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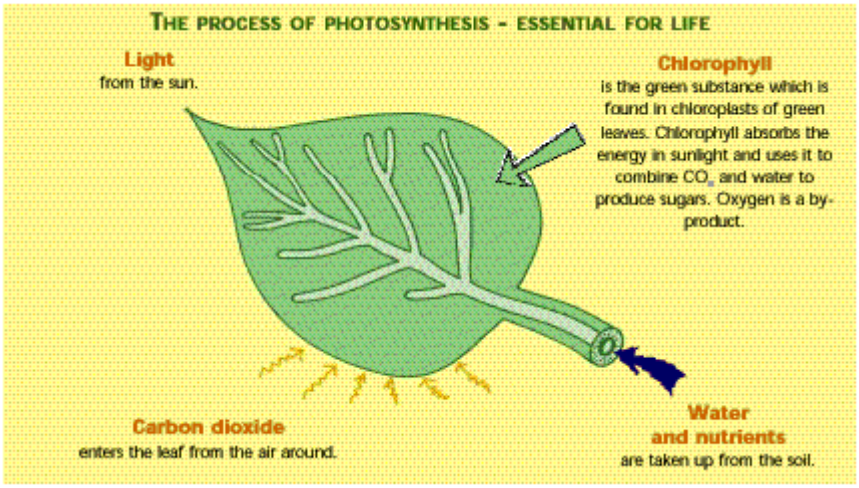
How does the concentration of carbon dioxide affect the rate of photosynthesis?

Introduction

In this course work, I will be discussing how the concentration of carbon dioxide affects the rate of photosynthesis. To find this out I will do an experiment to find out how much oxygen a piece of Elodea (Canadian pondweed) produces over a set period under controlled supervision.

Back Ground Knowledge

All plants photosynthesise, They do this in order to create their own food by converting sunlight, carbon dioxide and water into glucose and oxygen, which is a by-product ($6Co + 6H O \rightarrow C H O + 6O$) Plants have a part in their cell called chloroplast which contain chlorophyll the diagram below explains:



What are the limiting factors of photosynthesis?

Although the diagram shows you what you need for photosynthesis it does not tell you what the limiting factors are. The limiting factors in photosynthesis are **carbon dioxide, water, light and chlorophyll.** This is because up to a point the more of each factor that is available to the plant will result in an increase in the photosynthesizing rate.

Why did I use pondweed?

I used pondweed so I could measure the amount of oxygen it produced accurately. I can do this by catching the oxygen bubbles under water, because of this choosing an aquatic plant was the best choice. I will use 5cm of elodea because it is a big enough piece to get a measurable result. I will know how

quickly the elodea has photosynthesised by taking readings of how much solution was left in the burette after 24 hours and again after 48 hours.

Why use the sodium bicarbonate?
I used sodium bicarbonate solution in the experiment because it reacts with water to make carbon dioxide, which meant I could control the amount of carbon dioxide available to the pondweed. However, because of the time limitations I got my results by sharing the class results, this meant that I had to use the following concentrations of sodium bicarbonate: 0% 1.25% 0.5% 1% 5%. I used these percentages so that I had a good range of percentages but this didn't give very good results because I made a big jump from 1% to 5%. If I did the experiment, again I would use these percentages: 0% 0.5% 1% 2% 3% 4%and 5% so that it had a steady increase.

How will I control the variables other than the Co concentration?
To control the other variables (water, light and chlorophyll). I will be using a set amount of water, I will be using the same lamps at the same voltage and I will be using a set amount of pondweed so that the amount of chlorophyll level should be the same. They will all have the same window letting in natural light and the temperature will be the same because they are in the same room.

Plan
I plan to set up an experiment using pondweed to see how much oxygen is produced over 24 hours and 48 hours. I will then put my results in tables and graphs to help me answer my main question.

Preliminary
In my preliminary experiment, I tested the concentrations I had chosen to check that the Elodea photosynthesised. I used a plastic funnel and a ray box, after using these in the preliminary I decided to replace them with a glass funnel that was transparent so that more light could get through. I also decided that a ray box was not giving out enough light because the elodea was not photosynthesising well and so I decided to change it to a desk lamp to give it a more directed and stronger light source.
Here is a diagram of my preliminary experiment:-

Here is a diagram of the experiment I used to get my results:-

Method:

1. set up the equipment in the apparatus list as the diagram above.
2. Record the volume of solution at the start of the experiment
3. turn the light source on
4. record the volume of solution after 24 hours of the first recorded volume
5. record the volume of solution after 24 hours of the second recorded volume

Accuracy
To make my results accurate I will be measuring the water level from the bottom of the meniscus. I will do this by taking the results with my eyes level to the bottom of the meniscus. I will repeat the experiment twice so that including the average I have three sets of results, which I will then plot on a graph. If the results do not turn out how I am expecting I will look back at my work to check any problems I may have had.

I will be leaving my elodea for 2 days and taking readings after 24 hours and 48 hours. This is because it will give it a reasonable amount of time to photosynthesise. I will find out how much oxygen the plant has produced over that time by taking my original reading for O in the burette and deducting my readings at 24h and again at 48h.

Prediction

What do I expect to happen?

I expect that as the sodium bicarbonate concentration increases that the rate of photosynthesis will increase until it hits its maximum rate of photosynthesis. I can tell this because as the sodium bicarbonate reacts with the water it will produce carbon dioxide, which will increase the rate of photosynthesis.

What I expect my graph to look like:

Why I expect this to happen:

I expect this to happen because this is the normal graph you would expect for a plant photosynthesising.

Results

Conc. Of sodium bicarbonate (%)		Amount of NaHCO before (ml)		Amount of NaHCO after 24h (ml)		Amount of NaHCO after 48h (ml)		Average oxygen produced over 24h		Average oxygen produced over second 24h	
		Expt 1	*Expt 2*	*Expt 1*	*Expt 2*	*Expt 1*	*Expt 2*	*Expt 1*	*Expt 2*	*Expt 1*	*Expt 2*
0	0	42.80	46.45	42.60	45.45	42.50	45.45	0.20	1.00	0.10	0.00
0.25	0.25	46.00	41.00	---	40.30	---	39.75	0.70	---	---	0.55
0.5	0.5	45.00	39.30	43.90	33.80	43.80	29.30	1.10	5.50	0.10	4.50
1	1	45.85	46.10	40.80	45.70	37.80	---	5.05	0.40	3.00	---
5	5	46.75	44.80	43.10	42.35	43.00	41.85	3.65	2.45	0.10	0.50

As you can see, from the results I have some missing results this is because while doing the investigation some burettes were knocked which meant that the liquid fell to the bottom of it. My group did 0.5% experiment.

The result in red is highlighted because I did not use this result to get the average. This is because the pondweed must have died because it did not produce any oxygen.

Concentration of NaHCO (%)	Sum used to calculate average amount of O	Average amount of oxygen produced in a 24hour period (ml)
0.00	$\frac{0.10 + 0.20 + 1.00}{3}$	0.43
0.25	$\frac{0.70 + 0.55}{2}$	0.63
0.50	$\frac{1.10 + 0.10 + 5.50 + 4.50}{4}$	2.80
1.00	$\frac{5.05 + 3.00 + 0.40}{3}$	2.82
5.00	$\frac{3.65 + 0.10 + 2.45 + 0.50}{4}$	1.68

Analysis

My graph shows that when I increased the concentration of sodium bicarbonate from 0% to 1% the rate of photosynthesis increased. At first, it increased quite quickly but then it slowed down until eventually when we did 5% it decreased rapidly the only problem with my graph is there are not enough results between 1% and 5% so I cannot be sure how the rate of photosynthesis drops.

My graph starts similarly to my prediction however then it drops when my prediction says it should hit its optimum and stay there but instead it drops. I think this happened because when I increased the percentage of sodium bicarbonate the alkalinity of the solution goes up and disrupts the plants enzymes. A way to find out if this was happening would be to test the alkalinity of the solution. A way you could do this would be to use an electronic device that measures the PH in the water. If the alkalinity was different in each concentration then it would be an unfair test of how the concentration of carbon dioxide effects the rate of photosynthesis because the PH would also be a variable and I wouldn't know which variable, the carbon dioxide or the PH was effecting the plant and its rate of photosynthesis.

Evaluation

From my investigation, I can conclude that to a point an increase in sodium bicarbonate concentration the rate of photosynthesis will increase. However because I did not use any concentrations between 1% and 5% I don't know how the rate of photosynthesis decreases but by the time it had gotten to 5% it had dropped to 1.7ml of oxygen produced by photosynthesising. There are two possible reasons for this happening, it could be an anomaly or it could just be a drop at that point. To find this out I would have to redo the investigation to include experiments with 2, 3 and 4 percent concentration of NaHCO . The results from the concentrations are not very close but the 0.50 and 1.00 were very similar with only 0.02ml difference but the same jump from the 0.25 to 0.50 had the difference of 2.17ml. This suggests that because the spread of results were so different that the evidence may not by trustworthy.

To improve my experiments I could have used a different light source that did not heat up the solution so much. I also would use more pondweed so that I would get a clearer set of results. I would also have to find a different way to supply the carbon dioxide so that the PH was not a variable.