NUTRITION IN PLANTS

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NUTRITION IN PLANTS

- Nutrition refers to the ***process by which living organisms obtain, consume and use food substances to maintain their life processes*** (metabolic processes).
- These food substances are called ***nutrients***.
- These nutrients in green plants include; water, mineral salts, carbon dioxide and in animals include; carbohydrates, proteins, lipids, etc.

MODES OF NUTRITION

Nutrition is broadly classified into two groups namely;

- Heterotrophic nutrition (***nourishment on others***).
- Autotrophic nutrition (***self-nourishment).***

AUTOTROPHIC NUTRITION

- This is a mode of nutrition where by an organism is able to synthesize its own food from inorganic nutrients using some external source of energy. Such organisms are called **Autotrophs.**
- Since the nutrition of all other organisms depends either directly or indirectly on these Autotrophs, they are referred to as **producers.**
- Autotrophic nutrition can be divided into two depending on the external source of energy used to drive there processes;

Photosynthesis:

•This is the type of nutrition where organisms make food with the help of sunlight energy. Examples include; green plants, algae, photosynthetic bacteria.

Chemosynthesis:

•This is where organisms make their own food with the help of energy from specific chemical reactions (oxidation of various inorganic compounds). Examples include; chemosynthetic bacteria.

HETEROTROPHISM / HETEROTROPHIC NUTRITION

This is the mode of nutrition where by organisms obtain their food by feeding on already manufactured organic (food) compounds.

- Heterotrophs are **incapable of making their own food**.
- They include; **all animals**, **fungi**, **insectivorous plants** and **most bacteria**.

Heterotrophic nutrition is of 4 major types, which include:

- **Parasitism** (*one organism (parasite) obtains food and shelter from the other organism (host) which instead suffers injury and harm*)
- **Phagocytosis** (*unicellular organisms engulf solid food particles*)
- **Saprophytic nutrition** (*organism feeds on dead decaying matter*)
- **Holozoic nutrition**(*food nutrients are taken into the body and broken down into smaller soluble molecules*)

MAJOR PLANT NUTRIENTS AND THEIR DEFICIENCIES

- Plants make their own food (carbohydrates) through the process of photosynthesis.
- The main elements present in carbohydrates are carbon, hydrogen and oxygen. In addition to these three elements, plants

ELEMENTS	ABSORBED AS:	FUNCTION	DEFICIENCY
Nitrogen	Nitrates, NO^-_3, Ammonium ions NH^+_4	- Synthesis of proteins, Protoplasm and nuclear acids. - Consistent of chlorophyll and respiratory pigments.	- Stunted growth. - Yellowing of leaves (chlorosis)

Phosphorus	Phosphate, **PO_3^{-4}**	- Form part of the nuclear acid. - Necessary in nuclear division. - Acts as a buffer in the cell sap.	- Poor root growth. - Poor fruit development. - Stunted growth. - Premature leaf fall.
Calcium	Calcium ions **Ca^{2+}**	- Activates enzymes - Forms part of the cell wall.	- Poor root growth.
Magnesium	Magnesium ions Mg^{2+}	-Formation of chlorophyll of leaves.	- Yellowing of leaves or chlorosis.

Potassium	Potassium ions **K^+**	- Opening of the stomata. - It is an enzyme activator.	- Chlorosis of the margins and tips of leaves. - Stunted growth.
Sulphur	Sulphate ions **SO_2^{-4}**	- forms part of proteins. - it is a constituent of enzymes.	- cholorosis - weak and slender stems
Iron	Iron(II) (green) **-Fe^{2+}** Iron(III)-Fe^{3+} (brown)	- Formation of chlorophyll. - Activates enzymes	- Chlorosis.

Manganese	Manganese ions Mn^{2+}	- It is an activator of enzymes	- Chlorosis between veins
Chlorine	Chloride ions, **Cl^-**	- Activates enzymes.	-Chlorosis stunted root growth.
Copper	Copper ions, **Cu^{2+}**	- It is a constituent of enzymes	- Wilting of leaves
Zinc	Zinc ions, **Zn^{2+}**	- Activates enzymes. -It is important in the formation of growth hormones.	-Interveinal chlorosis. - Stunted growth

NUTRITION IN PLANTS

Nutrition in plants is by a process called photosynthesis. The process of photosynthesis is divided into two stages;

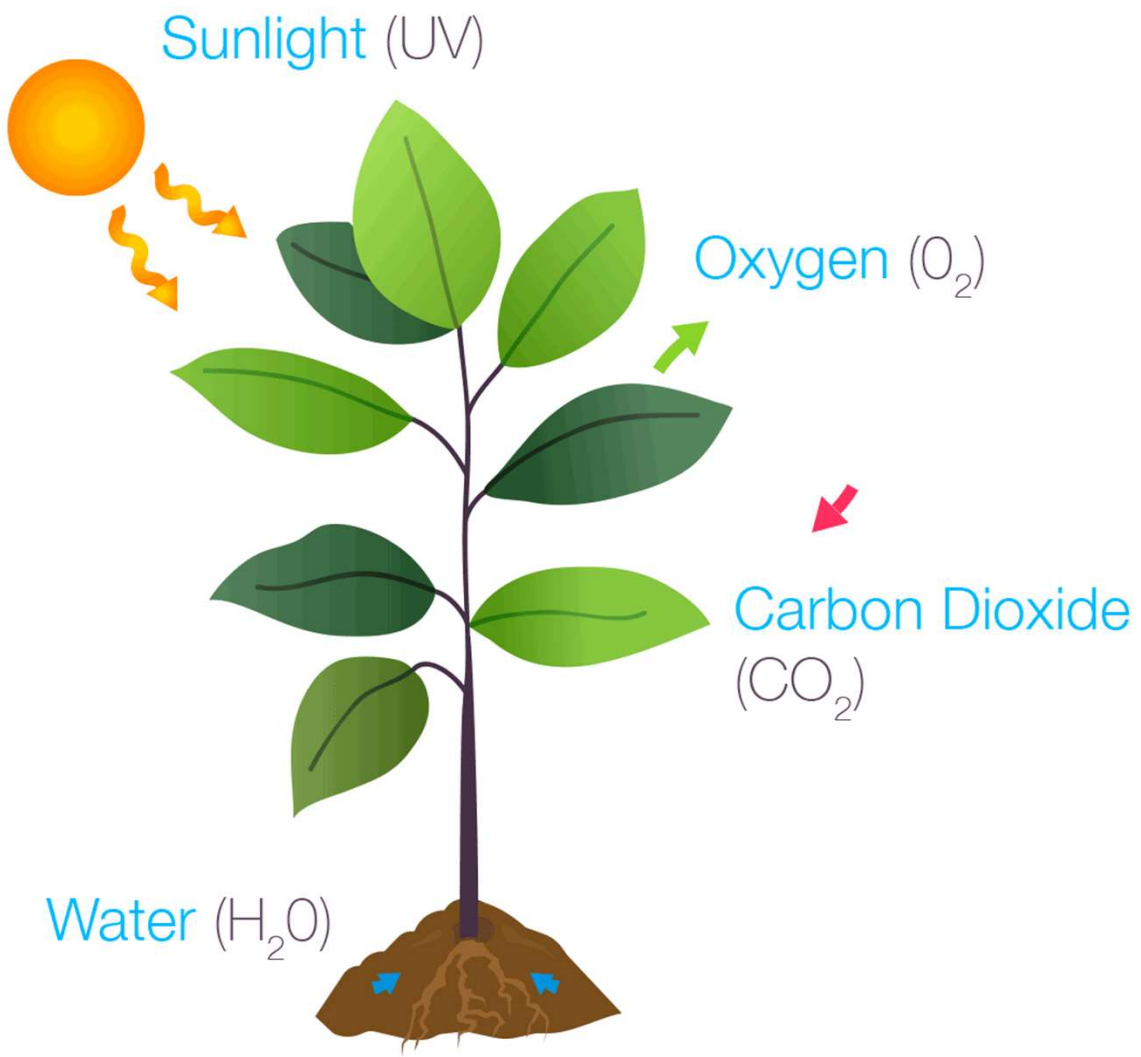
i) Light stage

ii) Dark stage

Photosynthesis is the process by which living plants manufacture their own food in form of carbohydrates (starch) from raw materials i.e. **carbon dioxide** and **water** using sunlight energy trapped by chlorophyll and give off oxygen as a bi-product.

Summary photosynthesis is a natural process that;

- requires two raw materials (carbon dioxide and water)
- requires two conditions (i.e. chlorophyll and sunlight energy)
- and forms two products namely (starch or carbohydrates & oxygen)


Sunlight (UV)
Oxygen (O_2)
Carbon Dioxide (CO_2)
Water (H_2O)

CONT.....

- 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.

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

$$6CO_2(g) + H_2O(l) \xrightarrow[\text{Sunlight energy}]{\text{chlorophyll}} C_6H_{12}O_6(s) + 6O_2(g)$$

soluble glucose which is then transported by the phloem to different parts of the plant body especially storage organs like the roots (in cassava and sweat potatoes) stems (in sugarcanes and Irish potato) or transported to actively metabolizing parts of the plants e.g. the growing regions, and the respiring parts.

•On reaching these storage organs, the soluble glucose is then reconverted back to insoluble starch for storage.

•

CONDITIONS NECESSARY FOR PHOTOSYNTHESIS TO TAKE PLACE

- **Chlorophyll**

Chlorophyll is a green pigment that absorbs light energy from the sun.

- **Carbon dioxide**

It is absorbed from plants through their stomata. For aquatic plants like algae, they absorb it as hydrogen carbonates which diffuse directly from the water in plant tissues. The use of carbon dioxide is to combine with hydrogen atoms to form carbohydrates.

- **Light**

This is the source of energy necessary for the process of photosynthesis to take place. The rate of photosynthesis increases in light intensity and has the following purposes

Used to split water molecules into hydrogen atoms and oxygen. The oxygen is given off by the photosynthesizing plants. The hydrogen atoms combine with CO2 to form carbohydrates.

The process by which light energy splits water into H+ and oxygen is called **photolysis** of water.

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**C) rise in temperature up to about **40C** where the rate of photosynthesis drops drastically because the enzymes are denatured

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.

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.

External adaptations Leaves for photosynthesis

broad and flat

This provides a large surface area for trapping sunlight and taking in of Carbon dioxide.

- **Numerous leaves**

This helps to increase the total surface area exposed to the sun thus increasing the rate of photosynthesis.

- **Thinness**

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

- **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. .

INTERNAL ADAPTATION OF A LEAF

Palisade mesophyll layer

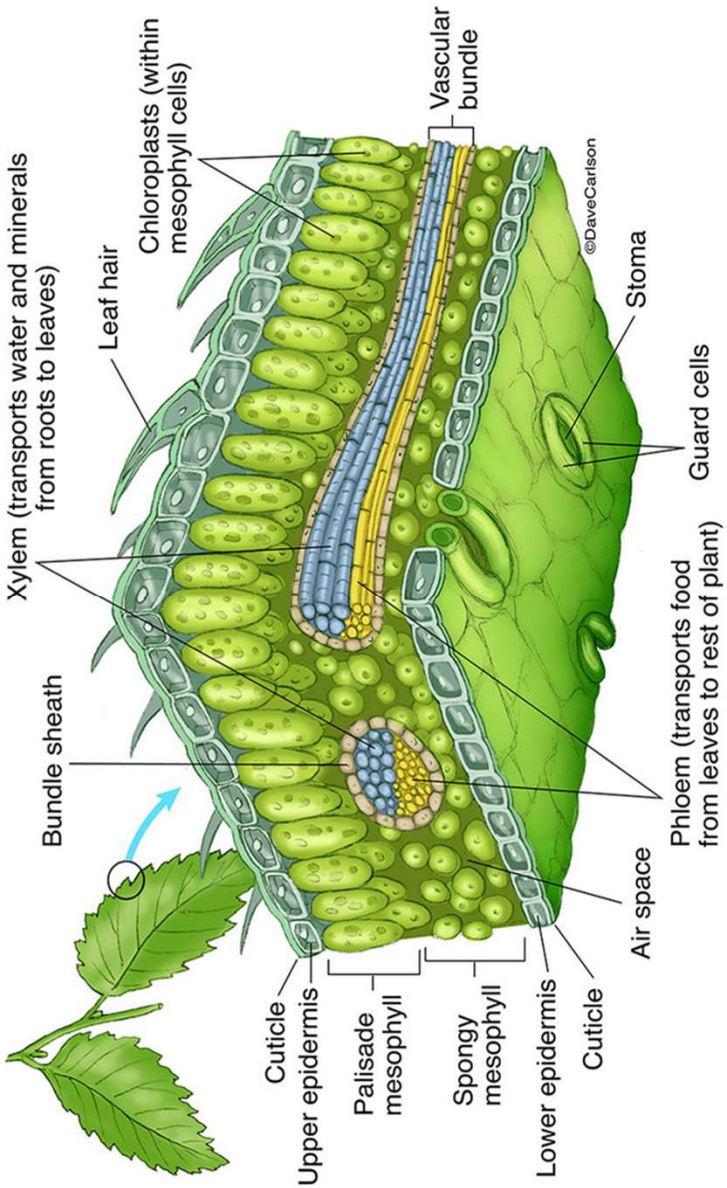
•The layer **contains numerous chloroplasts** especially the palisade providing a large surface area for photosynthesis

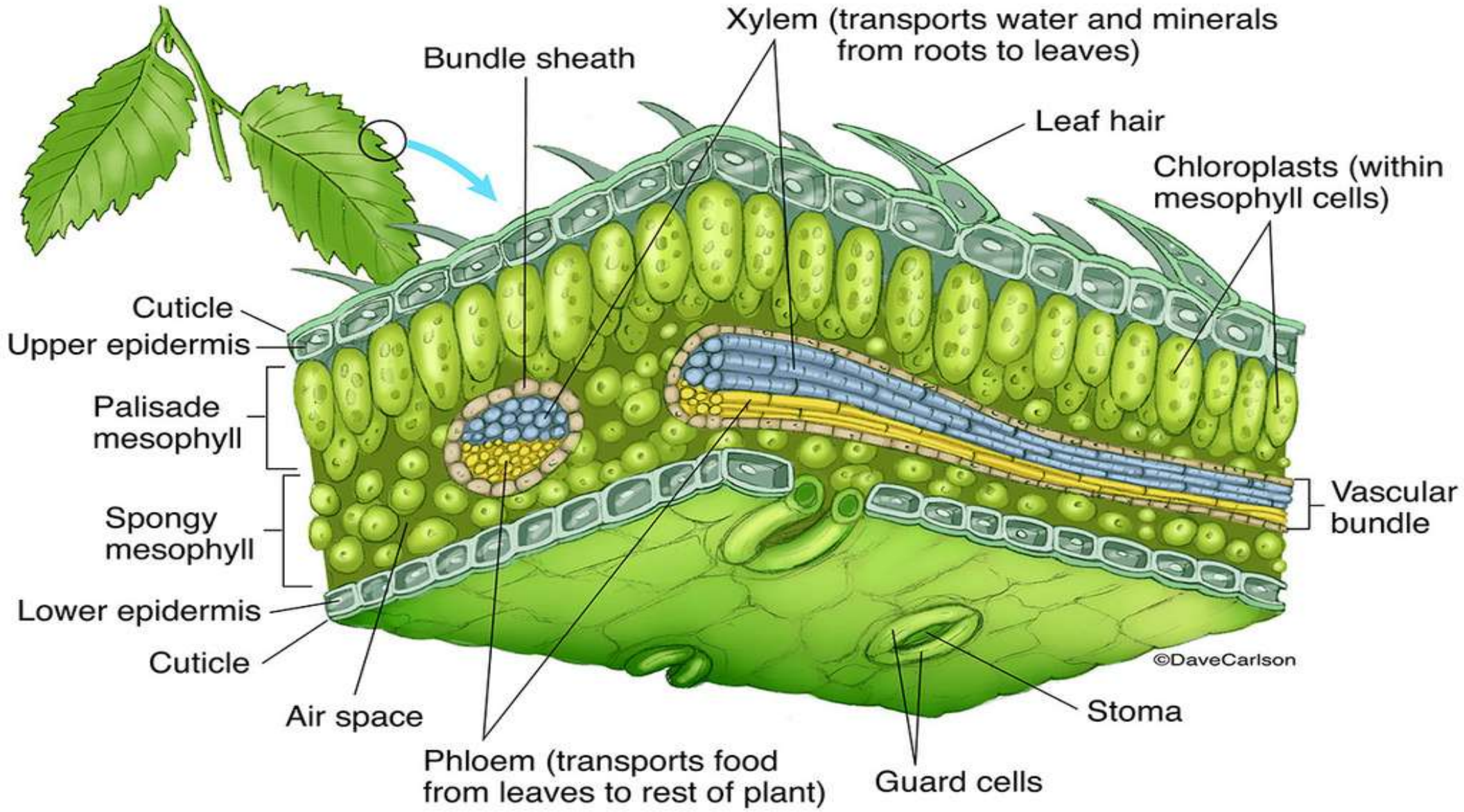
The spongy mesophyll layer

•This layer has mainly **air spaces** thus allowing many gases to easily diffuse into all the photosynthesizing cells.

Network of veins (vascular tissues)

•The vascular tissues include the xylem and phloem where by xylem transports water and mineral salts up to the stem while the phloem transports food (starch) up to the stem.




Xylem (transports water and minerals from roots to leaves)
Bundle sheath
Leaf hair
Chloroplasts (within mesophyll cells)
Cuticle
Upper epidermis
Palisade mesophyll
Spongy mesophyll
Lower epidermis
Cuticle
Air space
Phloem (transports food from leaves to rest of plant)
Guard cells
Stoma
Vascular bundle
©DaveCarlson

CONT……

- **Presence of stoma:**

This 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.

- **The cuticle**

This is a water tight layer and so it helps to prevent desiccation (water loss) by the photosynthesizing tissues.

- **Numerous chloroplasts**

These ensure that enough sunlight is trapped by the chlorophyll.

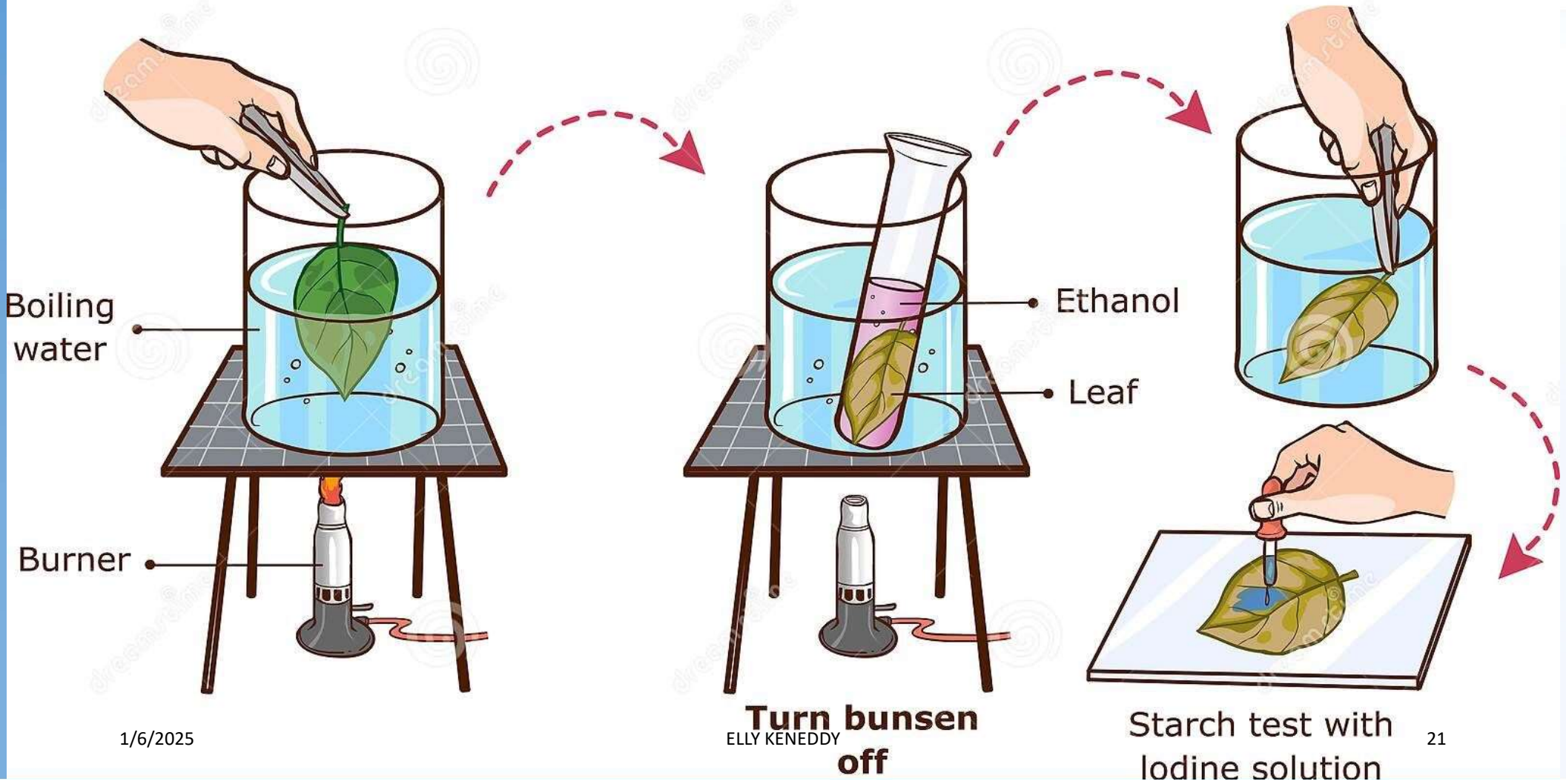
AN EXPERIMENT TO TEST LEAF FOR STARCH

Aim: To prove that photosynthesis takes place in the leaf of a plant.

Apparatus

- A green leaf.
- Water bath,
- Iodine solution,
- Water
- Absolute alcohol (99%)
- Beaker,
- White surface or tile
- Heat source, **etc**.

Testing a leaf for starch



PROCEDURE:

- Remove a leaf from a health plant which has been receiving sunlight and place it in boiling water (water bath) for about 5 minutes. **This softens the leaf cell wall protoplasm and makes it permeable to Iodine.**
- Place the leaf in a beaker containing 99% alcohol and boil 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.
- The leaf is then washed in hot water which softens it.
- The leaf is now spread on a white surface tile and drops of iodine added on it.

Observation

- The leaf turns blue black showing that starch is present.

Conclusion

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

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

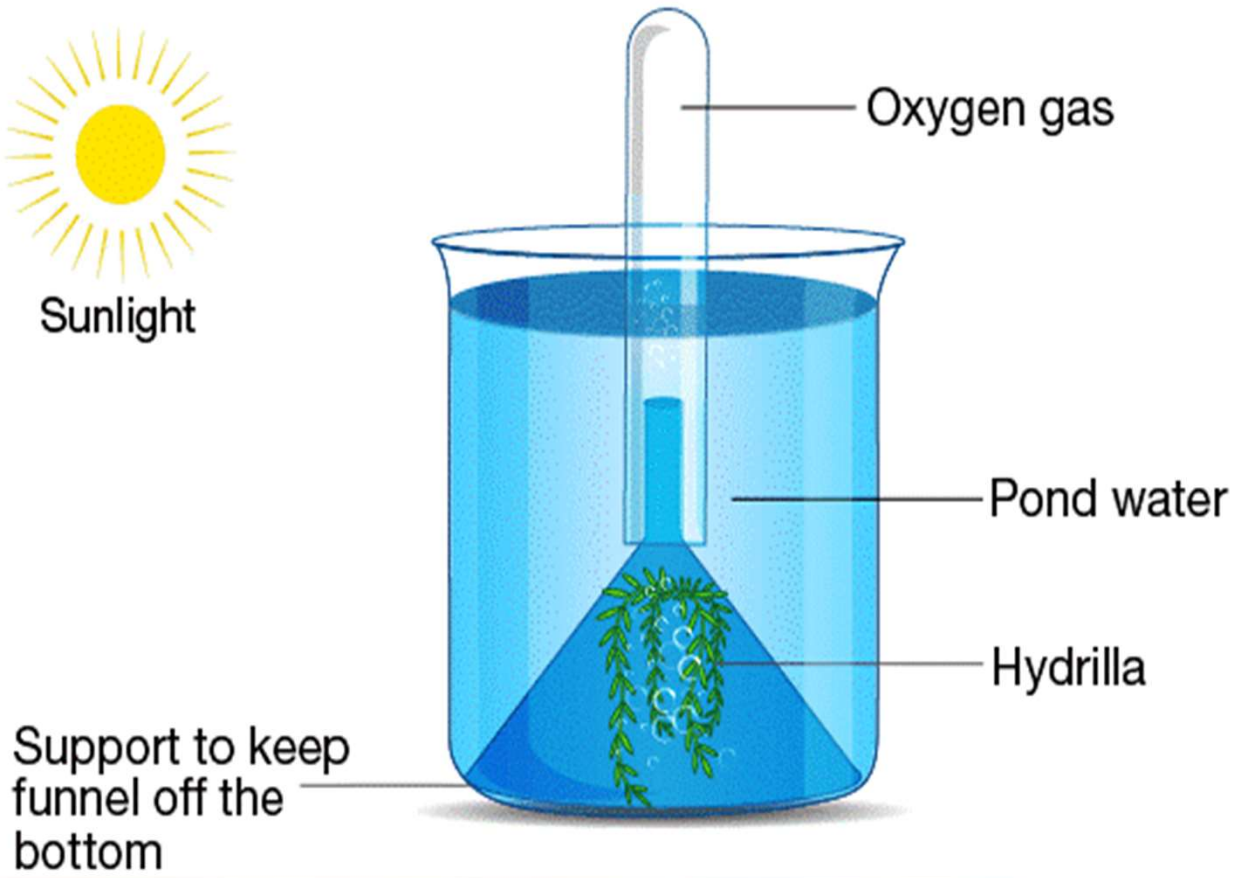
AN EXPERIEMENT TO SHOW THAT OXYGEN IS GIVEN OFF DURING PHOTOSYNTHESIS

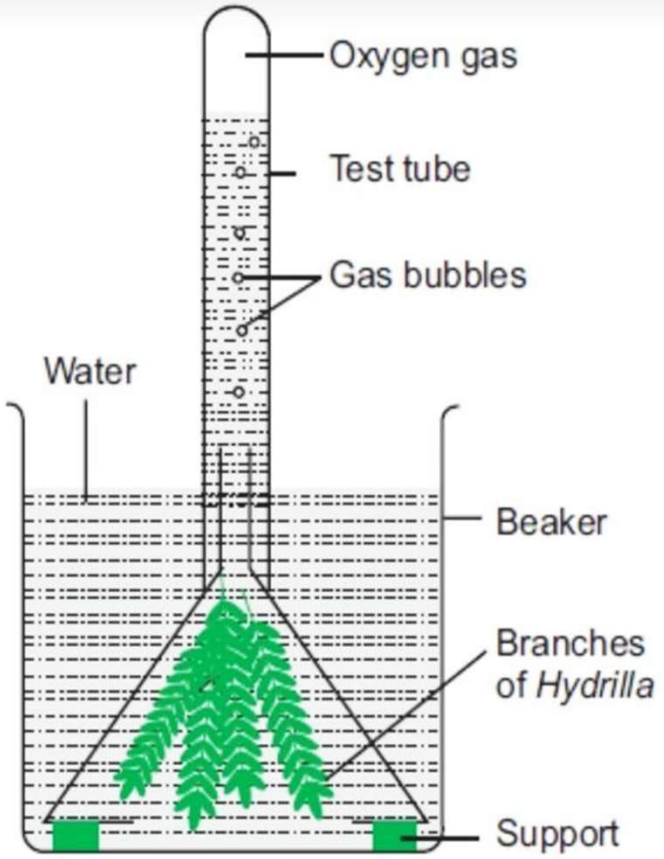
Aim: To show that oxygen is given off during photosynthesis

Apparatus

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

SETUP


Sunlight
Oxygen gas
Pond water
Hydrilla
Support to keep funnel off the bottom


Oxygen gas
Test tube
Gas bubbles
Water
Beaker
Branches of Hydrilla
Support

Procedure

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

RESULTS

Observation:

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

Conclusion:

The gas collected relights the glowing split proving that it is oxygen.

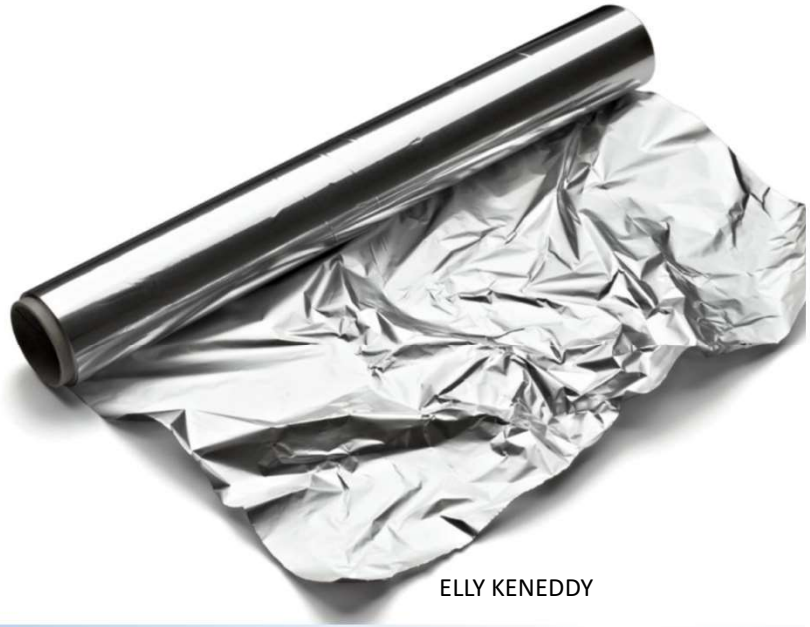
The evolution of oxygen by the water plant in the presence of sunlight is an indication that photosynthesis is taking place.

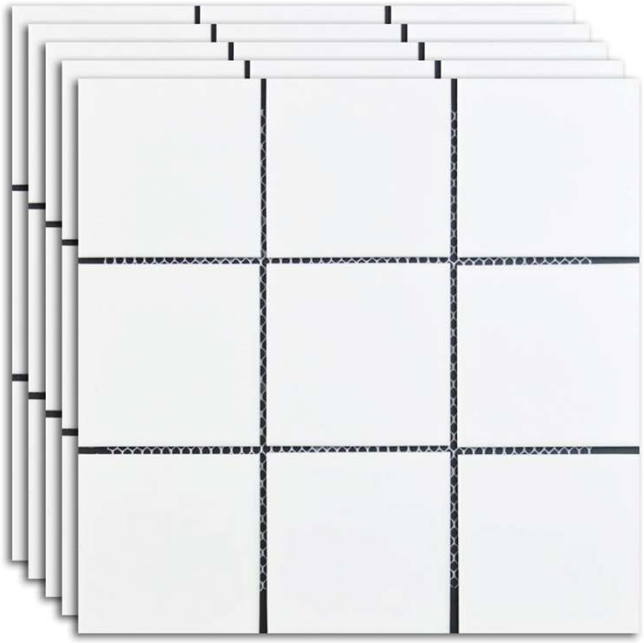
NOTE: This experiment can also be carried out **to estimate the rate of photosynthesis** (speed) **by counting the number of bubbles produced per unit time**

AN EXPERIMENT TO SHOW THAT LIGHT IS NECESSARY FOR PHOTOSYNTHESIS

Apparatus/materials

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

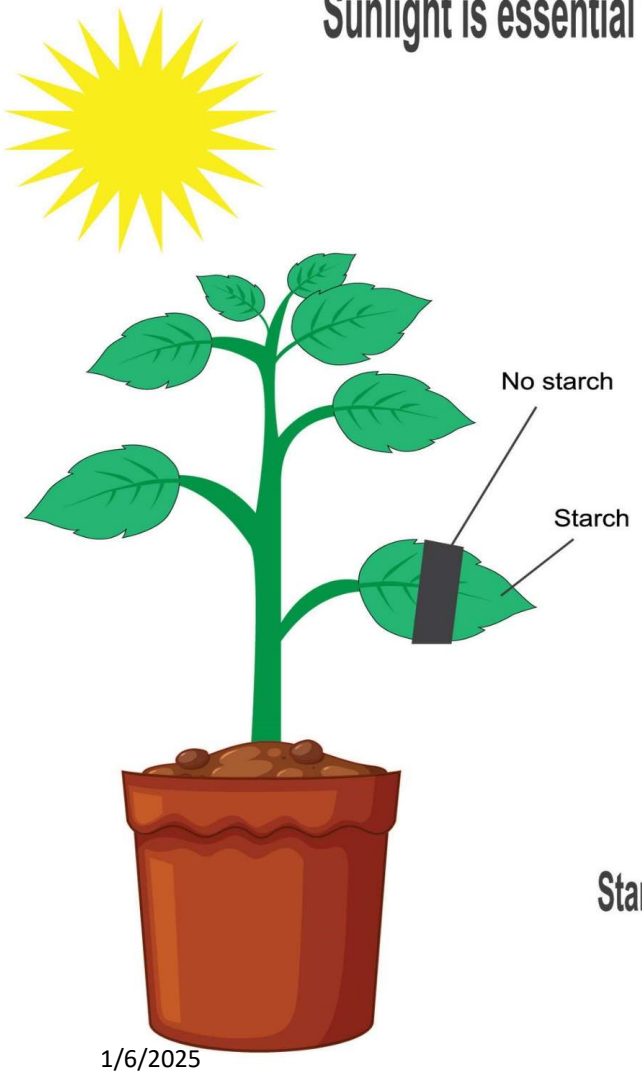


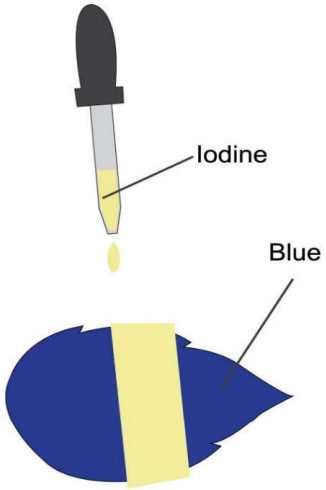


Procedure

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

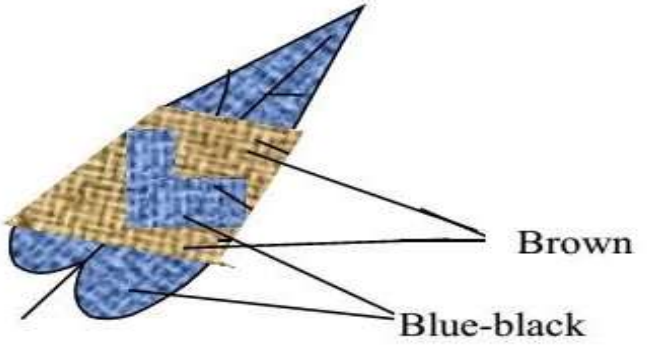
Sunlight is essential for Photosynthesis

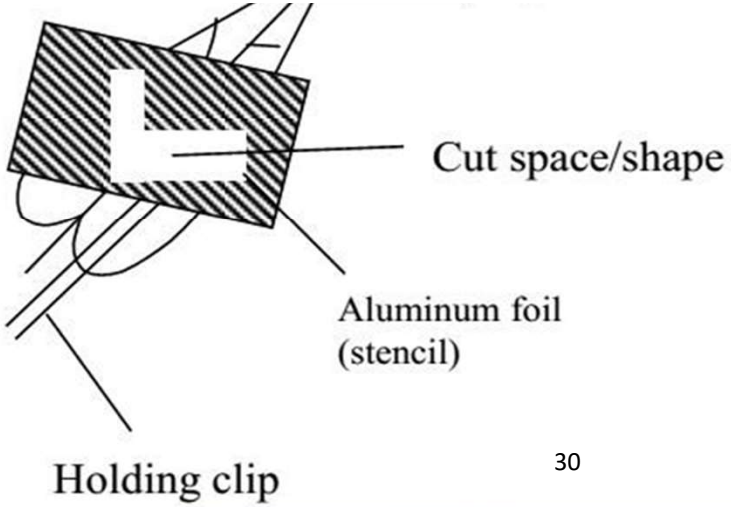




Starch + Iodine → Blue

After testing for starch



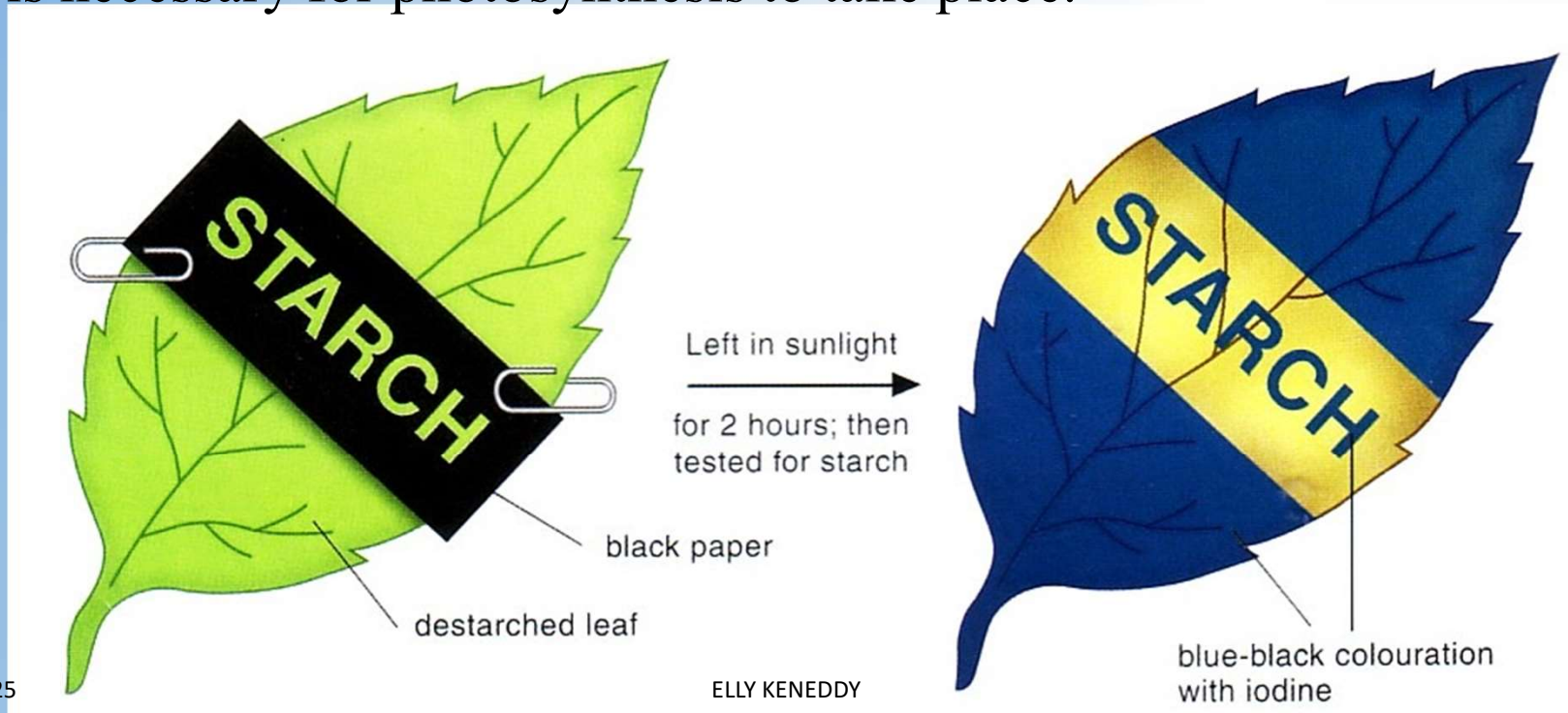


Observation:

•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 PHOTOSYNTHESIS

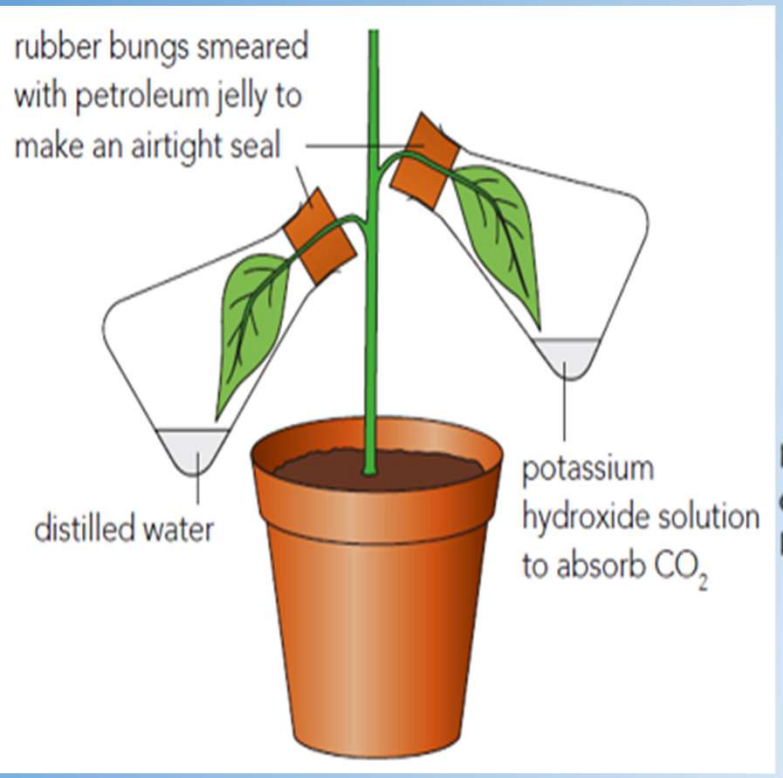
Apparatus

- Sodium hydroxide (NaOH) / Potassium Hydroxide (KOH),
- Conical flasks fitted with corks with a hole
- well-watered de-starched plants
- Iodine,
- (99% alcohol)
- Water
- Beaker.
- white tile
- Test tubes.

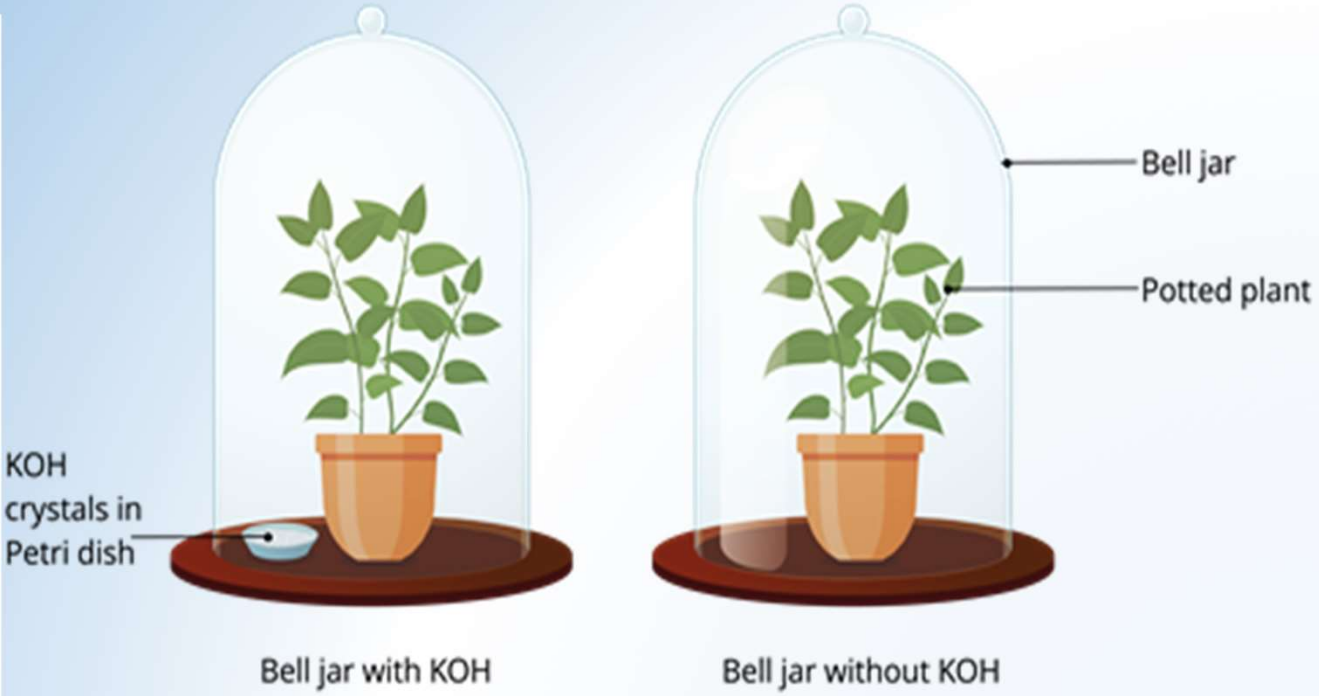
Procedure

- De-starch a well-watered potted plant by keeping it in a dark place for at least 24hours.
- Using a cork, enclose one leaf in a conical flask containing soda lime, label it A.
- Enclose another leaf in another conical flask but with sodium bicarbonate, and label it B.
- In both cases apply Vaseline at the neck of the flask to avoid passage of air to the flasks.
- A control experiment is also, however here the flask contains water which does not absorb Carbon dioxide.
- Place the plant and the flasks in sunlight for **6** hours.
- Remove the enclosed leaves from the plant and test for starch using Iodine solution.

SET UP



ALTERNATIVE EXPERIMENT.



RESULTS

RESULTS

Observation:

•The leaf in the flask **containing Sodium Hydroxide** solution **remains brown** (the colour of Iodine persisted) when tested for starch **while** that with 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,
- white tile
- Iodine
- test tube
- Plant with variegated leaves
- Tripod stand
- wire gauze
- Bunsen burner

PROCEDURE

- De-starch (removing starch) the leaf by placing a plant in a dark cupboard for two days.
- Expose the plant with variegated leaves to sunlight for about two (2) hours.
- At the end of the two hours, the leaf is remove and then test for starch.

Note ; 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.

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

Factors that affect the rate of photosynthesis

- The rate of photosynthesis can be determined by considering **how much oxygen is evolved** by the plant or **increase in the weight of the plant** due to **accumulation of starch**. Some of the factors include the following:

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

Amount of CO2 in the atmosphere

- It is required as a raw material for photosynthesis thus the rate of photosynthesis increases in CO2 concentration and it decreases with the lowering of CO2 concentration.

➢Light intensity

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

➢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.

➢Number of stomata

The more the stomata, the more the gaseous exchange. This avails more CO2 to the plant leading to high rate of photosynthesis.

➢Surface area for photosynthesis

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

ALWAYS AIM FOR EXCELLENCE

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