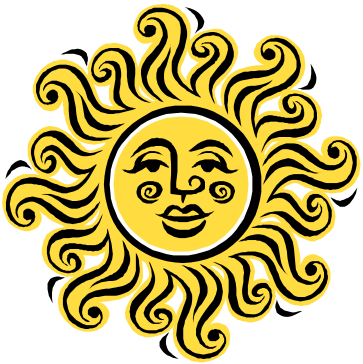
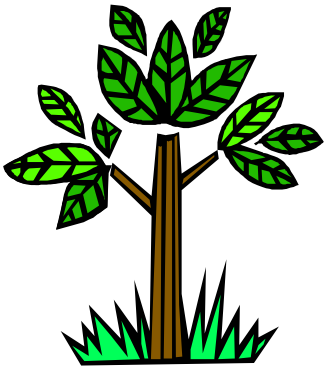
Biology Coursework





Investigating the effects different factors have on the rate of photosynthesis in pondweed.

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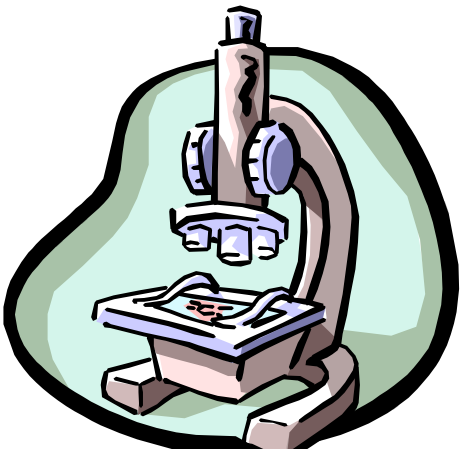


Q)A pupil in a biology class observed that there were large numbers of bubbles around the pondweed in the fish tank on sunny days; however, on the dark mornings fewer bubbles were observed. Devise an investigation to explain this observation.

Problem.

The problem I intend to investigate is why there were large numbers of bubbles around the pondweed on sunny days and on the dark mornings there were fewer bubbles.

These bubbles are oxygen gas and they are present as oxygen is a product of photosynthesis. Photosynthesis is the process by which plants make food, it is a chemical reaction between carbon dioxide and water. Sunlight provides the energy for this process to occur. Chlorophyll is a green pigment present in chloroplasts which enables plants to absorb energy.

The equation for photosynthesis is:

Carbon dioxide + water $\xrightarrow[\text{Sunlight}]{\text{Chlorophyll}}$ Glucose +oxygen.

This equation demonstrates that sunlight/light is needed for photosynthesis and also that oxygen is a product of photosynthesis.

Background Knowledge.

The rate of photosynthesis is dependent on the following environmental factors: light intensity, temperature, and the availability of carbon dioxide, water, and certain minerals. A shortage of any one of these factors can limit the rate of photosynthesis, and an increase in the particular rate-limiting factor will, up to a point, speed up the process. The rate also varies with the plant species and its physiological state.

Light– Photosynthesis will not occur in the dark. As light intensity increases the rate of photosynthesis also increases. Therefore light is a limiting factor. The rate will continue to increase however once a particular intensity is reached the rate of photosynthesis stays constant even if the intensity is raised (the rate levels off.) This is when some other factor has now become the limiting factor. (carbon dioxide, water or warmth.)

Temperature- Photosynthesis only occurs very slowly at low temperatures. As the temperature increases, photosynthesis increases as the enzymes (Enzymes control chemical reactions in living things), involved in the chemical reactions will work faster. Therefore plants will photosynthesis faster on a warm day than a cold day. However above 30°C, the rate decreases as the enzymes become denatured. Temperatures below 0°C and above 30°C destroy proteins and reduce enzyme activity.

Carbon dioxide- As more carbon dioxide is added, the rate of photosynthesis increases. Carbon dioxide is the limiting factor up to a point where the maximum rate is reached. At this point the plant does not have enough light, water or heat to make use of all the available carbon dioxide and so these become the limiting factors. Carbon dioxide is no longer a limiting factor because even if more carbon dioxide is added, the rate will not increase any further. We are only able to increase the amount of carbon dioxide in a greenhouse as it is not practical to o so outside.

Water- Water is one of the raw materials for photosynthesis. Lack of water affects so many cell processes that it is impossible to single out its direct effect on photosynthesis.

I am going to investigate light intensity

Prediction.

I predict that the closer the lamp (i.e. increase the light intensity),[this is what I am changing] is to the pondweed the more oxygen will be produced [this is what I am measuring]. I.e. I think that when I move the lamp nearer the pondweed the rate of photosynthesis increases and speeds up. I also predict that the rate will eventually reach a maximum, as other factors will now limit the rate of photosynthesis. These limiting factors maybe-:

a) Amount of carbon dioxide available.
b) The temperature of the surrounding
c) The availability of water.
d) Amount of chlorophyll in the leaf.

Independent variable.

I plan to change the light intensity and I will see if it has an effect on my results. I will change the light intensity by placing a lamp at different distances from the pondweed. The distances I intend to use are:

1) 05cm
2) 10cm
3) 15cm
4) 20cm
5) 25cm

I would have to give the pondweed a minute to adjust to its environment every time I move the lamp. At each distance I will take three readings and then I will work out an average for every distance.

Dependent variable.

To measure the rate of photosynthesis I will measure the oxygen gas produced by the plant whilst it is photosynthesising. I could count the oxygen bubbles produced but I feel it would be more reliable to measure the volume of oxygen produced. This is the volume of water displaced by

oxygen in the test-tube of water. It would be very easy to get lost whilst counting the bubbles or miss a few dew to surrounding distractions so I feel it is more reliable to measure the volume than the number of bubbles..

Control Variable.

I am going to keep the concentration of carbon dioxide and temperature the same. I have chosen to keep these the same as they could effect the rate of photosynthesis if we weren't to control them and they would effect our results, also we wouldn't just be measuring the effect light intensity has on photosynthesis if we didn't control the other factors that could limit the rate. The carbon dioxide will be the same as it will be dissolved in the water. In order to keep the temperature the same I will have to place a water aquarium in front of the lamp as the lamp gives of heat, the water in the aquarium will absorb any heat from the lamp. I will also keep the amount of environmental light the same as this would affect the overall light intensity, the extra light intensity would affect the rate and so it would not be a fair test. I will also need to keep the power of the light bulb, the piece of pondweed and the adjustment time the same. If the power of the light bulb was not controlled the results would not be fair as the pondweed would receive more light at some distances than others and light effects photosynthesis. I need to keep the same piece of pondweed as all plants even if they are of the same species and origin will react differently to any factors, no two plants are the same. The adjustment time will need to be kept the same for each distance as it too will effect the rate that oxygen will be produced, if the plant gets longer to adjust at one distance than another the results will be unfair.

Plan.

Apparatus.

- Lamp.
- Meter ruler.
- A big Beaker.
- Filter funnel
- Test tube.
- Pondweed.
- Water (dissolved carbon dioxide).
- Water bath.

1) Collect all apparatus needed.
2) Set up the experiment as follows-:
   a) Cut some pondweed and set it into the filter funnel. (See diagrams).
   b) Pour the water (dissolved) carbon dioxide into the beaker, (See diagrams), make sure not to fill the beaker to full as other apparatus still needs to be placed in it and so it will overflow.
   c) Put pondweed and filter funnel into big beaker.
   d) Take the test tube fill it with water, turn the test tube upside down over the end of the filter funnel and try not to lose any water from the test tube. (The idea is that any oxygen bubbles produced will float up from the pondweed, be trapped by the funnel where they will go up into the test tube). (See diagrams).
   e) Take a large bowl/bath and fill it with ordinary water. This will be the water aquarium to absorb the heat given off by the lamp. Place it beside the large beaker with the experiment inside. Always have the water aquarium between the lamp and the beaker. (The only apparatus that needs moving is the lamp).
   f) Take the metre ruler and place it on the table to the side of the beaker. (See diagrams).

g) Now place the lamp at the maximum distance away from the pondweed. (i.e. at the far end of the metre ruler). (See diagrams).
h) Switch the lamp on and leave for three minutes before beginning to record the results. This gives the plant time to adjust to its rate for the conditions being tested. (Equilibrate).
i) Measure the oxygen gas which collects at the top of the upside down test-tube after five minutes. Calculate the average amount of oxygen produced per minute. This is a measurement of the rate of photosynthesis. (See diagrams).
j) Now move the lamp closer to the pondweed. Allow time to equilibrate and then repeat the experiment for the new, higher light intensity.
k) Do this for a range of distances and then record your results.
l) Repeat the entire experiment again to get more reliable results, compare your results and see if you can account for any anomalies if they should appear.
m) Now plot a graph of the distance of the light source from the pondweed, against the amount of oxygen produced per minute.

Safety.

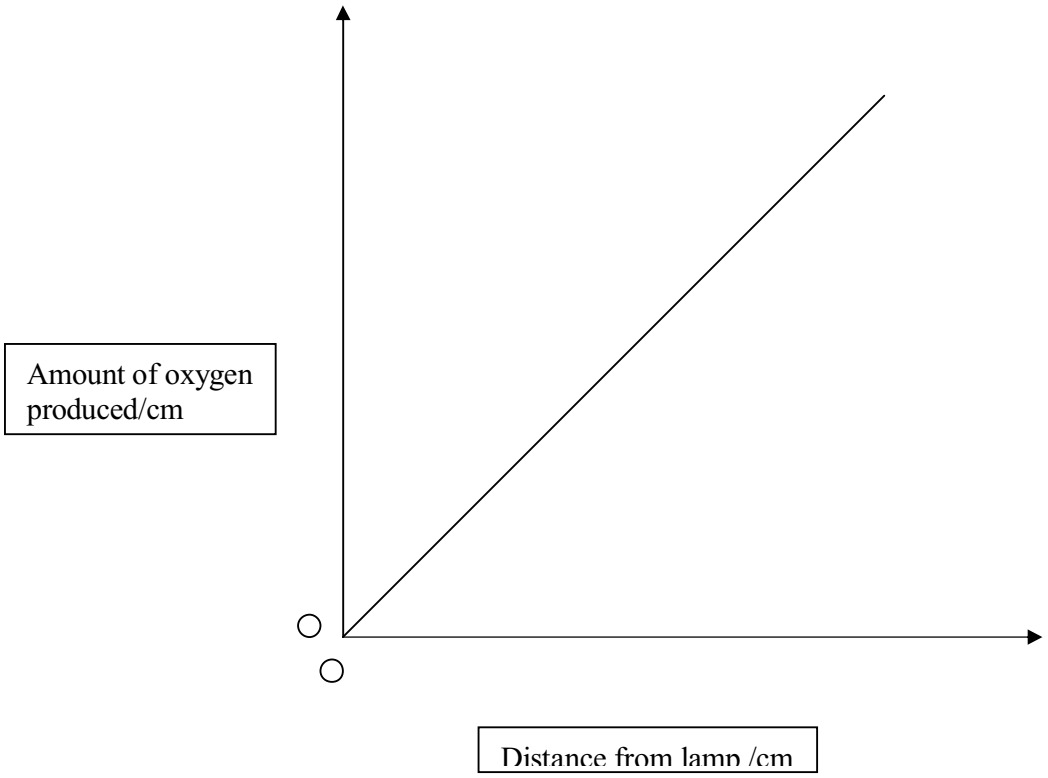
N.B:

- Avoid spillage.
- After time the lamp will become warm, take care when putting it away as you will need to let it cool to avoid burning yourself.
- Also the water aquarium that absorbs the heat from the lamp could become warm, so be careful.
- If beakers, test tubes or any of the apparatus are broken they could have sharp edges which can cut or pierce skin.
- Be careful with the metre ruler as you could get a splinter.

Strategy for Results.

Distance of lamp from Pondweed./cm	Amount of oxygen gas produced.		
	Repeat 1	Repeat 2	Repeat 3
05cm			
10cm			
15cm			
20cm			
25cm			

The graph below shows an example of what I think my graph will look like. When the light intensity is increased the amount of oxygen produced is increased and so the rate of photosynthesis is increased.



From my graph showing the effect of distance on the average number of oxygen bubbles produced, I have noticed that the further away the light is from the experiment, increasing the distance the less oxygen bubbles produced.

For evidence of less oxygen bubbles produced, see the average number of bubbles produced per minute column.

Table showing bubbles produced when the light source is at different distances.						
Distance from pondweed /cm	Amount of bubbles produced					Average number of bubbles produced per min
	Repeat 1	Repeat 2	Repeat 3	Repeat 4	Repeat 5	
0	16	17	20	14	20	17.4
5	8	10	12	9	6	9.0
10	6	8	4	10	7	7.0
15	6	3	5	6	5	5.0
20	3	4	5	2	4	3.6
25	1	2	1	1	0	1.0

I also decided to plot a graph of 1/distance against the average number of oxygen bubbles produced as it allows me to relate the rate of photosynthesis (measured as oxygen bubbles) to light intensity (light is inversely proportional to distance of lamp i.e. $^{1}/d$ their trend as the correlation is positive. In general as I decreased the distance the average number of oxygen bubbles increased also. See table of results below. For example at 15cm from the lamp an average of 5 bubbles were produced but at only 5m from the lamp (i.e. closer to the lamp) an average of 9 oxygen bubbles were produced per minute, therefore these results prove my prediction; the closer the lamp (i.e. increase the light intensity) is to the pondweed the more oxygen will be produced.

Table showing amount of bubbles produced when the light source at different distances.						
1/Distance from pondweed /cm	**Amount of bubbles produced**					**Average number of bubbles produced per min**
	Repeat 1	**Repeat 2**	**Repeat 3**	**Repeat 4**	**Repeat 5**	
0.04	**1**	**2**	**1**	**1**	**0**	**1.0**
0.05	**3**	**4**	**5**	**2**	**4**	**3.6**
0.06	**6**	**3**	**5**	**6**	**5**	**5.0**
0.10	**6**	**8**	**4**	**10**	**7**	**7.0**
0.20	**8**	**10**	**12**	**9**	**6**	**9.0**
1.00	**16**	**17**	**20**	**14**	**20**	**17.4**

The amount of oxygen bubbles produced is an indication of the rate of photosynthesis in the pondweed as oxygen gas is a product of photosynthesis. The more oxygen gas produced the more reaction there was and vice versa. Changing the distance of the light represents different light intensities and illustrates the effect light has on photosynthesis. The distance of the light from the pondweed was changed to show us that light is essential for photosynthesis to take place.

In conclusion I have realised that my results support my prediction which I made earlier. I stated that, "the closer the lamp is to the pondweed the more oxygen will be produced." Increasing the light intensity increased the rate of photosynthesis. My results confirm this prediction.

However although I was happy with my results and how my experiment was carried out, I know that generally it could have been improved as most everything can be; there is always room for improvement. My results could have been more reliable if I had taken more readings as I would be able to identify any anomalous results better. Some bubbles came out in rapid succession and the bubbles were different sizes, so sometimes it was quite hard to interpret if I should account for two bubbles or just one, also some bubbles could have been trapped under the glass and so they wouldn't have been counted. I feel it might have been better to measure the volume of space left at the top of the test tube as you don't have to watch the experiment constantly, although it may be hard to get the test tube turned upside down over the top of the filter funnel without losing water but I still feel that the results might have been more reliable. In this way we could estimate the actual volume of oxygen produced. However I still liked the procedure in which we used to carry out the investigation, as we were kept alert during the experiment because we knew that if we missed counting bubbles that our results would be unfair, the other method would be very boring and I wouldn't feel part of it as the photosynthesis takes place and hence the oxygen is

produced, the volume of oxygen gas is measure at the end therefore we wouldn't be doing anything in the experiment, what are we suppose to do whilst the plant is photosynthesising? So I preferred the method we used in comparison to the "measuring the volume method" as I felt I had responsibility and an important role to play in our results being fair.