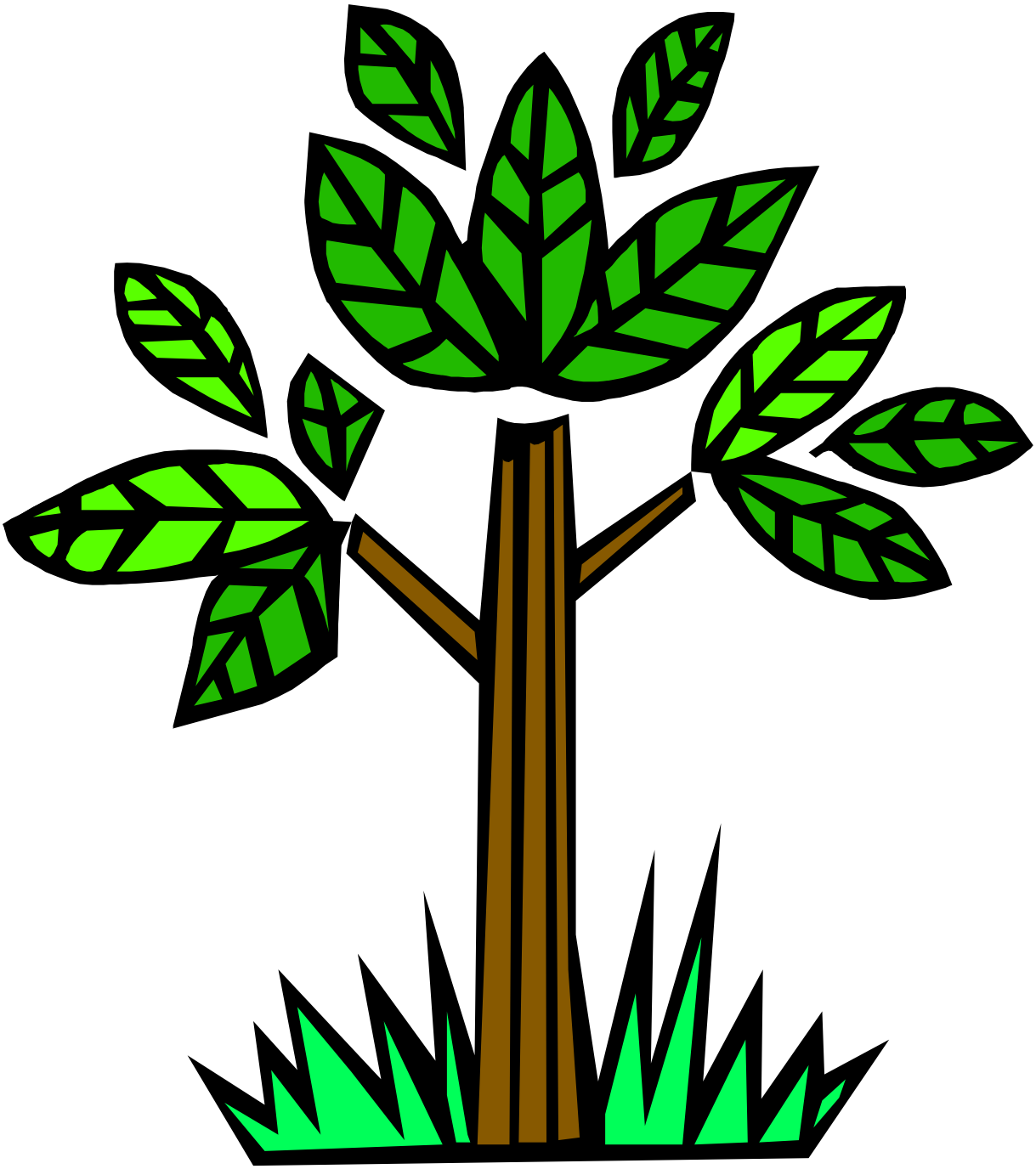
Photosynthesis Investigation



By

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Introduction

Flowering plants, like all living organisms, need a supply of food. They need it as a source of energy in respiration and they need it as raw material for growth and repair. Animals and most micro- organisms get their food in an organic form: they eat products from other organisms (such as fruit and eggs) or, nowadays, the organic substances made in laboratories and factories. Animals and the microorganisms that do this are called consumers.

Due to the flowering plants can make their own organic food from simple inorganic substances and an outside source of energy, they are called producers. Once the producers have made their food they use it in the same way as the consumers do as a source of energy and as raw material for growth and repair

Photosynthesis

The simple inorganic substances from which flowering plants make their food are carbon dioxide (CO_2) and water (H_2O). These contain no energy that a flowering plant can use an outside source of energy is needed to combine them into a compound that the plant can use as food. The source of energy is sunlight; the food compound that is made up the simple sugar, glucose ($C_6H_{12}O_6$), and the waste product that is left photosynthesis, is shown in an equation as:

Carbon dioxide + Water ⟶ Glucose + Oxygen

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

Light energy is trapped by photosynthesis and converted into chemical energy in compound glucose.

Carbon Dioxide

Carbon dioxide is a gas which is present in air only in small amounts about 0.04% of air is carbon dioxide. But carbon dioxide is continually added to air by respiration of all living organisms and by burning of fuel such as wood, coal, gas, oil and petrol all give off carbon dioxide when they burn. There is no danger that carbon dioxide will run out in fact it is slowly increasing in the air because so much burning takes place. Carbon dioxide dissolves in water, which can release carbon dioxide: flowering living plants living in water therefore also have a supply of carbon dioxide.

Water

Flowering plants that live on land get the water for photosynthesis through their roots from water in the soil. The water travels through the plants in veins called vascular bundles. Plants that live in water get it from their surroundings.

Energy

Light rays are a form of energy they are wave movements traveling at great speed. Those of a certain wavelength, which are seen by our eyes, are light rays. Flowering plants have a green pigment called chlorophyll which can absorb some of these light rays and use their energy to build up the simple sugar, glucose , from carbon dioxide and water. The light energy is trapped as chemical energy in the glucose molecule. Plants can use any source of light rays, but the source that does not run out is sunlight. Artificial light is used in glasshouses when extra light is needed. In water, only the top few meters get sufficient light for plants to use in photosynthesis. Plants that are able to detect a source of light grow towards it, for example, cress.

The growth of plants in relation to the direction of light is called phototropism. Because the stem grows it is said to be positively phototropic. Phototropism is an example of a plant responding, in the direction of its growth, to the stimulus of light. Growth responses in plant is positive phototropism: it puts its leaves into the light for photosynthesis.

The products of photosynthesis

If you look at the equation for photosynthesis , there are two products called glucose and oxygen. They cannot accumulate in the mesophyll cells indefinitely.

A the glucose forms, it is usually stored in the chloroplasts as starch. If you test a leaf for glucose during photosynthesis, you are likely to find very little because it is changed to starch so quickly after it is formed. If you test a leaf for starch during photosynthesis, you find quite a lot. But at night, when photosynthesis stops because there is no light, the starch is changed back into sugar and removed from the leaf through the veins either to a growing part of the plant or to a more permanent storage place.

Throughout photosynthesis waste oxygen is given off as a gas, because it is in a high concentration in the cells, it diffuses to the outside of the leaf, where it is in a lower concentration, via the air spaces and open stomata. The formation of oxygen during photosynthesis is of great importance to all living organisms. All living organisms, including plants, carry out respiration, and most of that respiration is aerobic (using oxygen). Photosynthesis is the only way in which oxygen used in respiration is replaced in the air.

The site of photosynthesis

For photosynthesis to occur, carbon dioxide, water and light energy must come together where there is chlorophyll in the flowering plant. Leaves, which are usually broad and flat, are the parts of the plant most suitable for photosynthesis.

- Contain chlorophyll
- Have a broad flat area which is supported by veins and is exposed to the rays of the sun.
- Contain veins (vascular bundles) which supply water
- Are thin, allowing quick diffusion of carbon dioxide to all parts inside the leaf.

The site of photosynthesis is in the cells inside the leaf. The diagram below show a view of the sort of cell that caries out photosynthesis in the leaf. The living parts of the cell, the cytoplasm and nucleus, are surrounded by a non-living cell wall of cellulose: the cell wall keeps the cell in shape. The green pigment chlorophyll is held in small disc-like shapes, made from specialized parts of the cytoplasm, called chloroplasts. The central part of the cell is a vacuole containing cell sap, which is mainly water.

The cytoplasm is surrounded by a cell- surface membrane. A nuclear envelope surrounds the nucleus.

Chlorophyll pigments absorbs the light energy and convert it into food. This is why it is called photosynthesis. So by using the light energy the plant manufactures its food.

In my investigation I will be looking whether the four factors of photosynthesis, which are – Light, Chlorophyll, Carbon Dioxide and Water are actually needed for photosynthesis to occur. For this investigation to occur I will need to de-starch the plant and then for each factor check whether starch is available or nor.

De-starching a plant

Aim

My aim to de-starch a plant is to see the effects of the four factors of photosynthesis is needed during photosynthesis

Method

- Get some plants
- Cover the whole plant with black bag so no light can go pass
- Place the plant inside the cupboard leaving no light to go in
- Leave the plant inside the cupboard for about 2 – 3 days (48hrs – 72hrs)

Testing a plant for starch

Aim

My aim for this experiment is to see whether starch is present in the leaves of a plant whether the plant has been photosynthesising or not been photosynthesising

Preliminary work

Get a fresh pot of plant, which has all the minerals and has been photosynthesising or a plant which has not been photosynthesising for several reasons such as it has not got any sunlight, water or carbon dioxide.

Apparatus

Large Beaker Small Beaker Tripod Bunsen burner Clamps

Chemicals needed

- Water
- Iodine
- Ethanol

Safety rules

- During the experiment wear the laboratory coats
- Wear gloves on the hand because of chemicals being used
- Don't touch any chemicals with naked hand
- Do not run around in the lab

Method

I will be explaining the method to test whether starch is present in the leaves of the plant.

- Set up the apparatus
- Boil some water in the large beaker at approximate of 150 ml
- When it starts to boil put the leaf inside the water (we put the leaf inside the water of boiling water to remove all the cuticles of the leaf)
- Let the leaf boil in the water for about few minutes
- While leaving the leaf to boil, put some ethanol on the smaller beaker
- When the leaf has been boiled, take out the leaf from the beaker and now place the smaller beaker containing ethanol inside the large beaker
- Put the leaf inside the ethanol to remove the chlorophyll from the leaf
- The reason why we put the ethanol inside another smaller beaker to boil inside the large beaker because ethanol is highly flammable and can catch fire very easily
- Leave the ethanol to heat inside the water till the ethanol starts to boil
- Once the ethanol starts to boil take it out from the water and place it on the tile and put back the leaf from ethanol to the water for about 30 seconds
- After 30 seconds are over place the leaf on to the tile flat
- Now using the syringe put some iodine over all parts of the leaf after a while turn the leaf and put some iodine on that side as well
- After few minutes hold the leaf on the hand facing the light and you will see some colour patches on the leaf
- Now the experiment is over

After completing the experiment I now need to see whether the leaf had some starch present in it or it did not have any starch present it. For this we need to look on to the leaf and look at the colour patches, there will be two types of colour patches that can happen to the leaf and they are

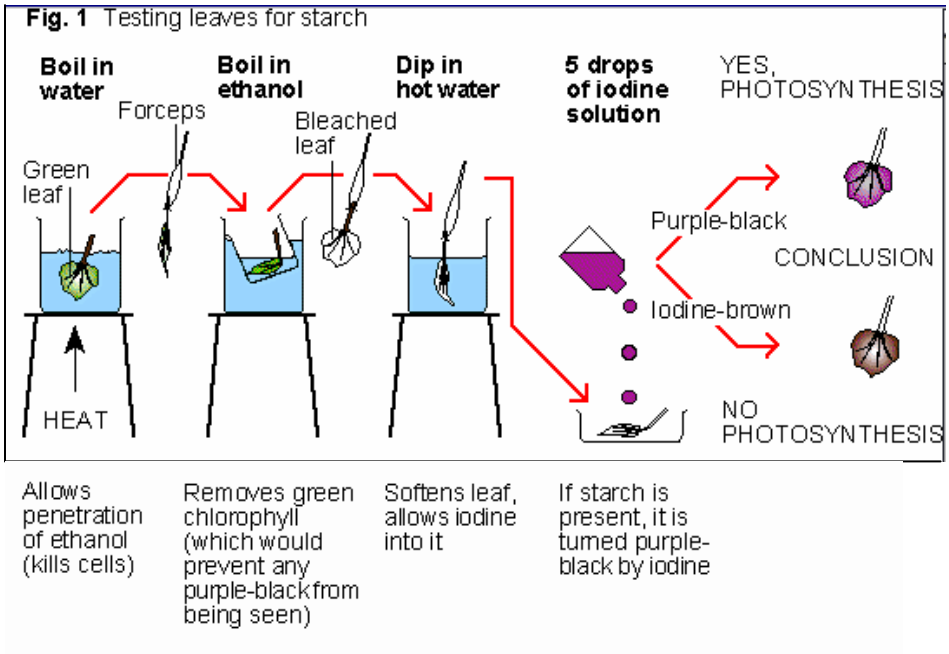
If the leaf has some patches with colour of blackish purplish or blackish bluish then the leaf has starch in it presents which means that the leaf from which plant has been photosynthesising

But if

The plant show patches with colour of yellowish brown or yellowish orange then that states that leaf has no starch in it presents which also states that the leaf has not been photosynthesising. And the leaf has not got one or more of the factors that needs for a plant to photosynthesise

For this experiment I used a leaf from a plant, which had been photosynthesising and has all the four factors needed to photosynthesis so the colour patches on the leaf showed the colour of blackish bluish. We also use this method of testing for starch when we will be looking for the four factors if they are needed for photosynthesis to happen.

Starch Test Diagram



Testing for Chlorophyll in plants

Aim

My aim in this experiment is to see whether chlorophyll is actually needed by the plants to photosynthesis.

Prediction

I can predict that all plants need chlorophyll to photosynthesize. I can predict it from the general formula for the photosynthesis

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

Apparatus

- Small beaker
- Large beaker
- Clamps
- Tripod
- Bunsen burner

Chemicals needed

- Ethanol
- Iodine
- Water

Safety Rules

During the experiment we will need to keep in mind about the safety needed during the experiment. During the experiment we will need to wear gloves and lab coats. While turning the flame on for the Bunsen burner always try to keep hands as far as possible. Never touch beakers with naked hand when it has been heated. The main safety I will need to keep is that ethanol is highly flammable and can catch fire very easily so always keep matches and the Bunsen burner away from it

Method

- De- starch a plant from not less than 48 hrs (2 days)
- Take the plant out to give sunlight after 48 hrs or more
- Set up the apparatus
- Tear a leaf apart from the plant
- Do the test for starch experiment

Now the results from the test for starch we get will be the answer whether if chlorophyll is needed for photosynthesis

Results

On the leaf after spreading out iodine on it I saw that the leaf had patches of yellowish orange and this states that there is no starch present in the leaf.

Conclusion

I found out that my prediction was quite true and the leaf did not have starch present in it because there was absence of chlorophyll

Diagram for the experiment

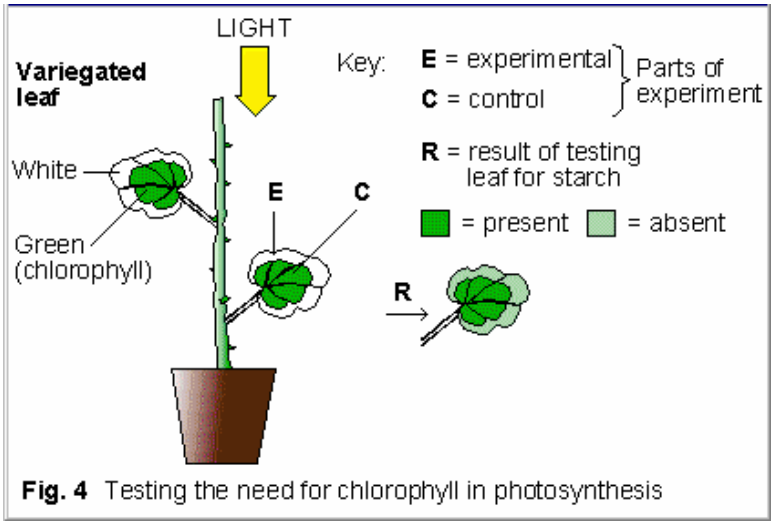


Fig. 4 Testing the need for chlorophyll in photosynthesis

Testing for Carbon Dioxide

Aim

In this experiment my aim is to see whether carbon dioxide is actually necessary for photosynthesis to occur.

Prediction

I can believe carbon dioxide is needed for photosynthesis because it is a reactant of the photosynthesis equation.

Fair test

In order to make my experiment fair and get accurate results I will have two keep in mind the following points:

- Make sure the leaves are de-starched for more than 24 hours
- While applying Iodine on the leaves there should be same amount applied to both the leaves

Preliminary test

Firstly we de-starched the plant for 24hrs – 48hrs then took out the plant and applied a polythene bag on 2 the leaves
one of them contained sodium hydrogen carbonate – which provide carbon dioxide to the leaves, and the other one contained soda lime, which takes carbon dioxide away from the leaves. Now we gave the plant some sunlight for few hours before carrying out the starch test

Apparatus required

Equipment list

- Polythene bags
- Rubber bands
- 2 small and 2 large beakers
- Bunsen Burner
- Tripod

Chemicals required

- Sodium hydrogen carbonate ($NaHCO_3$)
- Soda lime
- Iodine
- Ethanol
-

Safety precautions

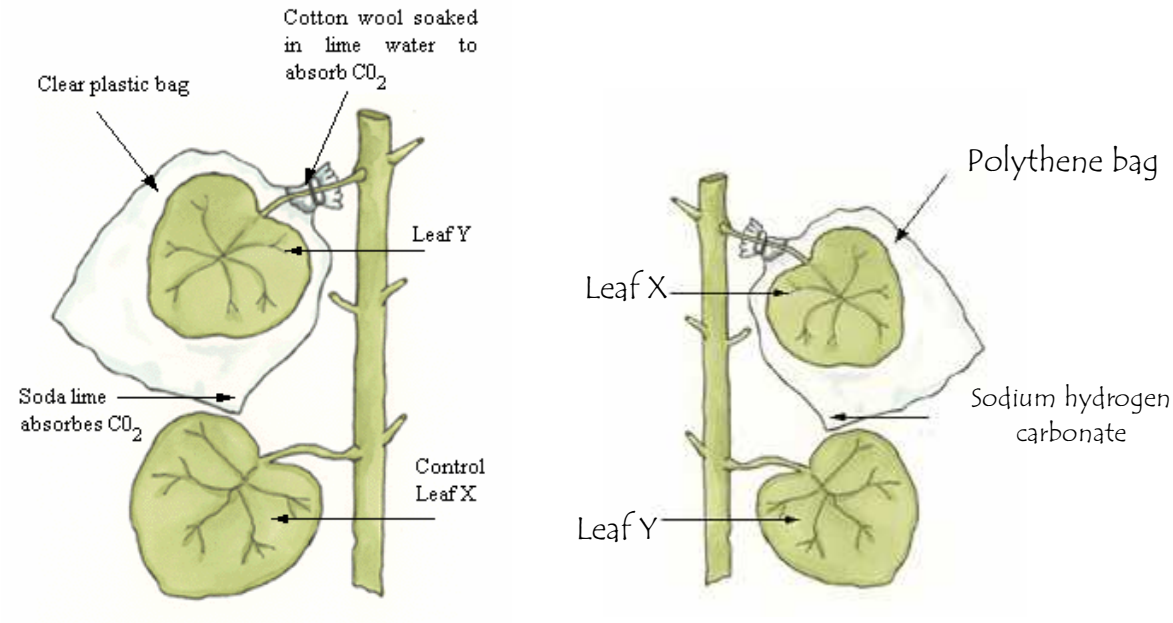
- Be careful with ethanol against the Bunsen burner because it is highly flammable
- Wear gloves, Lab coats and goggles to protect bare skin from chemicals

- Use any equipment to hold the beaker when it is hold

Method

- Apply polythene bags on 2 leaves – 1 containing the soda lime and other sodium hydrogen carbonate
- De-starch the plant for more than 24 hours
- After 24 hours – 48 hours take out the plant from the dark cupboard and give some sunlight
- Now take the two polythene bags away from the leaves and peel those leaves away from the plant
- For each leaf do the starch test and collect the results

Experiment diagram



Results

The leaf that had soda lime attached to it while being de-starched showed patches of yellowish brownish colour on it when applied iodine to it which means that there is no starch present it the leaf

AND

The leaf that had sodium hydrogen carbonate showed bluish blackish patches on I, which represents that there, is starch present in the leaf

Conclusion

My predictions have been proved correct, by doing this experiment I have found that carbon dioxide is a limiting factor of photosynthesis and also that it reduces the rate of photosynthesis

Testing for Sunlight

Aim

My aim on this experiment is to see whether sunlight is essential for photosynthesis to occur

Prediction

I predict that without sunlight photosynthesis cannot occur, I can predict this by knowing that photosynthesis does not occur during the night which can only mean that at that time sunlight is not present so the photosynthesis cannot occur

Fair test

To make my experiment fair and receive accurate results I will have to keep in mind the following points:

- The leaves should be de-starched for more than 24 hours and in a very dark place
- The leaves that would be half covered by the aluminum foil should be tightly placed leaving no light being pass through
- Iodine should be applied with accurately measured amount

Preliminary work

Before we de-starched the plant we covered 2 leaves with aluminium foil but only on half of the leaves. We did this to two leaves to get accurate results. Then we de-starched the plant for 24 – 48 hours and then took the plant away from the dark place and placed it on an open place giving it some sunlight. Here the leaves that are halfly covered by the aluminium foil will not receive any sunlight but those areas next to the aluminium foil, which are not covered, will gain sunlight and will start to photosynthesis again.

Apparatus Required

Equipments

- 2 large, 2 small beakers
- Bunsen burner
- Tripod
- Aluminum foil

Chemicals

- Iodine
- Ethanol

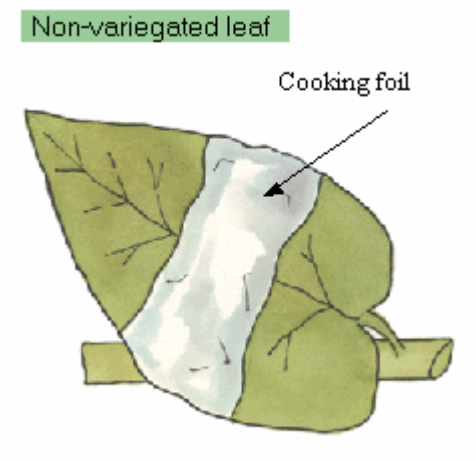
Safety precautions

- Be careful with ethanol as it is highly flammable
- Wear gloves, Lab coats and goggles to protect bare skin from chemicals and hot water
- Use any equipment to hold the beaker when it is hold

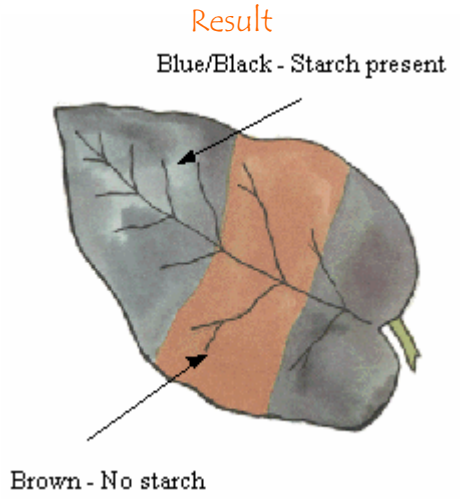
Method

1. Cover half of the 2 leaves with aluminum foil
2. De-starch the plant for 24 – 48 hours
3. Now give the plant some sunlight by taking it out from the dark area
4. Now take off the aluminum foil off the leaf
5. Now do the starch test for it
6. Record the results
7. Now do the steps 4 and 5 for the second leaf and record the results and compare both the results if they vary in anyway

Experiment diagram



Result



Results

For both the leaves we got the same results which are that the covered part of the leaf shoed yellowish brownish colour which states that no starch is present there. (A figure of my result is also shown above)

AND

The areas, which the aluminum foil was NOT covered, showed bluish blackish colour, which states that starch was present. (This can also been seen in the result diagram above.)

Testing for Water

Aim

My aim for this experiment is whether water is necessary/unnecessary for a plant to photosynthesize

Prediction

I can predict water is as necessary as all others I investigated; this is because plants cannot survive without water as they can't make their own food. I can also predict this by having a knowledge that when a leaf is been taken of a plant, the leaf cannot then survive for longer than few days even if it was getting all the product it needs to photosynthesize except of water which can only mean that without water plants cannot photosynthesize

Fair test

To gain accurate results I will need to make my test fair, to do this I will have to follow the following points:

- De-starch both the plants (1. which can gain water, 2. which cannot gain any water) for the same time and at the same area
- Use same amount of iodine to get the results for both the leaves

Preliminary work

We took out the whole plant from the soil letting it have no more water and also took another plant, which could have water. We then de-starched both the plants on the same place and for the same time. Then after we took the plants out from the dark area when 24 –48 hours were up and gave both them some sunlight for few hours

Apparatus Required

- Bunsen Burner
- Tripod
- 2 small, 2 large beakers
- Iodine
- Ethanol

Safety precautions

- Be careful with ethanol as it is highly flammable
- Wear gloves, Lab coats and goggles to protect bare skin from chemicals and hot water

- Use any equipment to hold the beaker when it is hold

Method

- Pluck out a plant from the soil
- Get another plant which can get water and de-starch both of the plants at the same area and for the same time
- After 24 –48 hours take out the plant from the dark area and now give them both some sunlight for few hours
- Now take out a leaf from each plant and carry out the starch test
- Record both the test results and compare them

Diagram for the experiment

Results

The plant, which could get water, showed patches of bluish blackish colour, which states that there is starch present in the leaf

AND

The plant which never had any water in it showed darkish brownish patches which states that there is NO Starch present in that leaf, which also proves my prediction that water is necessary for photosynthesis to occur

Conclusion

My predictions have been proved absolutely correct, by doing this experiment I have found out why exactly a plant dies when it is taken out from the soil.

LIGHT INTENSITY

Aim

My aim is to carry out an investigation into photosynthesis.
I want to find out if light intensity has any effect on the rate of photosynthesis. I want to know if the intensity of light is high, then will the rate of photosynthesis will be faster.

Hypothesis

The effect of light intensity on the rate of photosynthesis

Photosynthesis depends on the amount of light available. Increase in light intensity increases the rate of photosynthesis and less of it decreases its rate. This is what is going to happen in my experiment. When the lamp is closest to the beaker, the rate of photosynthesis or the number of bubbles produced will be the most. As the lamp will be moved away from the beaker the number of bubbles produced will decrease so will the rate of photosynthesis.

Therefore I predict that as the lamp will be moved away from the beaker the number of bubbles will decrease thus decreasing the rate of photosynthesis.

Variables

The effect of light intensity on the rate of photosynthesis

Independent Variable

- Oxygen is independent
- The light intensity is independent
- The time is a constant independent

Dependent Variable

- The amount of oxygen produced is dependent on the rate of photosynthesis
- The rate of photosynthesis is dependent on the light intensity

Precautions

Precautions play an important part in every experiment

- Bags and books must be kept away from the apparatus and the place where the practical is set up.
- There should be no smoking in the laboratory

- In both of the particles, the lamp must not be kept too close to the leaves for a long period of time. This is because chlorophyll is an enzyme and gets denatured by excessive heat.
- The leaves chosen for the practical must not be variegated or yellow. They must be green.

Fair Testing

By applying fair testing to a practical, a candidate can be fair in obtaining his or her results. The fair testing I am going to apply to my practical is: -

- I will set up the apparatus exactly as shown in my method.
- In the effect of light intensity on the rate of photosynthesis experiment, I will use a ruler to measure the distance of the lamp from the jar.
- I will count the number of bubbles produced by marking dots on the paper as the bubbles are produced. Then I will count them to write how many bubbles are produced.
- I will repeat my experiment thrice to improve their validity and reliability.

Apparatus

1. Pondweed
2. A beaker of water
3. 10cm3 of sodium hydrocarbonate
4. Funnel
5. Bench Lamp
6. Stop Watch

Method

1. Fill a beaker with tap water and add 5cm3 saturated sodium hydrocarbonate solution.

2. Select a pondweed shoot about 2-4cm long

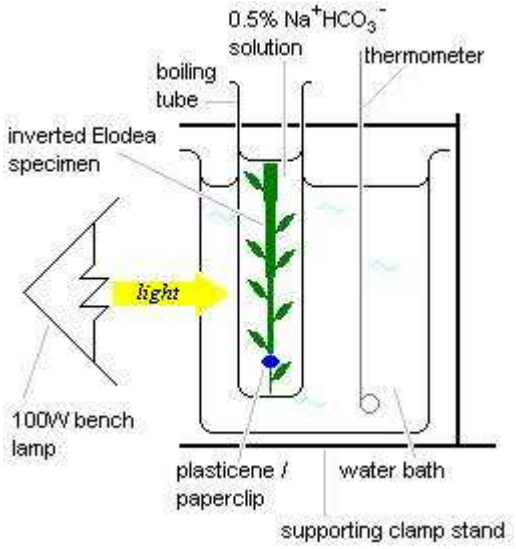
3. Set up apparatus as shown in diagram

4. Place a bench lamp about the distance needed away from the beaker, switch on and start the timer

5. Record the number of bubbles produced at each distance.

6. Repeat step 1-5, moving the bench lamp to different distance away from the beaker.

Diagram for Method



Results

Distance (Cm)	No. Of Bubbles Produces		
	Trial 1	Trial 2	Trial 3
10	298	296	294
20	241	241	240
30	199	201	200
40	180	179	185
50	174	172	175

Conclusion

Using my results, I found my hypothesis is correct. The higher the light intensity, the more bubbles were produced. However the diagram in page 7 shows how photosynthesis does change.

The bubbles produced are bubbles of oxygen. In the chemical equation for photosynthesis it states glucose and oxygen is produced from carbon dioxide and water.

From my results, I didn't come to a reasonable conclusion. Perhaps there was a limiting factor in the process of photosynthesis. It could be because the light was too far away or the change of surroundings. The temperature of water may not be accurate enough for photosynthesis to take place, there may not be enough carbon dioxide or even too much. Whatever the reason the main conclusion for normal results is dependent on the light intensity.

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 had occurred during the experiment, which were then corrected to get accurate results.

My first graph, which is calculating the average number of bubbles, produced shows that as the distance of the light increase (means moving away from the pond weed) the number of average bubbles produced decreases, which means that the rate of light intensity depends of the distance of the light. Now to prove that statement I created another graph showing the light intensity and the distance. This graph shows as the distance of the lamp increase the light intensity decreases rapidly which proves that rate of light intensity depends on the distance of the light

Errors, Limitations and Improvements

Like all experiments there is always room for improvement and this one is no exception. My main limitation was time. If there had been enough time I could have carried out the same experiments in various coloured light to see whether the colour helps the rate of photosynthesis to occur faster or not. Another problem that occurred with my experiment was that the temperature had been fluctuating whilst the experiment was occurring which means that it never had a steady temperature to get accurate results. I could have also used a couple of different types of pondweed to see if this made a difference to the results. If I was to do this experiment again then this is the method that I would use to improve it.

- Collect a beaker that can hold 100 ml of water. Then fill it up with 100 ml of water
- Collect a fresh piece of Elodea (Canadian pondweed) about $5cm^3$ long
- Attach the pondweed to two paper clips, so that it is weighed down. Then place the Elodea into the water
- Take the funnel and place it over the Elodea upside down
- Measure 10cm intervals up to 1m away from the lamp, with different light colours
- Start stopwatch when the light is turned on
- Count how many bubbles are produced in every 2 minutes
- And repeat the same experiment 3 times.

Hopefully using this method will make a better experiment and produce better primary results, so that secondary data doesn't have to be used. Apart from some problems the experiment went quite well.