INVESTIGATION INTO PLANTS   BY GURPAL GREWAL 10GY

Introduction: Photosynthesis is the process in which a green plant makes its own food in which it lives on. Photosynthesis is the combination of two different words, 'photo' meaning light and 'synthesis' meaning to manufacture. The food that a plant makes is called glucose, a food made up from inorganic to help grow the organic substances of a plant. This is called "autotrophic nutrition." There are different inorganic substances needed for photosynthesis, including carbon dioxide, water and other minerals. A plant also needs light for photosynthesis.

The main leaf cell mostly found in a plant is the palisade leaf cell. These cells are largely adapted to the photosynthesising method. For example, the palisade leaf cell contains chloroplasts, which absorb the vital amount of sunlight needed for photosynthesis to occur. Another very good adaptation the palisade cell has is the length of the cell; it covers more surface area so there's more of a chance of light hitting being absorbed by the chloroplasts, and there's a larger area to absorb CO_2. The shape that they are in also means that there would be more palisade cells in one small area (shown below).

Only green leaves can photosynthesis for the plant, as only the green leaves can absorb sunlight. This is due to the chemical found in the chloroplasts of a palisade leaf cell, known as 'chlorophyll.' The chlorophyll captures and takes in the sunlight until the chloroplasts are full, and then the leaves use the light energy to react the carbon dioxide and water together, along with help from enzymes in the leaf. The leaves are green because they only absorb the red and blue ends if light; once green comes it is reflected away due to the leaves colour. The main waste product of photosynthesis is oxygen. Photosynthesis is the opposite of respiration.

The word and chemical equation for photosynthesis looks like this:

$$\text{Carbon Dioxide} + \text{Water} \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \text{Glucose} + \text{Oxygen}$$

$$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_6H_{12}O_6 + 6O_2$$

Carbon Dioxide has to enter the plant by diffusing through the stomata; tiny holes found on the underside of the leaf. A leaf is adapted to absorb the Carbon Dioxide by the way the leaf is positioned. The leaf is at the end of a leaf stalk, which is attached to the stem, suspending the leaf in, mid-air to absorb the Carbon Dioxide. There is a tiny amount of Carbon Dioxide in the air (0.03%), so the leaf must be efficient in absorbing it. The Carbon D ioxide enters the stomata through the process of diffusion, where the air fits through a small gap and diffuses (spreads outwards) into the leaves. Whilst the Carbon Dioxide diffuses inwards, water vapour and oxygen diffuses outwards. In every stoma there are special, unique 'guard cells,' which are used to open up and close whenever the leaves need to either gain or get rid of any products, hence their name 'guard.' They have a thick inner wall, and also a thinner outer wall, which helps it to open and close. The leaves can go turgid (when the palisade cells fill up with water, making it supported) or flaccid (when the palisade cells lose their water, so it droops and can easily break), depending on the reaction it takes. When nightfall comes, the guar d cells close up, so all the water can be trapped inside the leaves. Once the leaves have gone turgid, the guard cells open the stoma so some water can escape. When the cells go flaccid, the guard cells close the stoma so no more water can escape. This also means that no more Carbon Dioxide can enter the plant, so the photosynthesis then stops.

Water enters the plant via osmosis of the root hairs. The root hair cells absorb the water through its selectively permeable membrane. The water fills the vacuole of a cell, also causing the cytoplasm to swell. The cell does not burst, however, as the cell wall helps it not to burst and keeps it turgid (full of particles, stiff). During osmosis, water spreads to where there is none, so when one cell's vacuole is full of water, the water goes through into the next cells vacuole and the next cell and so on. It continues and repeats like this until the water reaches the xylem vessels. The xylem vessels are lined with a strong starchy substance named cellulose lignin. This helps keep the stem upright. Since water is lost from the stomata leaves all the time (transpiration), new water is needed to replace it (transpiration stream). As soon as water is lost through the stomata and more is needed, more water is rushed up the xylem vessel to the leaves. Nutrients get in the plant the same way, as the nutrients are dissolved into the water that the plant takes in. Water leaves the plant by evaporation, but can also leave when the Carbon Dioxide exits the leaf, as when the guard cells open up to release the CO_2 some water is also released.

There is another set of tubes named the phloem tubes. These tubes carry around the main food, which is needed by all the growing parts of the plant. It carries things such as sugars, fats and proteins to all the growing regions such as the tips of the shoots and roots. It also takes it from and to the organs used for storage, which are placed in the roots.

The main nutrients absorbed by the plant are magnesium ions, potassium ions, nitrate ions and phosphate ions. These are needed to make chlorophyll, growth and also to keep all parts of the plant healthy. The nutrients are kept in the plant via Active Transport (when energy is used by cells from respiration to take the nutrients up).

Sugars are stored in different ways when in the plant. It can be kept as simple sugars to be transported and used straight away, it can be stored as starch and can be stored for long times with the ability to change into simple sugars or a cellulose substance which is only used for keeping the plant firm and strong.

Plants are adapted for photosynthesis in many ways. The leaf stalks and large leaf surface areas expose it to more light and air, the thin leaves allow it to absorb substances easier, air spaces and stomata allow the CO_2 to diffuse in and out, Chloroplasts in mesophyll layer and none at the surface so sunlight can penetrate deeper and makes the CO_2 react with the H_2O, the chloroplasts stay broad and on flat membranes so more chlorophyll is exposed to sunlight and the 'vascular bundles' stay near the mesophyll layer so they supply water to chloroplasts and they take away any other organic products.

Photosynthesis occurs so that the Plant can have its own food, which is glucose. The plants use the glucose in many different ways, such as:

1) The glucose helps them respire, which in turn releases new energy which is used to help make and re-build parts of the plant.
2) The glucose is used to make chlorophyll in a plant.
3) It's used to turn into any fat or oil (lipid) to help store seeds.
4) Glucose is made into cellulose, which is used for the making of cell walls.
5) Glucose is stored in the roots as starch but later is turned back to glucose to be used, whenever photosynthesis cannot occur (e.g. the winter).
6) Glucose mixed with nitrates from the soil is made into amino acids, which is then turned into proteins.

The rate of photosynthesis to respiration is at an alarming rate at present, especially due to the amount of deforestation. Plants give us oxygen, and in turn we give them carbon dioxide; it's like a life cycle. But as there are fewer plants with more and more animals, the rate of CO_2 is increasing. As is shown in the CGP biology guide, "the level of CO_2 could rise if there's too much 'animal' compared to 'plant.'" But plants not only photosynthesis; at night they respire, another worrying factor, as is shown by how it says "at night the level of oxygen will fall because the plants respiration will use it up, and none is being produced." The plant would not photosynthesise, as it needs Light to do so. Light, at night, is a "limiting factor."

Our investigation is to see what factors affect photosynthesis and to prove whether or not a plant needs one of these four factors. The four main factors are:

1) Water
2) Carbon-Dioxide
3) Light
4) Temperature

Water

The right amount of water needs to be used when watering plants. If too little water is used, then the palisade cells can go flaccid and the leaves would lose their green colour, so less photosynthesis would occur and eventually die out. If too much water is used, then the plant would drown in the water and also die out.

Light

The light is absorbed into the chloroplasts and the light is needed for the plant to photosynthesis. Photosynthesis can only go as fast as it receives the light energy.

Carbon Dioxide

Carbon dioxide is a raw material, but seeing as there's only a small amount, 0.03% in fact in the air, it's hard for the plants to absorb it as easy as it does with the other raw material, water. Once again, photosynthesis could only occur as fast as he CO_2 arrives. As soon as there is enough CO_2, one of the other products becomes the limiting factor.

Temperature

The chlorophyll acts like an enzyme; only warm conditions make it work properly, not hot or cold conditions. If the temperature is too low then the chlorophyll will not work. If the temperature is over 45 ^{o} then the chlorophyll will gradually stop working. The chlorophyll would wo rk at its peak just before this mark.

Aim: My aim is to see if a plant is affected by light and if it can photosynthesis with a weak source of it.

Prediction: I think that once the plant has the most light focused onto it, then it will photosynthesis much more. I think this because once more energy is given to the chlorophyll from the light, then much more carbon dioxide and water can be joined to make the actual glucose, hence a much more faster photosynthesis reaction.

When the plant has less light focused onto it, I think that less of a reaction would occur. This is because with less light, the chlorophyll will have a lower amount of energy for it to react the water to the carbon dioxide, therefore making fewer amounts of glucose.

Apparatus: Elodea, a Glass Beaker, a small measuring cylinder, 10g of bicarbonate of soda, a Glass funnel, Water, a ruler and a lamp.

Method:

1) Place the elodea and 1g of the bicarbonate of soda at the bottom of the glass beaker and place the wide-open side of the glass funnel over it. Fill the beaker with water until the water level reaches over the tip of the funnel.
2) Place the water filled small measuring cylinder directly over the small end of the funnel upside down.
3) Place a lamp directly next to the beaker so its 0cm away.
4) After 3 to 3½ hours check how much oxygen has been released. Measure 5cm away from the beaker. Place the bulb there.
5) After a further 3 to 3½ hours, check results and move to 10 cm. Repeat until 20 cm away.
6) Repeat the experiment again and see if the results and conclusion are similar.

Fair Test: To keep this a fair test I will keep the amount of starting water, bicarbonate of soda and elodea the same.

Diagram:

Results:

Distance From Lamp to Plant	Experiment 1- Amount of O_2 Collected	Experiment 2- Amount of O_2 Collected
0cm	9.80	8.10
5cm	8.35	7.10
10cm	9.15	4.55
15cm	5.10	1.25
20cm	3.50	1.80

Distance From Lamp to Plant	Average Amount of O_2 Collected
0cm	8.95
5cm	7.725
10cm	6.85
15cm	3.175
20cm	2.65

Averaged Results Graph:

Conclusion:
I have discovered that with rays of light focused properly on to the actual leaves of the plant, more of the photosynthesis reaction occurs. This is due to the amount of light energy from the lamp being given directly to the chlorophyll in the chloroplasts. The chlorophyll makes the carbon dioxide and water react with one another, so having the chlorophyll with a high amount of energy is crucial to having a speedy reaction. Once the light gave its highest amount of energy it could give, other limiting factors came into play. For example, when the lamp was 0cm away, then the heat from the bulb was absorbed into the chloroplasts, helping the chlorophyll to work. Once the heat reached a point where the plant or water became 'warm,' then the reaction became even faster as the chlorophyll worked better on the water and carbon dioxide reacting.

The average results table above shows what we had worked out overall, and according to those averaged results, we got what we predicted we would get. However, when you see our actual experiment results, you can see that we got a 'freak' result in the first experiment when the lamp was 10cm away from the plant. Since the result at 5cm away from the plant was 8.35, the next result should have been lower than that, but it ended up being 9.15.

The graph shows two slow gradual drops; when the lamp was right next to the plant and when the lamp was further away from the plant. There was, however, a massive drop in between 10cm and 15cm, where it went from 6.85 to 3.175. This could be due to the amount of light that it was receiving, since it absorbed less light, as the light would have gone in different directions as it got farther away. The reaction also goes faster with more heat, and I have noticed that as the lamp was closer to the plant it also released more heat, which the plant also had absorbed.

Evaluation: In the beginning, as we planned and began the experiment for the first time, it was slightly difficult; as we needed to come back in out of school hours to set up the experiment.

There was a great deal of hassle over the amounts of products we used. Firstly, we were unsure if we had all put in the same length of elodea (as there were three of us coming in at different times). Then, as we put in the right amount, different parts of the elodea had more leaves than others, making it difficult to tell if it was unfair or not. If one part had lots more leaves than another, then obviously the rate of photosynthesis would easily increase rapidly.

Next time, I would make sure that the elodea would have the same amount of leaves (by maybe counting how many leaves there are). Also, another important factor was the conditions in the area. We were only testing light, but once we set out the experiment in the classroom we found due to the windows being open and closed, as well as the sunlight and light from other experiments lamps', the conditions changed from humid to dry with lots of sunlight at some time but less sun light at other times. To fix this, I think we could complete the experiments in separate closet compartments. If when I do the experiment next time I only would want to see how light changes the rate of photosynthesis in plants, then I would need to find a way in which to control the temperature and humidity of the surrounding area, so they cannot affect the experiment.

In our experiment, we had one freak result (as explained in 'conclusion'), which was not the figure we were expecting to see. That was, however, the only unexplainable result we had in our first and second experiment, so overall it had turned out okay.

I could extend and improve my experiment in a number of ways. I could include different aspects, which I did not include in this experiment, such as heat or water. With heat, I could put the heat there through a radiator of some sort or just measure and use the heat from the light bulb itself. With water, I could add different amounts of water with the different light intensities (e.g. have $0cm^2$ and 0cm of water, then $0cm^2$ and 5cm etc.).

Bibliography:

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