes are used in photosynthesis and the respiration of the plant. Therefore, increasing the temperature will increase enzyme reaction and the photosynthetic rate until a certain point is reached when the enzymes denature. The temperature can be kept somewhat a constant by performing the experiment in one session, when the air temperature shouldn't change enough to affect water temperature. A transparent glass block will also be placed in front of the lamp to retain some of the heat from the lamp.
Plant- Different species plants have different photosynthetic rates due to the different leaf structures of the plants. Even plants of the same species may have slightly different rates of photosynthesis since there may be more or less chlorophyll in the leaves to absorb light. The size of the plant is also important since this would affect the amount of surface area for gas exchange. The only solution to controlling this variable is by using the same plant throughout the experiment.
Limiting Factors- Light, carbon dioxide, temperature, and chlorophyll are all

limiting factors, meaning that even when there is surplus of every other variable, the rate of photosynthesis will be limited by the limiting factor until there is an optimal amount of the limiting factor to increase the rate of photosynthesis further. Otherwise, the rate of photosynthesis can no longer increase.

Prediction: I predict that increasing the light intensity will increase the rate of photosynthesis at a proportional rate where LI is inversely proportional to 1/d2 when LI= light intensity and d= distance (from light source to plant). This is true to a certain point until another factor is limiting the rate of photosynthesis.

Hypothesis: When chlorophyll absorbs light energy, the light energy cannot be immediately used for energy conversion. Instead the light energy is transferred to a special protein environment where energy conversion occurs. This happens by using the energy of a photon to transfer electrons from a chlorophyll pigment to the next. When enough light energy has been harnessed at a reaction center, ATP can be synthesized from ADP. During this reaction, oxygen is produced as a by-product and it is the oxygen bubbles that are being measured in the experiment. The greater the light intensity, the more light energy that can be transferred and harnessed to fuel reaction in photosynthesis.
Light intensity is inversely proportional to the distance squared because the light energy spreads out as it travels further and further from its source. Light energy travels along the circumference of an expanding circle. When light energy is released from a point, the energy is dispersed equally along the circumference. But since the circle is expanding, the circumference increases and the same light energy is distributed along a greater surface.

Method:

1. Set up the apparatus as shown in the diagram above but leaving out the pond weed, funnel, test tube, water, and the sodium hydrogen carbonate.
2. Fill the beaker with 450 cm3 of water and 50 cm3 of $NaHCO_3$.
3. Select 1 or 2 pieces of pond weed each roughly 5-10 cm long and cut off the stems.
4. Place the pond weed in the beaker and secure the funnel upside down over (on top of) the pond weed using the plasticine.
5. Place a water-filled test tube upside down and over the funnel (see diagram).
6. Place the ruler so that the "0" measurement is aligned with the side of the beaker. (distance measured from side of beaker to edge of light bulb)
7.) Place the lamp directly in front of the plant so that it is 0 cm away from the beaker. 8.) With the light shining on the plant, record the number of bubbles emitted in a 1 minute duration. Switch off the lamp and wait for another minute before taking another reading.
9.) Take 3 readings at the current distance and move the lamp 5 cm further away from the plant.
10.) Repeat steps 8 and 9 until 3 readings from at least 5 intervals of 5 cm have been taken.
11.) Proceed to the data analysis stage.

Results:

Distance (cm)	Light Intensity (LUX)	Bubbles per Minute			Average bubbles/minute
		1	2	3	
0	(off scale)	240	249	251	246.7
5	11,000	201	222	214	212.3

10	5,800	183	185	188	185.3
15	3,570	154	152	158	154.7
20	2,320	128	118	124	123.3
25	1,780	93	88	90	90.3
30	1,320	67	65	70	67.3
35	1,050	53	50	48	50.3
40	850	38	38	37	37.7
45	690	26	25	24	25
50	580	17	17	18	17.3

The temperature of the water stayed a constant at about 29.5O C throughout the experiment.

Conclusion:

From the results that I have gathered I can state that an increase in light intensity certainly does increase the rate of photosynthesis. As was also expected in my prediction, the relationship between light intensity and the rate of photosynthesis was non-linear. From both graphs there is a best-fit curved line. This means that the rate of photosynthesis increases at an exponential rate. However, my prediction that light intensity is inversely proportional to the distance squared did not fit into my results perfectly. The rule existed but there was often quite a large margin of error.

When measuring light intensity in terms of distance, the greater the distance, the slower the rate of photosynthesis. While the rate of photosynthesis was decreasing, the rate at which it was decreasing at was also decelerating.

When measuring the light intensity in terms of LUC, the greater the distance, the slower the greater the rate of photosynthesis. While the photosynthetic rate increased, the rate at which it increased was decreasing.

The first of these can be explained by the fact that light intensity is inversely proportional to the distance squared. This means that as distance increases the light intensity decreases at an exponential rate. If light intensity decreases exponentially, photosynthetic rates that depend on light intensity also decreases exponentially. The line in graph 1 would eventually reach "0" where photosynthesis stops as light intensity limits this rate.

This the second is due to other factors limiting the rate of photosynthesis. These other factors do not immediately limit the rate of photosynthesis but rather gradually. As light intensity increases the photosynthetic rate is being limited by certain factors such as carbon dioxide and temperature. As light intensity increases further, these factors limit the rate of photosynthesis even more until photosynthesis is completely limited and the graphed line become horizontal. This is when photosynthesis is being carried out at a constant rate.

The reason that a "f 1/b2 did not apply was due to the apparatus used. The lamp that I used had a cover that directed the light energy somewhat. The light energy did not spread out as much as a plain light bulb with no cover. The distribution of the light energy was more concentrated,

Evaluation:

Overall, I would state the experiment as a success since my predictions were supported by my results. This is important in reflecting success only if my prediction was sensible and logical. Just as important is where the experiment was not a success and why. This photosynthesis investigation was probably not performed as accurately as it could have been due to some controllable and uncontrollable conditions. Some mistakes can be corrected.

While performing the experiment, the piece of pond weed did not photosynthesize at a steady rate, even when the distance from the plant to the light source was kept a constant. The second reading at 0 cm was far greater than the first reading at 0 cm. While the number of oxygen bubbles was being recorded, the rate at which the plant was photosynthesizing had increased several times. This may be due to the poor circulation of sodium hydrogen carbonate at the beginning of the experiment. Carbon dioxide may have initially limited the rate of photosynthesis. The readings at 0 cm and 5 cm were repeated many times until the rate of photosynthesis had begun to settle. From then on, there were no more similar problems during the experiment. To make sure that the there

The negative effects from this problem may be inaccurate data for some readings. These would show up on my graph. However, there seemed to be few anomalies than was expected when the experiment was being performed. Almost all readings were in correlation with each other and all of the anomalies were in the high photosynthetic rate end of the results. This was when the distance from plant to light source was 0 cm or only 5 cm.

A large factor in determining data accuracy is the amount of human error during experiments. The rate at which oxygen bubbles were being produced by my plant was so high that I found it difficult to count the amount of bubbles. I estimate a margin of error of at least 3 bubbles for each reading taken. To improve the accuracy of the results, the readings would have to be taken several more times. The entire experiment could have been performed again, and the new results could be combined if the same plant is used. But the photosynthetic rate of the same piece of pond weed would eventually decrease over time anyway. Repetitions would, however, improve the overall reliability of the results.

There are quite a few factors that could affect the results of my experiment. Some of these are variables that were mentioned earlier and could not be controlled, or they were variables that were not initially considered.

While performing the experiment, some of the oxygen produced from photosynthesis may have dissolved into the water. Some oxygen may have even been used by micro-organisms living on the pond weed. The amount of oxygen dissolved or used by microbes is probably insignificant to my results since the degree of accuracy at which I measured was not high enough. Some oxygen is also used during the respiration of the plant. But since only bubbles were counted, the volume of bubbles was not as important. But to volume of oxygen produced is important, since it was volume in terms of bubbles that were measured. As the rate of photosynthesis decreased due to a decrease in light intensity, the size of the bubbles produced also became smaller. This change in bubble size was no accounted for when the results were analyzed. For a more accurate analysis of the collected data, volume should have been measured instead of bubble quantity since the size of bubbles can vary. Using a capillary tube in place of the test tube so that the volume of each bubble could have been measured could have done this.

During the high intensities I had experienced counting difficulties of the bubbles being produced. There are also factors affecting accuracy at low light intensities. With low light intensity, the pon d weed receives some light energy from background light such as sunlight seeping through curtains or the light from the lamp of another student's experiment. To eliminate most all background light, the experiment must be performed in a completely dark room. Even then, some of the light from the lamp in my experiment would reflect of the table and reach the plant though this amount of light is probably insignificant in affecting the rate of photosynthesis.

Temperature was also another factor that was controlled by the lamp being used. Even though a glass block was used in front of the lamp to prevent some heat from reaching the plant, not all the heat can be blocked. The extra heat, however, did not affect the temperature of the water, which stayed at between 290 and 300 C.

The method of the experiment could probably also be improved to obtain more reliable results. As already mentioned, the a capillary tube should be used in place of a test tube to accurately measure the volume of the oxygen produced.

Due to the high rates of photosynthesis of the pond weed, readings should be taken within shorter time periods. I had originally chosen to count the number of bubbles in one minute but this produced miscounts in the readings. If during a repeated experiment, counting bubbles is still used, there is a smaller chance for human error when counting within a smaller time frame. If the capillary tube option was to be chosen, volume should be measured for a smaller time frame to reduce the overall time to complete the experiment. Also, during high rates of photosynthesis, it would still be difficult and impractical to measure the volume of oxygen produced for a long duration.
Due to the nature and convenience of the experiment, it could be easily modified to investigate another variable of photosynthesis. Since sodium hydrogen carbonate (NaHCO3) is used to provide the pondweed with carbon dioxide. Performing the experiment with different volumes of NaHCO3 could vary the amount of CO2. The plant would be kept at a constant distance from the lamp and a constant volume of water would be added to the sodium hydrogen carbonate. Another experiment using almost identical apparatus would be to vary the color of the light the plant absorbs. Using translucent color filters in front t he lamps could vary this. Since light wave length has already been identified as a variable of photosynthesis, it would be interesting to actually test it. The only problem of this experiment is that there is no way to define or "measure" the color of light. Wave length would be a solution but this cannot be measured with available equipment. We only have a general idea of how to class colors. Because of this, the colored light experiment should not be taken as seriously as light intensity or carbon dioxide

Photosynthesis is a very important process in nature. It is the production of energy in the form of glucose involving water from the soil, carbon dioxide from the air and light energy. It takes place in all green plants, which use the green chlorophyll, held in chloroplasts in the leaves, to trap light. The main site of photosynthesis is the palisade mesophyll cells in the leaf of a plant. It is these cells that contain the green chloroplasts and are very well adapted to their task. They are near the upper side of the leaf where they can obtain the maximum amount of light, they are packed very closely together and as already mentioned contain green chloroplasts clustered towards the upper side too.
Plants photosynthesise to produce food chemicals that are needed to allow them to grow. The main reaction is to produce oxygen and glucose to be changed into energy during respiration. Glucose is stored in the form of starch which is insoluble and does not affect the osmosis taking pace in the plant. As plants respire both day and night this starch is often used up during the night when photosynthesis cannot take place. The uses of glucose within the plant are for active transpiration, cell division, the production of protein and the production of cellulose. However many other things can also be produced with the addition of special mineral salts.
In photosynthesis the raw materials are carbon dioxide and water. They react to form the products of the reaction-oxygen and starch (glucose that has been stored). The reactions need energy and this comes from light. The green chloroplasts allow light to be used as energy and therefore both of these things are like helpers in the reaction. Glucose is formed firstly then turned into starch to be stored up for when it is needed.
Although photosynthesis is a complicated process it can be summed up in this equation:

6CO2 + 6H2O C6H12O6 + 6C2
carbon dioxide water glucose oxygen

It is important to the reaction that certain factors are present when it is occurring. We know that these are carbon dioxide, water, light and chlorophyll. Without these the reaction will not take place at all, but some of them also determine how quickly the reaction takes place. Water, carbon dioxide and light, along with temperature, all have a particular effect on the rate of photosynthesis. In terms of carbon dioxide the levels in the atmosphere do not really alter very much, but if gardeners wish to increase the rate of photosynthesis then sometimes carbon dioxide is pumped into greenhouses. Up to a certain point as temperature goes up so does the rate of reaction. After it reaches a certain point though the enzymes involved in the reaction become denatured and stop working properly. A drop in the amount of water present may cause photosynthesis to occur at only half the normal rate. The reason for this is the stomata are being closed.

The final factor which contributes is light. We decided to investigate how this affects the rate of reaction also.

METHOD

We need to find out how the of presence light and the intensity of it contributes to the rate of photosynthesis. To be able to measure the rate we need some type of visible sign that photosynthesis is actually taking place. We will use a type of plant that grows in water and produces bubbles when photosyn thesising. By counting these bubbles we can tell how fast oxygen is being given off and therefore produced from photosynthesis. We will place the pondweed in a beaker containing water and also a bit of sodium hydrogen carbonate-$NaHCO_3$-(0.5%). This is put in as it acts as carbon dioxide. If it wasn't there then another limiting factor may be the cause of the rate changing instead of just light.

By placing the beaker next to a lamp we can alter the light intensity. We will move the lamp further away every time and then count the number of bubbles that are produced within one minute. The weed will be given two minutes each time to adjust to the new level of light intensity. To start with the lamp will be 1cm away from the beaker, then the following distances:

2cm
4cm
8cm
16cm

The diagram will help to explain this more clearly.

The rate of reaction will be in number of bubbles per minute (b.p.m).

VARIABLES AND CONSTANTS

The factor that will be changed is light intensity. This is the only factor that will be changed. The factors that will be kept constant are the amount of water the weed is put in, carbon dioxide levels, lamp that is used and temperature. This means that out of all the possible factors we have chosen only one to monitor.

PREDICTION

I predict that as the light intensity is increased the rate of photosynthesis will also increase. However at a certain point the light will reach a certain point where the rate will not increase any more. The chloroplasts will no longer be able to absorb

any light so the rate will stay at its optimum level or even decrease. At this point light is no longer limiting.
The graph of results will probably look something like this:

Light is limiting at this point Maximum rate of photosynthesis
light is no longer limiting.

RESULTS

DISTANCE-CM
1 145 240 189 145 240 189 148 146 222
2 130 210 127 130 210 127 125 130 183
4 97 150 114 97 150 106 118 106 816
8 55 60 40 14 60 45 76 94 600
16 8 5 1 8 5 4 40 48 30

The last set of results is very anomalous and we won't be using it for our results.

And here are the averages of these results.

DISTANCE-CM NUMBER OF BUBBLES PER MINUTE
1 180.25
2 148.63
4 117.25
8 55.5
16 14.88

ANALYSIS

This is a graph of the averages. The light intensity for the distances used will be shown in the following units:

1cm- 1000 units
2cm- 250 units
4cm- 62.5 units
8cm- 15.6 units
16cm- 3.9 units

As you can see our results have turned out quite similarly to how we expected. In the first table of results there are some slightly different results according to the different experiments that were done. This shows that it can't have been 100% reliable. It does prove however that as light intensity is increased the rate of photosynthesis is increased also. This is because the more light there is available the more light the chloroplasts can absorb. They use this light in the reaction as energy; therefore the more energy there is available the faster the reaction can take place.

EVALUATION

On the graph there wasn't a point where the rate started to level off. We assumed that this would happen, as the chloroplasts would not be able to absorb any more light energy. However this did not happen so it may be that we did not take the pondweed close enough to the light so it would reach a point where the rate could no longer increase.
There was one set of results in the first table that I decided to leave out. These results were very unusual and anomalous so to include them would have greatly affected the average. I felt it was best to leave them out so they would not give us results that were inaccurate.

These anomalous results, among others, can be explained by many things. First off all our experiment was not completely fair. We did not attempt to regulate the temperature as well as we could have done which as we know is a limiting factor of photosynthesis. We could have put the test tube into a beaker filled with water of a certain temperature. This would have helped to regulate the temperature so we would have been certain that light was the only limiting factor. Also the size of the pieces of pondweed were not all the same so some people may have achieved different results depending on the size of their pondweed and therefore how much surface area was available for photosynthesis to take place in the palisade mesophyll cells. The distance may not have been completely accurately measured and we could also have taken each set of results twice to make doubly sure we were getting an accurate picture.
I think that another way we could have gone about doing this experiment would have been to use a method where the amount of carbon dioxide being produced displaces some water held in a burette. The experiment could be set up as shown:

This would help to give us a greater idea of how much carbon dioxide is being produced and therefore how fast photosynthesis is occuring. As the burette fills with the gas water is displaced and the level drops. By measuring the level every 10 second we would easily be able to work out the rate of the reaction in the pondweed.
I think that overall our evidence is very reliable and that our results show what we thought they would. It could have been more accurate than it is but I think we achieved what we set out to do which was prove that as light intensity is increased photosynthesis speeds up.

Investigation into the factors that affect the rate of photosynthesis in Elodea

<u>Introduction</u>

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.

The chemical equation for photosynthesis is:

Carbon dioxide + Water = Glucose and Oxygen

$6CO_2 + 6H_20 = C_6H_{12}0_6 + 6O_2$

Key Factors: CO2 is vital in photosynthesis because the plant takes in CO_2 from the air and joins with water molecules to make glucose. The CO_2 comes in through the stomata pores on the surface of the leaf and only 0.03 % of the air around is CO_2 so it's pretty scarce.

Temperature has to be kept at a certain level because if it gets too hot, about 45`C then the enzymes in the chlorophyll will be killed and photosynthesis will stop altogether. If the temperature is too cold then temperature becomes a limiting factor and the enzymes will stop working.

Light As chlorophyll uses light energy to perform photosynthesis, it can only do it as fast as the light is arriving. Chlorophyll only absorbs the red and blue ends of the visible spectrum but not the green light in the middle, which is reflected back. If the light level is raised the rate of photosynthesis will increase steadily but only to a certain point.

Water is important because it is needed to join with CO_2 molecules to make glucose and the amount of chlorophyll needs to be e nough so that the plant can photosynthesize to the best of its abilities.

Investigation

Prediction

I predict that the plastic sheets coloured green, yellow and orange will produce the least amount of bubbles because the light will be transmitted. Whereas placing red and blue sheets in front of the Elodea will result in the greatest amount of bubbles because the light is absorbed. Certain colours of light can limit the rate of photosynthesis depending on how well it is absorbed into the plants chlorophyll to photosynthesize. Also the wavelength can change the rate of photosynthesis. If the lamp supplying heat for the plant were placed twice as far away, I predict that there would be half as many bubbles. Also if it were moved twice as far closer then there would be twice as many bubbles. This is backed up with knowledge from previous experiments and ones done by other people and scientific understanding.

Diagram

Previous experiment

Method

For our experiment we chose as accurate equipment as possible to give us the most accurate results. The equipment is as follows: 1 lamp

A boiling tube

A small piece of Elodea

Plastic sheets of different colours

A beaker

The boiling tube was filled with water and the Elodea placed in. The boiling tube was placed in the beaker and the lamp placed at a set length away. He plastic sheets were individually wrapped around the beaker with an elastic band. For every new plastic sheet we counted the number of bubbles each time for a minute. It was important to keep the experiment the same each time to ensure it was fair test for example: The lamp stayed the same distance from the beaker, we used the same plant each time and the plastic sheets were all the same size. The experiment was repeated three times and the results were averaged to ensure they were regular and as expected. Results were recorded each time and patterns observed. Previous results for an experiment of this kind have been recognized and compared. Throughout the experiment we made observations for a number of distinctive things:

? Increase/Decrease in bubbles

? Temperature Increase/Decrease

? Change in Elodea

? Size of bubbles

Variables include:

? Length of Elodea

? Amount of water

? Distance of lamp

? Size of boiling tube

? Transparency of sheets

? Time spent counting

Changing either of the variables would have had effects on the end results; we kept ours all the same each time to ensure a fair test.

Results

Coloured sheet	**Red**	**Orange**	**Yellow**	**Green**	**Blue**	**White**
No. of bubbles	50	5	1	4	39	17
Repeat 1	45	2	0	0	41	10
Repeat 2	47	1	1	0	35	12
Average	47.333333	2.6666666	0.6666666	1.3333333	38.333333	13

As predicted, the results conclude that using sheets with colours near the red and blue end of the spectrum produce a higher amount of bubbles than those near green. Thereby proving that photosynthesis is increased with certain colours of light.

Conclusion/Evaluation

In observation of the results, I have seen how the rate of photosynthesis in the Elodea has been affected by the various factors. In reference to the prediction, I was correct in that the red and blue coloured sheets produced the highest rate of photosynthesis, whereas the sheets, which were green and yellow, resulted in the least bubbles. I feel that we had taken enough measurements to be sure of a fair test as the experiment was repeated several times so. Each plastic coloured sheet we used had the same time, and variables as the others so we obtained precise results for every test. We did not find anything, which stood out too much from the pattern except that the red plastic sheet, when used resulted more bubbles generally than the blue sheet. This shows that chlorophyll absorbs red light more easily than blue. We acquired similar results with each repetition and found ours to be similar to previous experiments. The Elodea produced more bubbles with sheets at each end of the spectrum because the chlorophyll in the plant absorbs all the colours but transmits green. When the light is absorbed the plant converts it into energy to photosynthesize. The more light energy it receives the better and faster it can do this so when the sheets near the blue and red parts of the spectrum are held in front of the Elodea it absorbs the light and can photosynthesize better. If plastic sheets are held up which are have a colour near the green part of the spectrum then the light will be transmitted and the plant will not be able to photosynthesize as well. In this experiment we have covered the main colours of the visible spectrum and they are sufficient to produce the results that we are looking for.

If we were to repeat the experiment then there are several ways we could improve it. For example to get around the problem of the heat from the lamp producing more bubbles then a thick glass panel could be placed in the middle to prevent any heat reaching the Elodea. To improve the accuracy of counting the bubbles, you we could only count the ones, which are a certain size, and only the ones coming from the very end of the Elodea. If there were lots of people counting the bubbles and the results averaged then that would be a more accurate way of obtaining the information necessary. To extend the investigation you could change certain variables for example the type of plant that you are using to count the bubbles from. You could try an entire species of plant and see if the results are similar for every type. You could use different chemicals in the water each time to see which chemicals result in the greatest rate of photosynthesis.