NUTRITION IN PLANTS

Nutrition in plants is by a process called photosynthesis.

The process of photosynthesis occurs in all green plants in organs called **chloroplast** most of which are found in leaves.

Chloroplast contains chlorophyll which traps sunlight energy.

The process of photosynthesis is very complicated but it can be summarized by the equations below.

Carbon dioxide + water $\xrightarrow[\text{Chlorophyll}]{\text{Sunlight energy}}$ starch (Glucose) + oxygen

$$6CO_{2(g)} + H_2O_{(l)} \xrightarrow[\text{Sunlight energy}]{\text{Chlorophyll}} C_6H_{12}O_{6(s)} + 6O_{2(g)}$$

Conditions necessary for photosynthesis to take place

1) Chlorophyll:

Chlorophyll is a green pigment that absorbs light energy from the sun. The amount of chlorophyll present in a leaf is directly related to the rate of photosynthesis.

2) Carbon dioxide:

It is absorbed from the atmosphere by terrestrial plants through their stomata. For aquatic plants like algae, they absorb the carbon dioxide as hydrogen carbonates which diffuse directly from the water in plant tissues. The use of carbon dioxide is to combine or react with hydrogen atoms to form carbohydrates. Thus CO_2 is used as a raw material.

3) Light:

This is the source of energy necessary for the process of photosynthesis to take place. The rate of photosynthesis increases in light intensity, up to a maximum when it levels off. The energy of light is used for the following purposes:

i) Used to split water molecules into hydrogen atoms and oxygen. The oxygen is given off by the photosynthesizing plants. The hydrogen atoms combine with CO_2 to form carbohydrates.

$H_2O \xrightarrow{\text{split by light energy}} 2H^+ + O_2$

ii) Provides energy for photosynthesis. The process by which light energy splits water into H^+ and oxygen is called photolysis of water.

4) Temperature:

Temperature influences the rate of chemical reactions which are controlled by enzymes which are protein in nature. The rate of photosynthesis doubles for every ten degrees centigrade (10^0C) rise in temperature up to about 400C where the rate of photosynthesis drops drastically because the enzymes are denatured

5) Water:

Water is a raw material for the process of photosynthesis. It is absorbed by the root hairs from the soil and transported up the rot by the xylem vessels.

A decrease in the concentration of water lowers the rate of photosynthesis.

6) Oxygen:

Oxygen is not necessary for the process of photosynthesis i.e. it is a bi-product of thus its accumulation instead lowers the rate of photosynthesis.

Adaptation of leaves to carry out photosynthesis

photosynthesis The leaf is the major organ of photosynthesis in a plant.
The leaf is adapted to carry out the photosynthesis process in a number of ways namely **External adaptations:**

i) **Leaves are broad and flat:** This provides a large surface area for trapping sunlight and taking in of Carbon dioxide.

ii) **Numerous leaves:** This helps to increase the total surface area exposed to the sun thus increasing the rate of photosynthesis.

iii) **Leaf arrangement / leaf mosaic:** Leaves are usually arranged in such a way that they rarely shade or block each other thus ensuring that each leaf obtains maximum sunlight for photosynthesis. This is termed as a leaf mosaic.

iv) **Thinness:** Most leaves are just a few cells thick thus providing a small diffusion distance for penetration of carbon dioxide and sunlight.

Internal adaptation of a leaf:

v) **Palisade mesophyll layer contains numerous chloroplasts** especially the palisade thus it is the best position to receive sunlight. **vi) The spongy mesophyll** layer has mainly **air spaces** thus allowing many gases to easily diffuse into all the photosynthesizing cells.

vii) **Network of veins (vascular tissues) which** contains the phloem and the xylem where by the phloem conducts food made by the leaf and the xylem conducts dissolved mineral salts up to the stem.

viii) **Presence of stoma which** controls passage of gases and water vapour between air and the leaf. There are more stomata on the lower side of the leaf compared to the upper side to reduce water loss by transpiration.

ix) **Has cuticle** which is a water proof layer and so it helps to prevent desiccation (water loss) by the photosynthesizing tissues.

x) **Numerous chloroplasts** ensure that enough sunlight is trapped by the chlorophyll.

Factors that affect the rate of photosynthesis

1) **Amount of chlorophyll:** The more chlorophyll, the more the light energy absorbed leading to increased rate of photosynthesis. The less the chlorophyll, the less light energy absorbed leading to decreased rate of photosynthesis

2) **Amount of CO_2 in the atmosphere:** It is required as a raw material for photosynthesis thus the rate of photosynthesis increases in CO_2 concentration and it decreases with the lowering of CO_2 concentration.

3) **Light intensity**

The rate of photosynthesis increases with increase in light intensity. And it lowers with decrease in light intensity.

4) **Temperature**

It is required for the activity of enzymes that control the rate of photosynthesis. Thus the rate of photosynthesis increases with increase in temperature till the optimum temperature for enzyme action. Beyond which the enzymes are denatured leading to decrease rate of photosynthesis.

5) **Number of stomata**

The more the stomata, the more the gaseous exchange. This avails more CO_2 to the plant leading to high rate of photosynthesis.

6) Surface area for photosynthesis

The larger the area for photosynthesis (more leaves) the more light energy is absorbed which causes increased rate of photosynthesis.

7) Availability of water

Importance of photosynthesis

i) Photosynthesis helps to purify the environment by removing excess Carbon dioxide from the atmosphere which is a pollutant.

ii) During the photosynthesis process, oxygen is released back into the atmosphere and it is very vital in the respiration process of most organisms. iii) It provides energy. This energy is mainly organic in nature in form of fuels like coal, petroleum, firewood, all of which are products of photosynthesis.

AN EXPERIMENT TO TEST A LEAF FOR STARCH

The presence of starch is evidence that photosynthesis has been taking place.

Apparatus:

- A green leaf, ➢ absolute alcohol (99%-OH),
- water bath, ➢ beaker,
- Iodine solution, ➢ white surface or tile
- Water **Procedure:**

1) A leaf from a health plant which has been receiving sunlight is removed and placed in boiling water (water bath) for about 5 minutes. This softens the leaf cell wall protoplasm and makes it permeable to Iodine.
2) The leaf is then placed in a beaker containing 99% alcohol and boiled using a water bath until all the chlorophyll is dissolved out. This decolorizes the leaf and makes detection of any colour changes possible and easier.
3) The leaf is then washed in hot water which softens it.
4) The leaf is now spread on a white surface tile and drops of iodine added on it.

Observation:

A blue black colour shows that starch is present.

NOTE: If the brown colour of iodine remains, this shows that the leaf lacks starch or the starch is absent.

Conclusion: The presence of starch in a leaf shows that photosynthesis was taking place.

AN EXPERIEMENT TO SHOW THAT OXYGEN IS GIVEN OFF DURING PHOTOSYNTHESIS Apparatus:

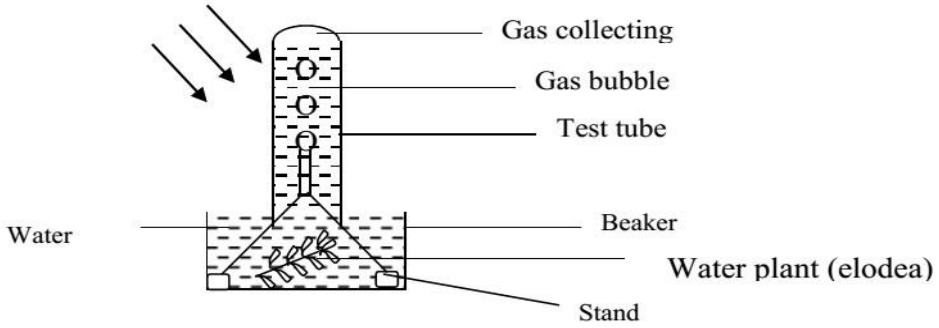
- Afresh water weed.
- Funnel and wooden blocks. ➢ Test tube,
- beaker
- Water.
- Sodium hydrogen carbonate.

Procedure:

a) The funnel is inverted in the beaker over the plant.
b) Sodium hydrogen carbonate is added to the water to provide CO_2
c) The funnel is raised slightly above the bottom of the beaker using small wooden blocks to allow water to circulate freely under it.
d) The apparatus is then placed in the bright sunlight.
e) Another similar set up is made and placed in darkness. This acts as the control experiment.

The apparatus is arranged as shown below:

Experimental setup



Observation:

Gas bubbles are evolved and sufficient gas is collected at the top of the test tube. In the control experiment, no bubbles are evolved.

Conclusion:

The gas collected relights the glowing split proving that it is oxygen. The evolution of oxygen by the water plant in the presence of sunlight is an indication that photosynthesis is taking place.

NOTE: This experiment can also be carried out to estimate the rate of photosynthesis (speed) by counting the number of bubbles produced per unit time.

AN EXPERIMENT TO SHOW THAT LIGHT IS NECESSARY FOR PHOTOSYNTHESIS

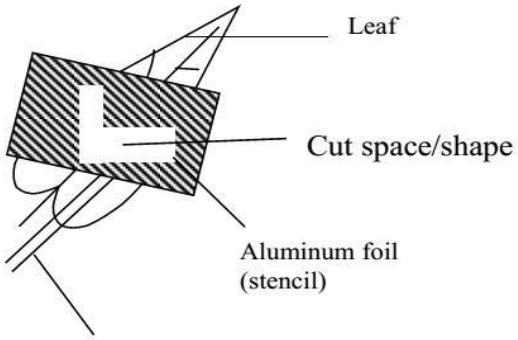
Apparatus/materials:

- ❖ Potted plant ❖ White tile ❖ Boiling tube ❖ Aluminum foil ❖ Source of heat ❖ Razor blade.
- ❖ Water ❖ Wire gauze
- ❖ Ethanol ❖ Dropper

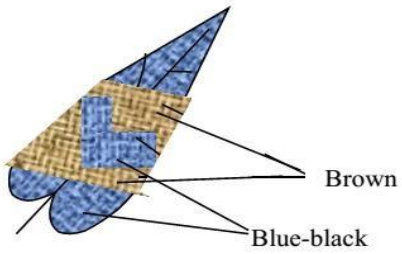
Procedure:

1) Get a potted plant and place it in darkness for 24 hours to de-starch it.
2) Make a shape in an aluminum foil and make a stencil
3) Place the stencil around the leaf with the cut shape facing upwards where light strikes.
4) Place the plant in sunlight for 3 hours.
5) Remove the leaf with a stencil from the plant using a razor blade 6) Remove the stencil and carry out the test for starch.

Before testing for starch



After testing for starch



Observation:

The parts, which were covered by the stencil, turned brown while the parts exposed to light turned blue-black. **Conclusion:** Light is necessary for photosynthesis to take place.

Explanation:

Putting the leaf in darkness removes starch in the leaf by all the starch being converted into simple sugars. Putting the plant in light is to allow photosynthesis to take place. Covering the leaf with a stencil is to prevent light from reaching certain parts of the leaf. During exposure to light, the parts covered do not access sunlight and do not photosynthesize while the un-covered parts access sunlight and photosynthesize. Testing for starch helps to find out whether photosynthesis took place or not.

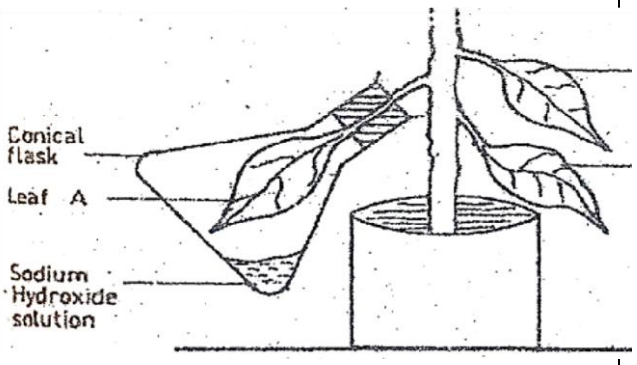
AN EXPERIMENT TO SHOW THAT CARBONDIOXIDE IS NECESSARY FOR THE PROCESS OF PHOTOSYNTHESIS

Apparatus:

- Sodium hydroxide/Potassium Hydroxide
- Conical flasks fitted with corks with a hole,
- well watered de-starched plants,
- Iodine,
- 99% alcohol
- water beaker,
- white tile
- Test tubes.

Procedure:

a) The leaves of a potted plant de starched by keeping the pl in darkness for two days.
b) The petiole of the leaf (stalk) is passed through the hole cork so that the leaf is completely enclosed in a flask cor Sodium Hydroxide (The Sodium Hydroxide absorbs all C dioxide enclosed in the flask.)
c) The flask is then made air tight by smearing Vaseline at of the flask to prevent any air from entering.
d) A control experiment is also set up, however here the fla contains water which does not absorb Carbon dioxide.
e) The plant and the flasks are then placed in sunlight for 6 hours.
f) The enclosed leaves are then removed from the plant and then tested for starch using Iodine solution.



Observation:

The leaf in the flask containing Sodium Hydroxide solution remains brown (the colour of Iodine persisted) when tested for starch while that (the flask containing water / control experiment) turned blue black.

Conclusion:

The leaf in the flask containing Sodium Hydroxide didn't contain starch since it lacked Carbon dioxide which was absorbed from the flask by the Sodium Hydroxide solution thus Carbon dioxide is necessary for photosynthesis.

AN EXPERIMENT TO SHOW THAT CHLOROPHYLL IS NECESSARY FOR PHOTOSYNTHESIS Apparatus:

- A beaker,
- Alcohol,
- Iodine,
- test tube, and
- white tile
- Plant with variegated leaves.

A variegated leaf *is one which has chlorophyll in some parts of the leaf lamina and not in other parts of the same leaf. It has green and yellow parches on the same leaf.*

Procedure:

a) After a period of de-starching (removing starch) by placing a plant in a dark cupboard for two days, the variegated plant is then exposed to sunlight for about two (2) hours.
b) The parts of the leaf that are not green are used as the control experiment.
c) At the end of the two hours, the leaf is removed and then tested for starch.

Observation:

The parts that were green are stained blue black with iodine solution while the yellow patches stained brown with iodine (brown is the colour of iodine).

Conclusion:

The green parts of leaf contained starch because they contained chlorophyll and thus turned blue black while the yellow patches (non-green parts) did not contain starch because they lacked chlorophyll. Chlorophyll is thus necessary for photosynthesis.

Gaseous exchange and compensation point

Both respiration and photosynthesis take place in a green plant. In darkness, Green plants do not photosynthesize, however they continue to respire. Here oxygen is used up (through respiration) and carbon dioxide is given off and there is an overall net consumption of sugars and glucose during respiration.

At low light intensity, some photosynthesis occurs and some carbon dioxide produced in respiration by plants is used up in photosynthesis. However, there is a net loss of Carbon dioxide. As the light intensity increases, the rate of photosynthesis also increases until a point is reached when all the Carbon dioxide produced during the process of respiration is reused in the process of photosynthesis. This point is called the **compensation point**.

The compensation point *is that point of light intensity at which the rate of Carbon dioxide produced by respiration is equal to the amount of Carbon dioxide consumed during photosynthesis.*

At the compensation point, the rate of photosynthesis is equal to the rate of respiration ie the rate at which food (glucose) is manufactured is equal to the rate at which it is used up in the process of respiration and this means that there is no net gain or loss in the mass of the plant.

MINERAL NUTRITION IN PLANTS

Pants need mineral elements for proper growth. Mineral elements are divided into two categories depending on the relative amounts of element needed.

i) **Essential elements:** These are elements needed in large quantities for proper plant growth, e.g. nitrogen, phosphorus, magnesium, potassium, calcium, sulphur, carbon, hydrogen, oxygen, etc.

ii) **Trace elements:** These are elements need in small quantities for proper plant growth they include manganese zinc boron silicon aluminum copper, molybdenum, and iron.

Plants obtain minerals from mineral salts present in the soil; Mineral salts are absorbed in form of soluble salts e.g. nitrogen as nitrate, phosphorus as phosphates, sulphur as sulphate. When a particular element is missing in the soil, a plant shows deficiency signs.