An Investigate into the Effect of Light Intensity on The Rate of Photosynthesis

Submitted by Simi Wang

Aim

The investigation aims to find the effect of light intensity on the rate of photosynthesis.

Predication

Before experiment, it is predicted that if the light intensity is increased the rate of photosynthesis will increase.

Why?

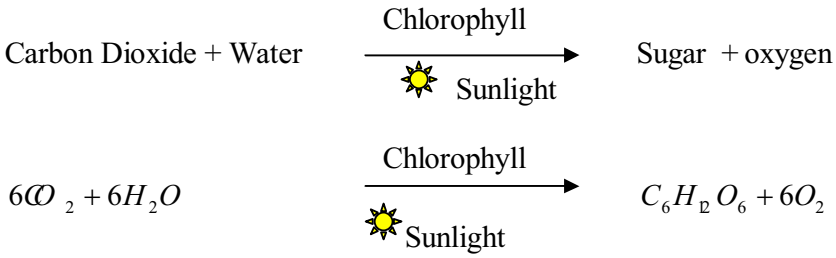


Figure 1. Formula for Photosynthesis

As shown in figure 1, in order for any plant to photosynthesis it needs three main raw materials:

1. Water
2. Carbon Dioxide
3. Light

These are also known as 'limiting factors' of photosynthesis (another limiting factor that has not been mentioned above is temperature). Therefore, if the limiting factors are increased, the rate of photosynthesis should also increase.

From figure 1, it can be concluded that photosynthesis couldn't happen without light. This is proven from a previous experiment, comparing a plant that has all the raw materials to photosynthesis, with a plant that has light limited. The result of this experiment was that when iodine solution, is added to the decolourised plant with all the right raw material to photosynthesis, it turned blue-black, which means glucose had been produced. And when iodine solution is added to the decolourised plant with limited light, it stayed reddish brown, which showed that glucose had not been produced.

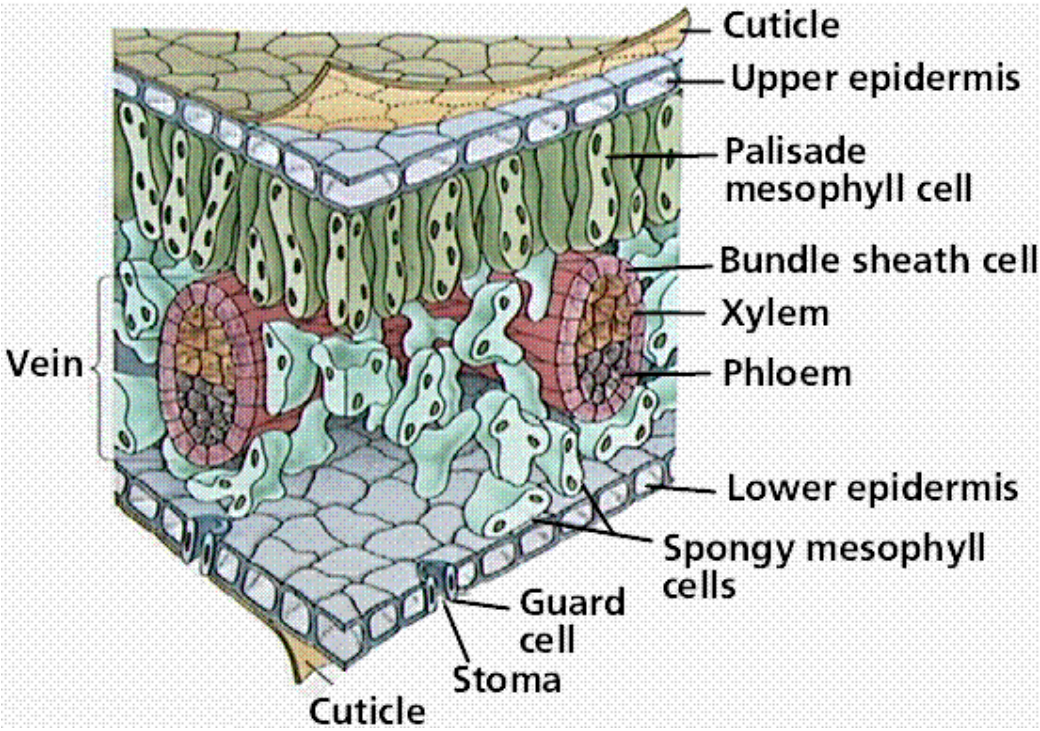
This prediction could also be proven by an another experiment, which tests the rate of photosynthesis when light intensity of a piece of pondweed changes.

Table 1. Result of Pondweed experiment

Distance between lamp and pondweed (cm)	Number of O_2 Bubbles given off in 1 minutes		
	Test 1	Test 2	Average
10 cm	106	116	111
50 cm	0	2	1

The result listed in table 1 show that the pondweed gives off more oxygen bubbles when a lamp is closer to it than the lamp is far away from it. In return, this means if the light intensity is increased the rate of photosynthesis also increases.

To back up the prediction the structure of the leaf, which is adapted to photosynthesis, is going to look at. In order for a plant to photosynthesis it need three raw material; water, carbon dioxide and light. The root hair cells in the root of the plant absorb water and minerals, and then it is transported to the leaves through the xylem vessel in the stem. Plants must guard against drying out (desiccation) and so have evolved specialised structures known as stomata to allow gas to enter and leave the leaf. Carbon dioxide cannot pass through the protective waxy layer covering the leaf (cuticle), but it can enter the leaf through an opening flanked by two guard cells via the method of diffusion.



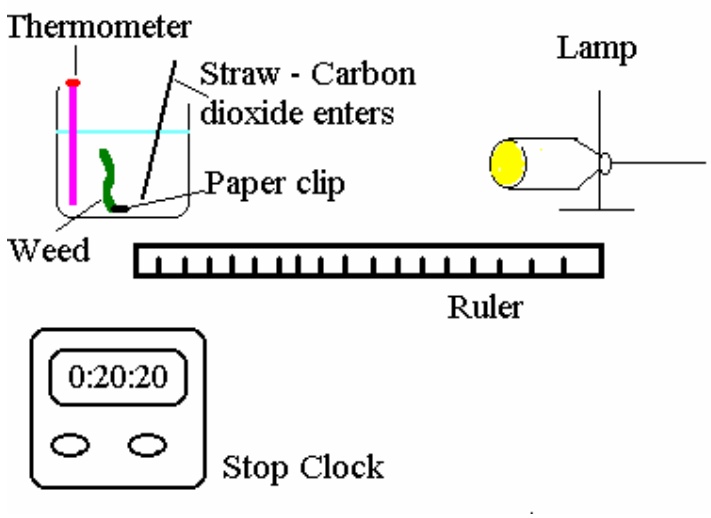
Picture 1. Cross section of a leaf.

In a leaf cell, there is a structure called 'Chloroplast'. Chloroplast is made of a green substance called Chlorophyll. Chlorophyll is the most important substance if photosynthesis is going to occur. When visible light from a light source shines on leaves, chlorophyll absorbs the energy in the light and uses it to combine the carbon

dioxide and water together. As a result of this combination glucose (sugar) and oxygen is produced. From this it could be seen that light plays an important part in photosynthesis. Therefore, the increase of light will lead to an increase of the rate of photosynthesis. In order to examine the above analysis, an experiment is undertaken.

Plan of Method

Diagram



Apparatus

Below is a list of apparatus for the experiment.

- 200 ml beaker
- table lamp
- a meter ruler
- a 5 cm pondweed
- a stop clock
- a straw
- thermometer
- paper clip
- Pondweed

Method

1. Darken the room so that the light from windows does not influence the results.
2. Cut off a piece of weed about 5 cm long.
3. Attach a paper clip to the uncut end of the weed to weight it down.
4. Put it into the beaker filled with 200 ml of water. The cut end should point upwards.
5. Use the meter ruler and place the lamp 5 cm away from the weed.
6. Blow bubbles through the water with a straw: this will ensure that the pondweed has a good supply of carbon dioxide.

7. Wait for about 3 minutes to allow the weed to acclimatise. Then count the bubbles of oxygen given off during a period of 1 minute. Do this twice and work out an average. Meanwhile, measure the temperature of the water after the acclimating time.
8. Repeat procedure 7 after placing the lamp at each of the following distances from the weed:
   - 15 cm
   - 25 cm
   - 35 cm
   - 45 cm

In order to make this experiment safely the following must be kept strictly:

- Do not fill the water to the top of the beaker to avoid spilling out on the floor, which might cause an accident when some one slips on it.
- When blowing into the water, blow gently to avoid water being blown out of the beaker.
- Place the wire of the lamp far away from any sink or water to avoid any electrical conduction, which would cause a serious accident.

To make this experiment fairly, and the most accurate result could be obtained, the following key factors must be take into account:

- The amount of water used must be the same in every experiment.
- The same piece of weed must be used in each of the experiments.
- The acclimatising time before each experiment undertaken must be the same.
- When removing the lamp to different distance, it is essential to place the lamp as accurate as possible.
- The amount of carbon dioxide blown into the water must be the same in each of the experiments.
- Measure the temperature of the water in each experiment and try to keep it at the same temperature, because the temperature could sometimes increase the rate of photosynthesis.

To compare the rate of photosynthesis when light intensity is changed, 5 different distance from weed to lamp are taken at each ranges, they are; 5 cm, 15 cm, 25 cm, 35 cm and 45 cm.

To make each result more reliable 2 results are picked up and an average workout, as the final result in each of the experiment. To make the result more precise, two people count the number of bubbles of oxygen produced simultaneously. Then a table could be formed.

Result

Table 2. Result of the number of bubbles produced at each distance.

Temperature of water	Distance between lamp and weed (cm)	Number of O_2 bubbles given off in 1 minutes		
		Test 1	Test 2	Average
28°	5	40	40	40
29°	15	16	32	24
30°	25	20	16	18
28°	35	16	12	14
28°	45	12	8	10
			Total bubbles	106

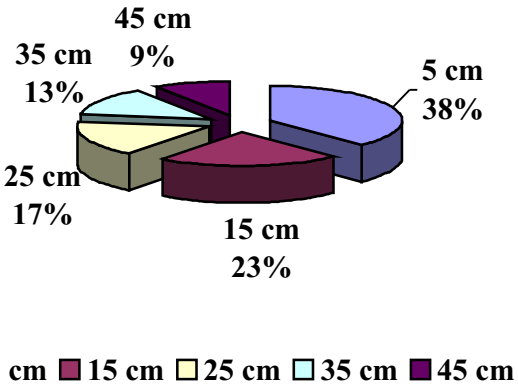


Figure 2. The average percentage of oxygen bubbles produced at each distance compared with the total number of bubbles produced.

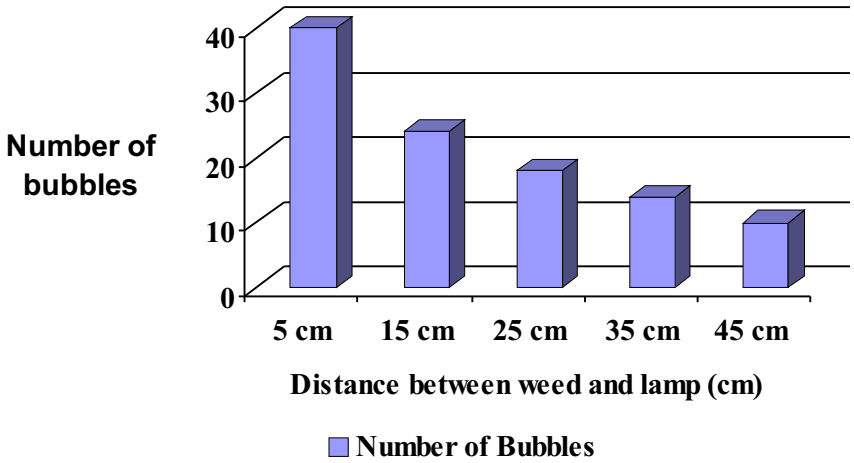


Figure 4. The average number of oxygen bubbles produced at each distance in 1 minutes.

Conclusion

Figure 2 shows the majority percentage of total number of oxygen bubbles produced at different distances of lamp. From this figure, it is clear that a stronger light intensity will result in an increase of the rate of photosynthesis. This is also able to outlined in figure 4. Therefore, it could be concluded that prediction made before is the same as the outcome of the experimental results. It is that the rate of photosynthesis would increase if the light intensity is increased.

As mentioned before, this phenomenon can be stated like the following. If a visible light is shone on the leave, a green substance called chlorophyll, stored in the structure of chloroplast in a leave cell, absorbs the light energy. The chlorophyll works with light energy to **combine** the carbon dioxide in the atmosphere and water in the soil to produce glucose and oxygen. Therefore, if the light intensity is increased, combination effect is increased and more glucose and oxygen is produced, which is an increase of the rate of photosynthesis.

Evaluation

In this experiment, the result obtained is very pleasing. There aren't any anomalous results in the experiments. However, the following may influence the accuracy of experiment:

1. Light exited from other people's, under blinds and glass in doors.
2. Heat from the lamp may have effected the result. Because temperature is also a limiting factor, if the temperature increases, the enzymes in the leaves would work faster which causes the rate of photosynthesis to increase.
3. Counting the bubbles of oxygen is difficult if they are out of the pondweed very quickly.
4. Carbon dioxide concentration is initially assumed unchanged during the experiment period. Actually, pondweed is using up the CO_2 as the experiment processes. Therefore, it is possible that the carbon dioxide concentration has been changed during the process of the experiment.

The above causes could be limited by adopting the following methods:

1. To overcome the effect of unwanted light sources, the experiment needs to be done independently in a dark room.
2. To eliminate the heat effect from lamp, it is suggested that a column of water is fixed between lamp and test beaker shown in figure 5.

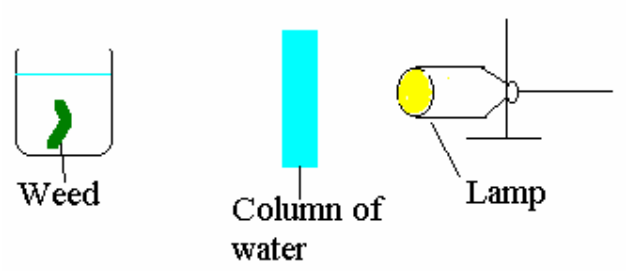


Figure 5. A method of preventing temperature as a cause of the rate of photosynthesis.

3. To reduce the errors of counting the bubbles, the two measuring method below can be employed:
   - Stoke count – one stroke every 5 bubbles

   Or
   - Only count for 15 second and multiply the result by 4.
4. To avoid the effect of carbon dioxide concentration in the experimental results, fill beaker with water of the same concentration of CO_2 in every experiment.

In addition, the following measures should be helpful to make experiment more accurate:

- Measure the volume of oxygen give off instead of counting the number of bubbles given off so it would be more accurate.

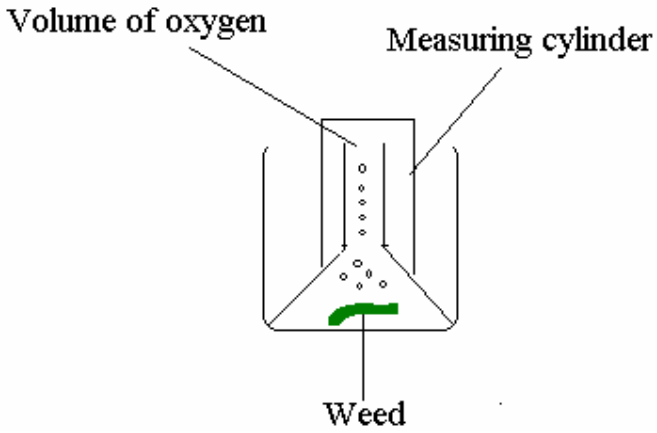


Figure 6. Measuring the volume of oxygen.

- Make multi-experiment at the same test condition.

The further suggestion is given below for further extended experiment:

1. Using different wattage of bulb to change the intensity of light.
2. Using different colours of light to see which of the light in the spectrum is most effective at photosynthesis.
3. Increase the volume of carbon dioxide in the water to see if the rate of photosynthesis would change.