Lectures in

Plant physiology

For the 1st year students

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Solutions

It is a common observation that when a little sugar or salt is dissolved in water, a homogeneous and stable mixture of the two components is obtained which is called as solution. Of these two components, the one (here sugar or the salt) which is present in small quantity is called as solute while the other (here water) present in larger quantity is called as solvent.

The solution is homogeneous because the molecules or the ions of the solute become evenly distributed throughout the solvent. It is a stable system because the molecules or the ions do not settle down. Sometimes more than one solutes may be dissolved in a solvent to form a stable and homogeneous mixture.

Types of solutions

True solution:

A true solution may be defined as a homogeneous and stable mixture of two or more chemical substances. In a true solution the particles are not visible. The size of particles less than 0.001 μm .

Suspensions and Emulsion:

If some fine sand is mixed with water in a beaker, the sand particles become dispersed in water. They do not break into molecules or ions but after a very short period settle down leaving almost a clear water above. Such an unstable system of a solid and liquid is called as suspension. Due to their large size, the suspended particles are visible under microscope and can be seen even with naked eyes. While emulsions is formed when two immiscible liquids are vigorously shaken together an unstable emulsion is formed.

The size of particles ranges more than 0.1 µm.

Colloidal solution:

If in place of sand, a little fine clay is mixed with water, the clay particles remain dispersed in it. They neither break into molecules or ions nor they settle down even after long period of time. Such a heterogeneous and stable system is called as colloidal system.

In the above colloidal system the clay particles form a dispersed phase while the water forms dispersion medium.

The sizes of the dispersed particles as well as the properties of the system are midway between the suspension and the true solutions. The size of particles ranges from 0.001 µm to 0.1 µm in diameter and they remain dispersed throughout water in a stable manner, forming a two-phase system.

The colloidal particles are not visible under microscope but can be observed under an ultra-microscope.

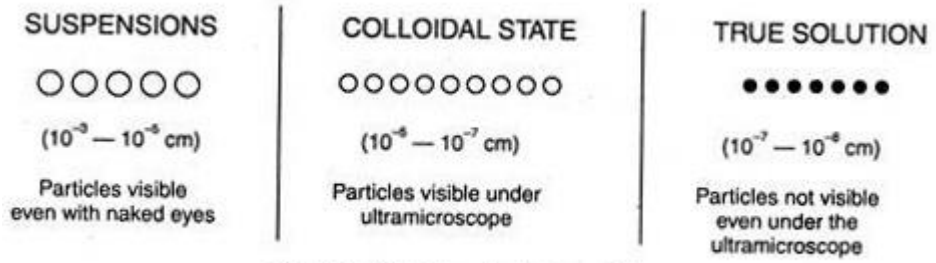


Fig. 2.2. Diameter of solute particles.

Types of colloidal solutions may be of two types:

(i) Lyophilic Colloidal solutions

(ii) Lyophobic Colloidal solutions

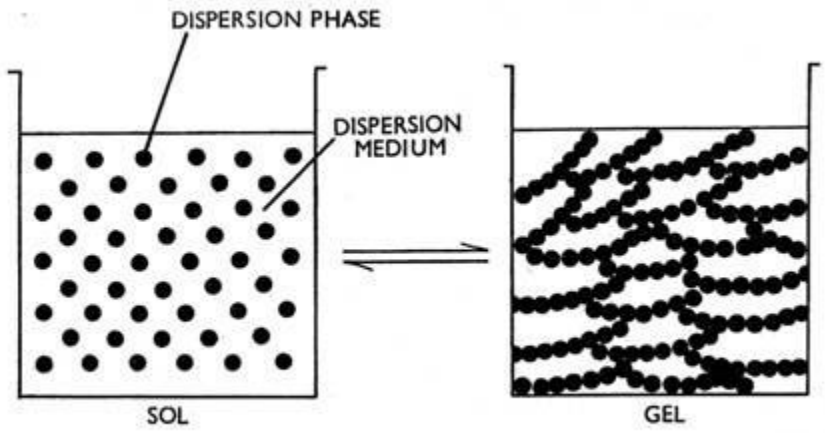


Fig. 2.3. Sol-gel forms of a colloidal solution.

Colloidal Nature of Protoplasm:

Although a large number of chemical substances are found in the protoplasm with water constituting the major portion, the protoplasm is not a true solution. Most of the particulate phase of the protoplasm is colloidal in nature. Again, it is not a simple colloidal system but is considered as complex colloidal system of many phases and shows many properties of the colloidal systems. The colloidal nature of the protoplasm is chiefly due to the presence of protein molecules. In fact, these macro-molecules of proteins constitute next major category of chemical substances after water in protoplasm. Moreover, all the enzymes are essentially proteins which provide large surfaces due to their large and often colloidal system to catalyse most of the biochemical reactions in the protoplasm, so important for life to exist.

Properties of Colloidal system:

(1) Tyndall Effect:

If a strong beam of light is passed through a colloidal suspension and observed at right angles through an ultra-microscope, its path is easily observed.

This is due to the scattering of light by minute particles which appear as bright spots. The size and form of the particles cannot be seen. This phenomenon is known as the Tyndall effect.

(2) Brownian Movement:

The colloidal particles show Brownian movement first described by Scottish botanist Robert Brown in 1827.

This is an erratic and continuous movement caused by unequal bombardment of the colloidal particles by molecules of the dispersion medium.

(3) Adsorption:

Molecules or ions tend to adhere to the interface of colloidal systems, and the process is called adsorption.

It is a surface phenomenon and the capacity for adsorption, therefore, is determined by the amount of surface exposed and also the chemical nature of the constituents in question. The process of sub- division of substances increases its surface area.

Therefore, the adsorptive capacity of a colloidal system is very high for a given weight of colloidal particles.

Most of the important functions of colloidal system found in the living cell are dependent upon their immense adsorptive capacity.

This enables the protoplasm to carry on a large number of complex chemical reactions at ordinary temperature which otherwise would need high temperatures in the laboratory.

(4) Electrical Properties:

Colloidal particles carry electric charge which may be positive or negative. For any one colloidal system the charge is the same on all the particles.

The charges are due to the adsorption of free ions in the dispersion medium. The preferential adsorption of positive ions by a colloidal particle will give it a positive charge and the reverse is true of negatively charged colloidal particles.

In case the dispersed phase has a positive charge, all the particles of a colloidal system will collect at the cathode and in case of negatively charged, they will collect at the anode. This phenomenon is called electrophoresis.

The similarity in the charge of the particles of a suspension is responsible for the stability of the colloidal suspensions.

The fact that units of like charge repel each other, prevent their aggregation and precipitation out of suspension.

(5) Flocculation:

Destruction of the electric double layer enforces the dispersed particles of a colloidal suspension to collide, aggregate and precipitate out of suspension.

This is caused by the addition of the certain amount of electrolyte. This practice of flocculation by adding electrolytes is called salting out.

Valency of an ion is very significant in determining the extent to which precipitation is caused by it when added to a colloidal system.

For instance, the monovalent sodium ion is far less effective than the divalent barium ion or the trivalent aluminium ion.

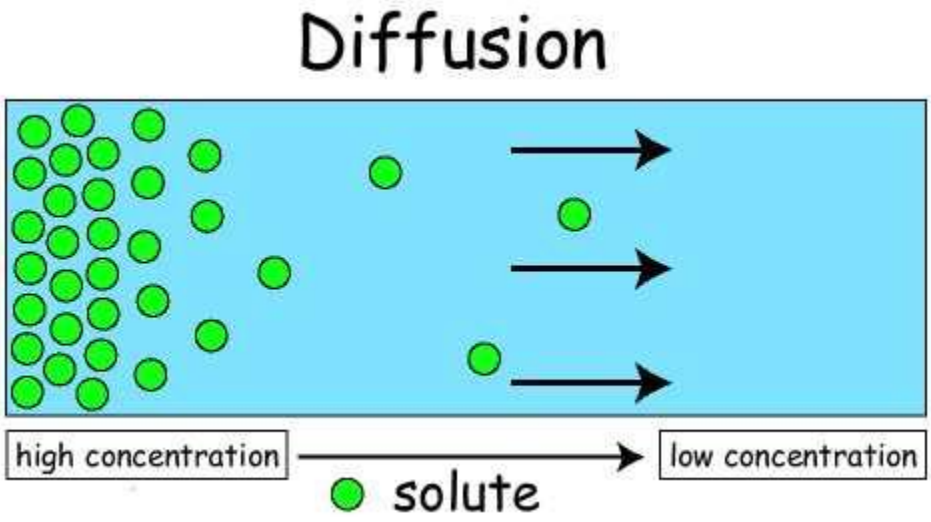
(6) Viscosity:

The viscosity of a colloidal solution is more than that of water. The collodial solution of albumin diffuses at a rate of about 1/7000 to that of sucrose solution.

Diffusion

Diffusion is a very important process for photosynthesis where carbon dioxide from the stomata diffuses into the leaves and finally into the cells. Also, during transpiration, the water and oxygen diffuse from the leaves into the environment.

It includes the movement of particles of a medium from the region of its higher concentration to the region of its lower concentration without the expenditure of energy. This process is slow and occurs mostly in gases and liquids. The rate of diffusion is affected by various factors like temperature and pressure, concentration gradient, separating membrane's permeability etc.



Factors affecting Diffusion in Plants

Temperature

The rate of diffusion is directly proportional to the increase in temperature.

Density

The rate of diffusion is inversely proportional to the density of the diffused particles.

Imbibition

It is a special type of diffusion in which water is absorbed by solid particles (or colloids) of an object resulting in an increase in volume. For example, when dry wood is soaked in water.

Water surface potential movement takes place along a concentration gradient; some dry materials absorb water. A gradient between the absorbent and the liquid is essential for imbibition.

Examples include the absorption of water by seeds and dry wood. If there is no pressure due to imbibition, seedlings would not be able to emerge from soil.

Osmosis

Osmosis is when a substance crosses a semi-permeable membrane in order to balance the concentrations of another substance. In biology, this is usually when water move high concentrated medium to lower concentrated one through semi-permeable membrane. Osmosis happens spontaneously and without any energy on the part of the cell.

Types of Solutions

In biology, there are three different types of solutions that cells can be in: isotonic, hypotonic, and hypertonic. Different types of solutions have different impacts on cells due to osmosis.

Isotonic

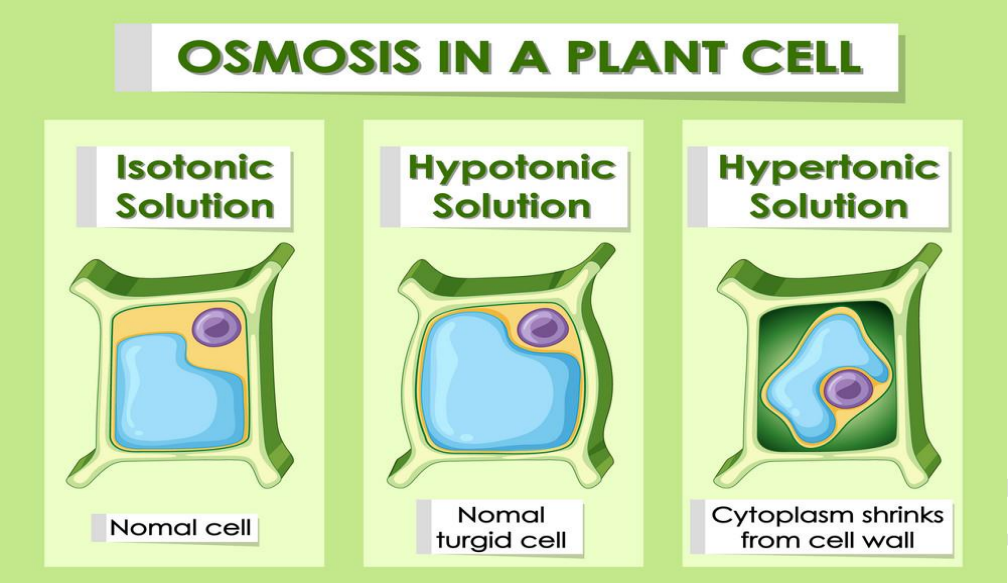
An isotonic solution has the same concentration of solutes both inside and outside the cell. Under these conditions, there is no net movement of solvent; in this case, the amount of water entering and exiting the cell's membrane is equal.

Hypotonic

In a hypotonic solution, there is a higher concentration of solutes inside the cell than outside the cell. When this occurs, more solvent will enter the cell than leave it to balance out the concentration of solute.

Hypertonic

A hypertonic solution is the opposite of a hypotonic solution; there is more solute outside the cell than inside it. In this type of solution, more solvent will exit the cell than enter it in order to lower the concentration of solute outside the cell.



The role of osmosis in plants

1. It helps the root system of the plants to absorb water and minerals from the soil
2. Helps maintain the turgidity (shape) of the plant cell
3. It play a key role in the movement of water and other substances from one cell to another
4. Enables the plants to overcome severe conditions such as drought and frost.
5. It helps maintain turgor pressure which control the opening and closing of stomata

A plant cell has a cell membrane and cell wall as its boundary. The cell wall is freely permeable to water, hence it is not barrier to movement.

(ii) In plant cells, the cells usually contains a large central vacuole, whose contents, the vacuolar sap, contribute to the solute potential of the cell.

(iii) The cell membrane (Ectoplast) and the membrane of the vacuole, the (Tonoplast), together are important determinants of movement of molecules into the cell

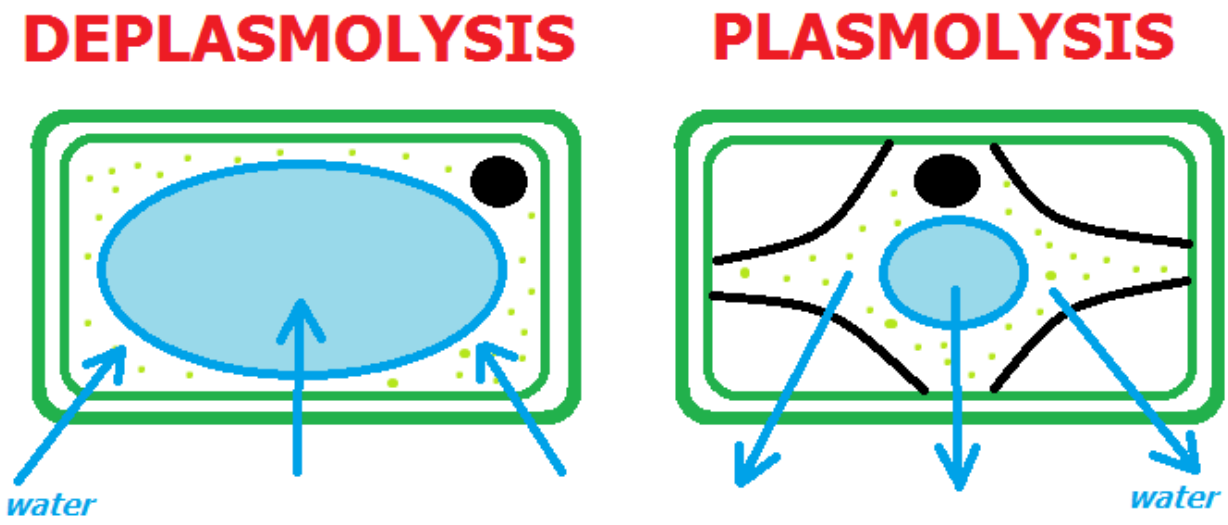
- A cell is an osmotic system. The net movement of the cell sap depends on the type of solution present in the surrounding.

If the osmotic concentration of the solution is less than that of the cell sap, the solution is called a hypotonic solution. This causes swelling of the cell takes place.

If the osmotic concentration of the solution is more than that of the cell sap, the solution is called hypertonic solution, this causes the cell shrinks.

If the osmotic concentration of both the solution as well as the cell sap is same, no net movement takes place. No net change occurs in the cell.

Plasmolysis is the process in which cells lose water in a hypertonic solution. The reverse process, **deplasmolysis**, can occur if the cell is in a hypotonic solution resulting in a lower external osmotic pressure and a net flow of water into the cell.



Loosing of water from the plant

TRANSPIRATION

Although large quantities of water are absorbed by plant from the soil but only a small amount of it is utilized. The excess of water is lost from the aerial parts of plants in the form of water vapours. This is called as transpiration.

Transpiration is of three types:

1. Stomatal transpiration: Most of the transpiration takes place through stomata.

2. Cuticular transpiration: Cuticle is impervious to water, even though, some water may be lost through it.

3. Lenticular transpiration: some water may be lost by woody stems through lenticells which is called as lenticular transpiration.

Guttation

The phenomenon of guttation is associated with the presence of special types of stomata at the margins of the leaves which are called as water stomata or hydathodes. Each hydathode consists of a water pore which remains permanently open.

Bleeding

Bleeding is the exudation of sap from the injured parts of a plant. The root pressure generated by a plant forces the cell sap to rise through the stem. This causes bleeding of the cell sap from the cut surface of the plant.

ENZYMES

An enzyme is a protein that functions as a catalyst to speed up a biochemical reactions.

CHARACTERISTICS of Enzymes

1. Enzymes do not make anything happen that couldn't happen on its own, just makes it happen faster.

2. Enzymes are not used up in reactions. They can be used over and over again!

3. Enzymes are only needed in small amounts.

4. Each enzyme is highly selective about its substrate.

5. Enzymes chemically recognize, bind and modify substrates.

Enzyme Nomenclature

There are many methods for naming enzymes:

1- according to the name of substrate by adding the suffix –ase to the end of the substrate for example sucrose sucrase

2- according to the type of the reaction which the enzyme catalyse and adding also, the suffix – ase to the end of the reaction for example carboxylation carboxylase

3- According to Enzyme Commission

Enzyme Code (EC): Each enzyme has a numerical code which is formed of four digits separated by dots:

- The first digit denotes the class (reaction type) of the enzyme.
- The second digit denotes the functional group upon which the enzyme acts.

 The third digit denotes the coenzyme.

 The fourth digit denotes the substrate.

For example :

1.1.1.1 enzyme, 1 means oxidoreductase,

1.1 means that the functional group is hydroxyl group (-OH),

1.1.1 means NAD is the coenzyme and

1.1.1.1 means alcohol.

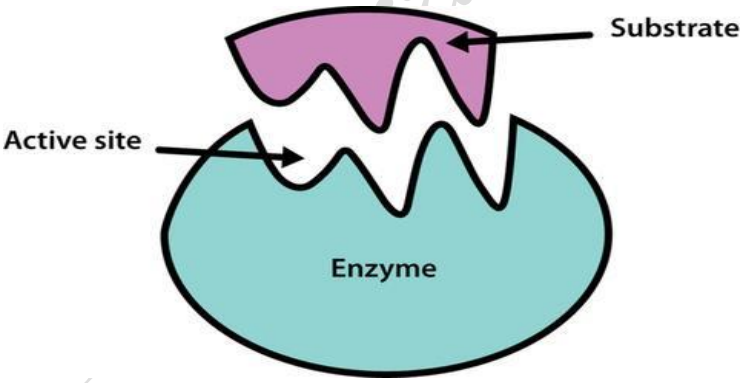
So, 1.1.1.1 means alcohol dehydrogenase enzyme

Chemical Nature of Enzymes

Protein enzymes are classified into 2 types:

1- Simple Protein enzymes: They are formed of protein only.

2- Complex (conjugated) Protein : They are formed of protein part and non protein part.



Complex (conjugated) Protein :

enzymes formed of two parts:

1) Protein part: called apoenzyme

2) Non- protein: called cofactor or co-enzyme

• The whole enzyme is called holoenzyme

Prosthetic group

• **Coenzyme:** Is organic, loosely attached to enzyme.

• They are mainly vitamin B derivatives e.g. FAD, NAD.

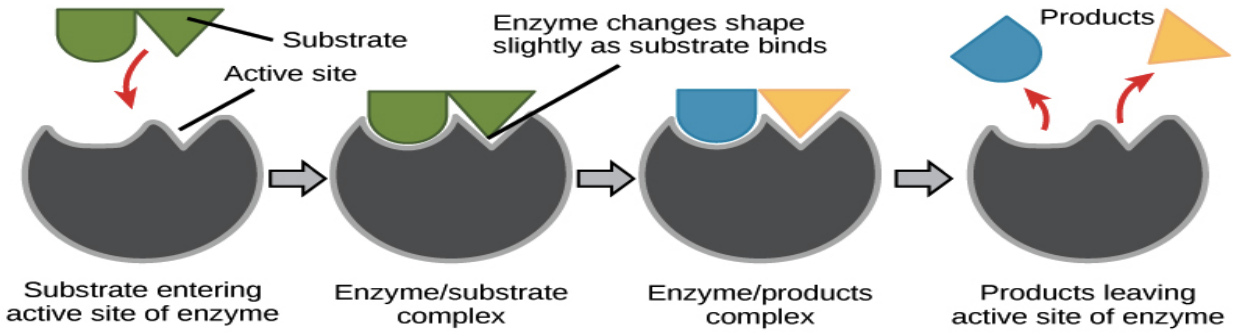
Activatores: Is inorganic, firmly attached to enzyme.

• They are usually metal ions e.g. Ca^{++}, Zn^{++}.

ENZYME ACTION

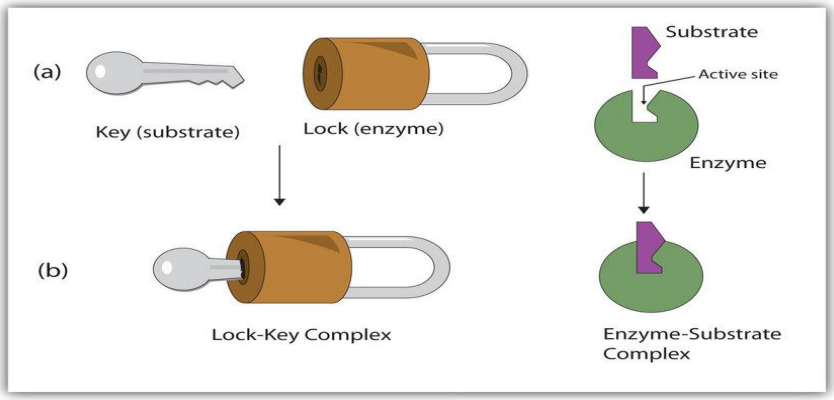
1- The substrate (S) binds to the enzyme (E) at its active catalytic site to form activated intermediate enzyme substrate complex (ES).

2- The activated complex (ES) cleaved to the products (P) and the original enzyme (E)



Lock and Key model –

the substrate molecule has a specific 3-dimensional shape that allows it to fit into the specific 3-dimensional shape of an enzyme's active site. Both enzyme and substrate already exist in these specific 3-dimensional shapes.



Enzymes Classification

Oxidoreductases

These catalyze oxidation and reduction reactions, e.g. pyruvate dehydrogenase, catalysing the oxidation of pyruvate to acetyl coenzyme A.

Transferases

These catalyze transferring of the chemical group from one to another compound. An example is a transaminase, which transfers an amino group from one molecule to another.

Hydrolases

They catalyze the hydrolysis of a bond. For example, the enzyme pepsin hydrolyzes peptide bonds in proteins.

Lyases

These catalyze the breakage of bonds without addition of water, e.g. aldolase (an enzyme in glycolysis) catalyzes the splitting of fructose-1, 6-bisphosphate to glyceraldehyde-3-phosphate and dihydroxyacetone phosphate.

Isomerases

They catalyze the formation of an isomer of a compound. Example: phosphoglucomutase catalyzes the conversion of glucose-1-phosphate to glucose-6-phosphate (phosphate group is transferred from one to another position in the same compound) in glycogenolysis (glycogen is converted to glucose for energy to be released quickly).

Ligases

Ligases catalyze the association of two molecules. For example, DNA ligase catalyzes the joining of two fragments of DNA by forming a phosphodiester bond.

Factors affecting on the rate of enzyme activity

1- Substrate concentration

2- Enzyme concentration

3- Temperature

4- PH

5- Inhibitors

Inhibitors

An enzyme inhibitor is a molecule that binds to an enzyme and decreases its activity.

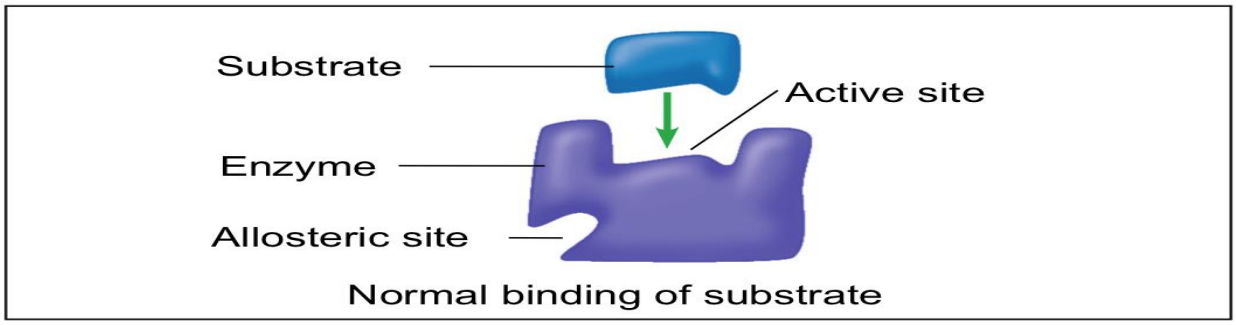
There are two types of inhibitors:

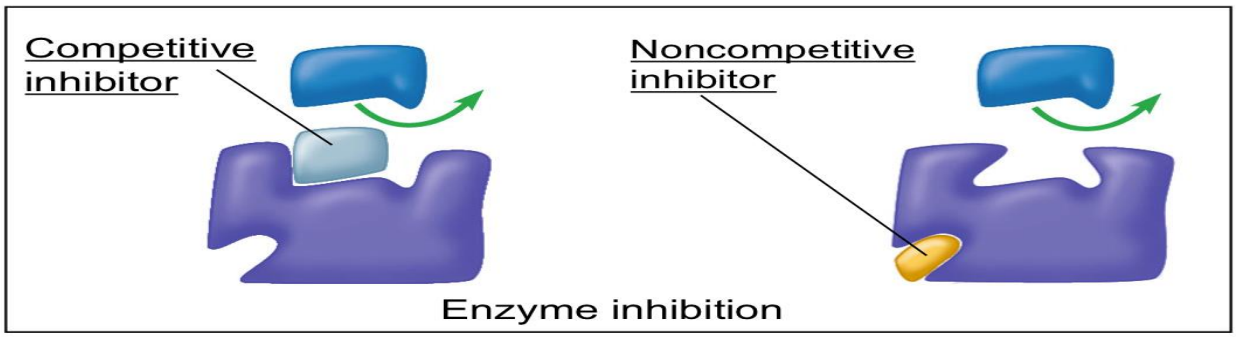
Competitive inhibitor:

the inhibitor and substrate compete for the enzyme (i.e., they can not bind at the same time). It can be overcome by increasing the concentration of substrate in the medium.

Non-competitive inhibitors

in contrast to competitive inhibitors, noncompetitive inhibitors do not compete with the substrate for the active sites. The inhibitor reacts with other parts of enzyme not involved in catalytic activity or with enzyme –substrate complex. It can not be overcome by addition of more substrate.





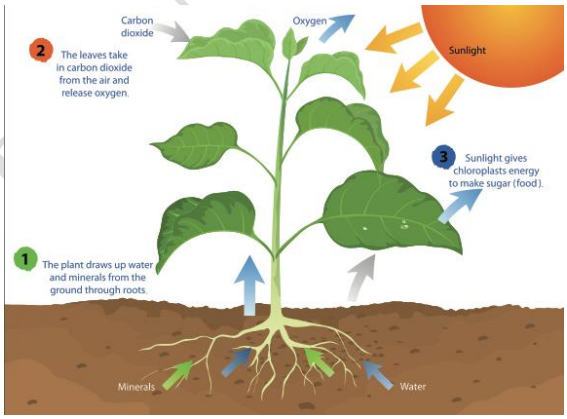
Metabolism

Plant metabolism is divided in to Anabolism and Catabolism.

- Anabolism is the total series of biochemical reactions involved in synthesis of organic compounds
- Catabolism is the series of biochemical reactions that breakdown larger molecules. Energy is released this way, some of it can be utilized for anabolism

Photosynthesis

Plants are called autotrophs because they can use energy from light to synthesize, or make, their own food source. Many people believe they are "feeding" a plant when they put it in soil, water it, or place it outside in the Sun, but none of these things are considered food. Rather, plants use sunlight, water, and the gases in the air to make glucose, which is a form of sugar that plants need to survive. This process is called photosynthesis and is performed by all plants, algae, and even some microorganisms. To perform photosynthesis, plants need three things: carbon dioxide, water, and sunlight.



Photosynthesis may be summarised by the word equation

carbon dioxide + water ⟶ glucose + oxygen

It divided in to two reactions:

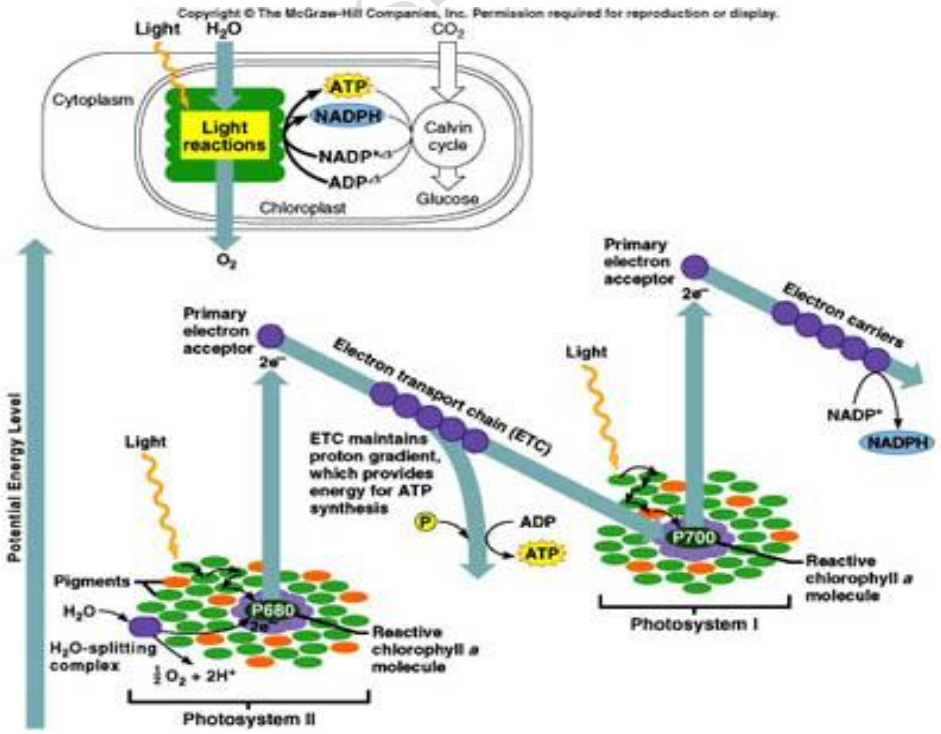
- Light reactions (Hill reactions)
- Dark reactions

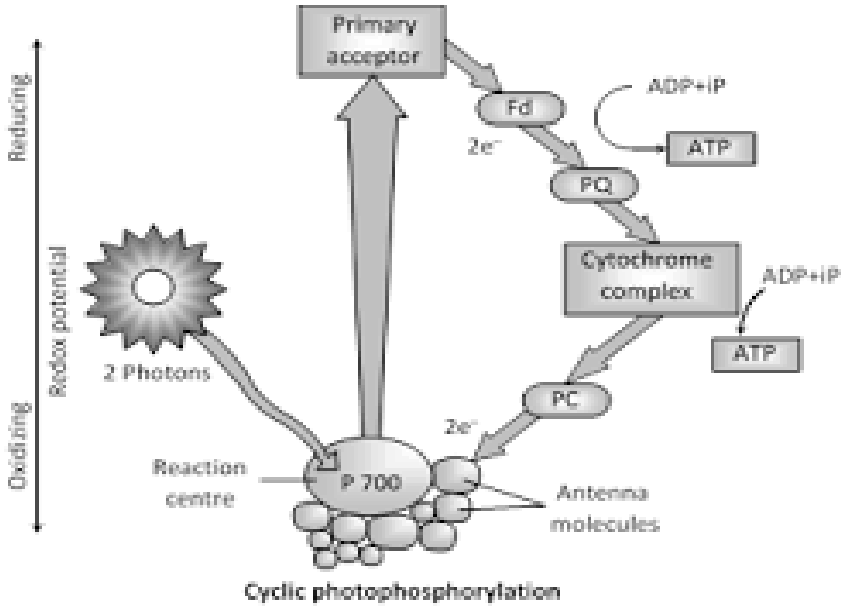
- **<u>Light reactions (Hill reactions)</u>**

  The light-dependent or "Light" Reactions: convert sunlight energy into chemical energy (stored in ATP & NADPH).

  Light reactions (Hill reactions):

  - Non-cyclic photophosphorylation
  - Cyclic phosphorylation

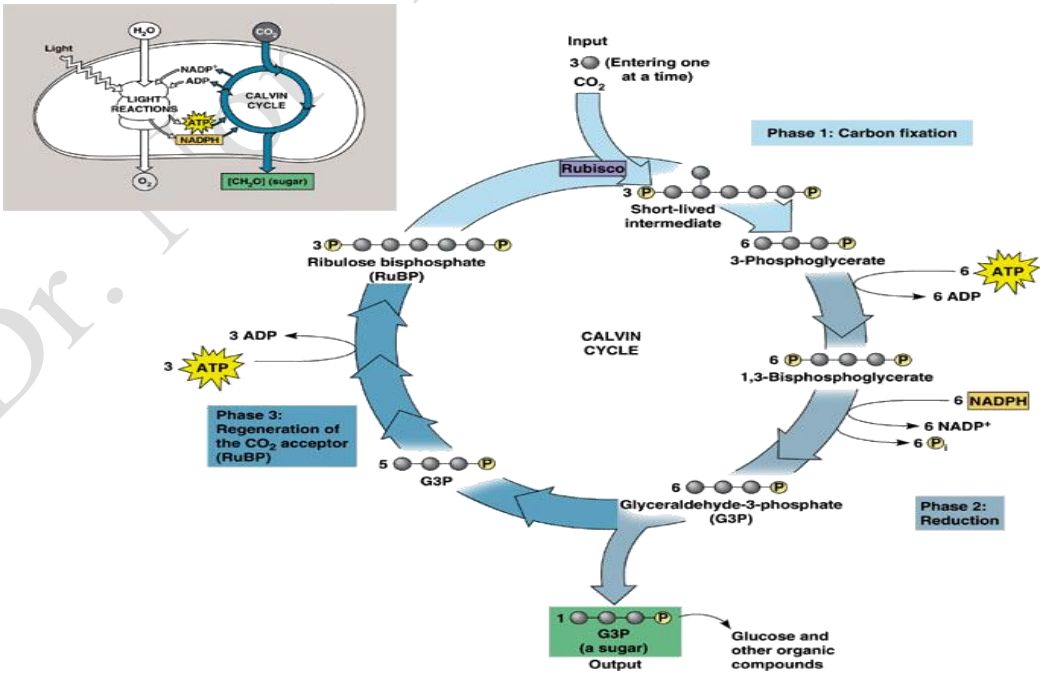




- **<u>The "Dark" Reactions</u>**

The "Dark" Reactions A series of reactions called the Calvin cycle that synthesize glucose from CO_2 and H_2O.

Endergonic reactions of this pathway are fueled by ATP & NADPH from the "light" reactions.



RUBP= Ribulose-1,5diphosphate = C5

Carboxydismutase

$CO_2 + C_5 \longrightarrow [C_6]$

PGA=Phosphoglyceric acid

PGAL= Phosphoglyceraldehyde.

Respiration:

Is the biochemical process by which organic compounds release energy.

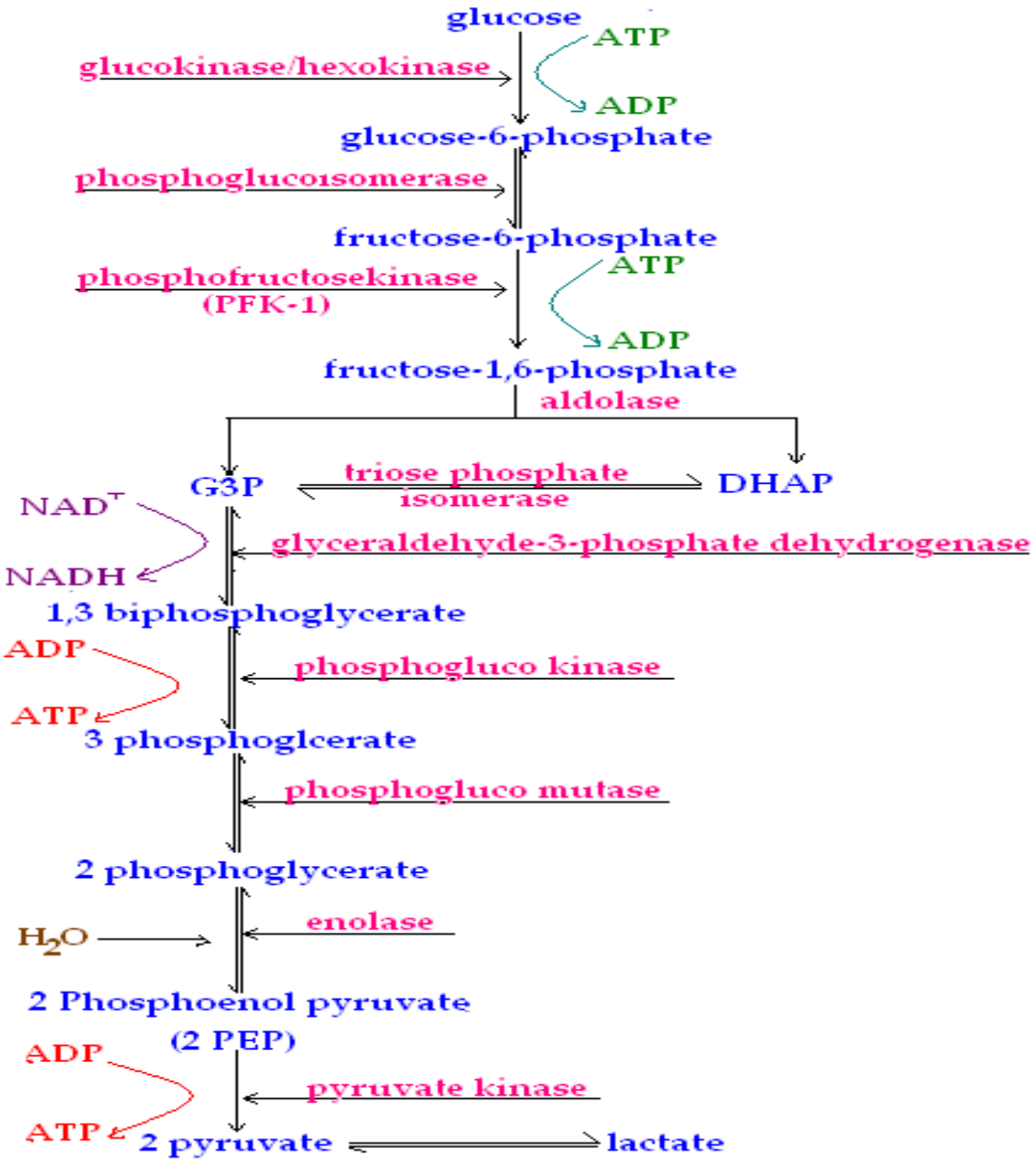
$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$ (oxidation of glucose).

There are two types of respiration:

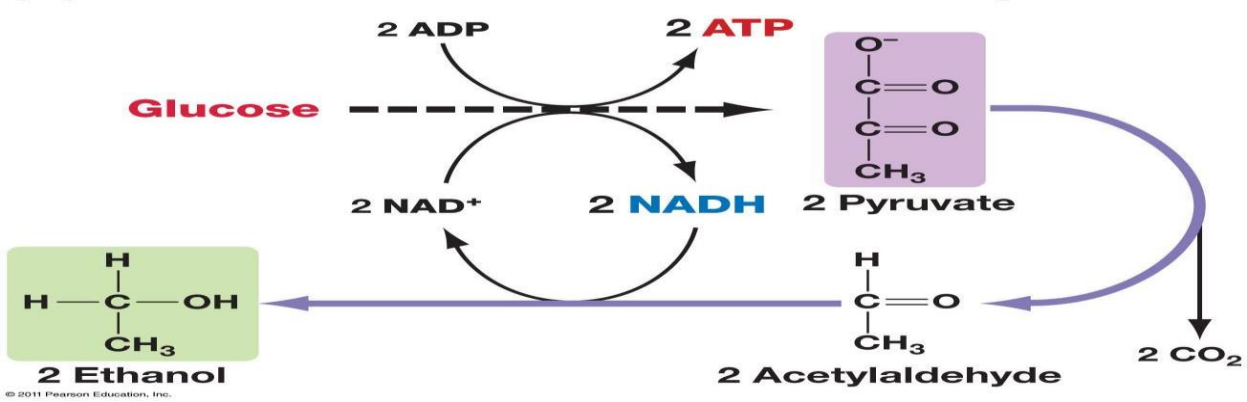
- Aerobic, which requires oxygen and releases lots of energy
- Anaerobic, which does not require oxygen but releases much less energy.

Aerobic respiration takes place in three steps:

1. Glycolysis/Embden-Meyerhof-parnas pathway (EMP pathway)
2. Kreb's cycle/Citric acid cycle/Tricarboxylic acid cycle
3. Electron transport system (ETS).

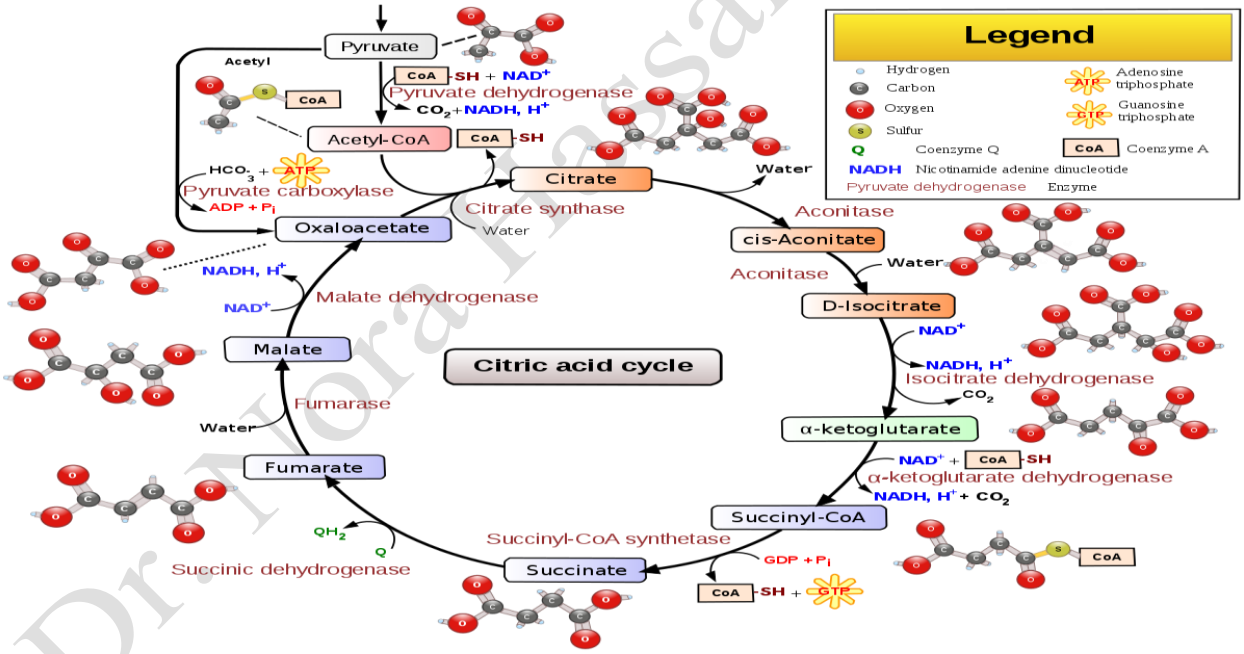

glucose
ATP
glucokinase/hexokinase
ADP
glucose-6-phosphate
phosphoglucoisomerase
fructose-6-phosphate
ATP
phosphofructosekinase
(PFK-1)
ADP
fructose-1,6-phosphate
aldolase
G3P
triose phosphate
isomerase
DHAP
NAD+
glyceraldehyde-3-phosphate dehydrogenase
NADH
1,3 biphosphoglycerate
ADP
phosphogluco kinase
ATP
3 phosphoglcerate
phosphogluco mutase
2 phosphoglycerate
H2O
enolase
2 Phosphoenol pyruvate
(2 PEP)
ADP
pyruvate kinase
ATP
2 pyruvate
lactate

Fermentation



2- Krebs cycle

The krebs cycle is the second of three stages of cellular respiration, in which glucose is oxidized. The oxidation of these molecules is primarily used to transform the energy contained in these molecules into ATP. The TCA cycle starts with the condensation of acetyl group with oxaloacetic acid (OAA) and water to yield citric acid .



Electron Transport System (ETS)

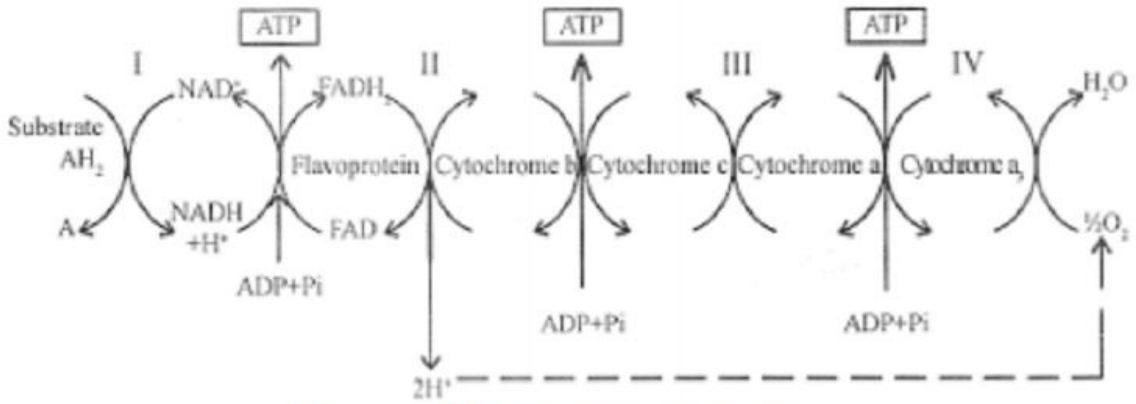


Fig. Electron transport system

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الجزء العملى

Mechanical adsorption

Tools:

Methylene blue- distilled water- conical flasks- filter papers – funnel- charcoal- absolute ethyl alcohol- beaker.

Procedures:

1- Filtrate about 40ml of Methylene blue soln. through filter paper and notice the filtrate colour

2- Add 10-15 gm of charcoal to the Methylene blue soln. in a conical flask with shaking for 5 min. and Filtrate.

3- Wash the ppt. from the previous test with 40 ml absolute ethyl alcohol with shaking for 5 min. and Filtrate.

Observation

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Chemical adsorption

Tools:

Iodine soln.- starch soln.-test tube.

Procedures:

1- Take 5 ml of starch soln.in test tube

2- Add drops of Iodine soln.

Observation

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Electrical adsorption

Tools:

Methylene blue soln.- distilled water- petri dishes- filter papers – light green soln.- burette-

Procedures:

1- Take 10-15ml of Methylene blue soln. in petri dish

2- Fix a filter paper in burette holder that touch the M.B. soln. in the petri dish.

3- Repeat this step using light green soln.

Observation

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Diffusion and dialysis

1-Diffusion through filter paper

Tools:

Starch soln.- NaCl soln.- iodine soln.- test tubes – AgNO3 soln.- beaker- filter paper.

Procedures:

1- Mix about 10 ml of Starch soln. with NaCl soln.in a beaker
2- Filtrate the mixture through filter paper.
3- Detect the presence of Starch soln. and NaCl soln. in the filtrate using iodine soln. and $AgNO_3$ soln. respectively.

Observation

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2-Diffusion through cellophane paper

Tools:

Starch soln.- NaCl soln.- iodine soln.- test tubes – AgNO3 soln.- beaker- cellophane paper- distilled water- string.

Procedures:

1- Mix about 10 ml of Starch soln. with NaCl soln.in a cellophane paper, tie it with string and hang it in a beaker containing distilled water.

2- Wait for half an hour.

3- Detect the presence of Starch soln. and NaCl soln. in the distilled water using iodine soln. and $AgNO_3$ soln. respectively.

Observation

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3-Diffusion through gelatinous membrane

Tools:

Starch soln.-gelatin- iodine soln.- test tubes –beaker

Procedures:

1- Prepare two test tubes and add 10 ml of gelatin in it.
2- Add 2ml of iodine soln. in one of these test tubes (tube 1) and 2ml of starch soln.in the other (tube 2).
3- Shake the test tubes well and leave them in refrigerator .
4- Add 2ml of starch soln. to tube 1 and 2ml of iodine soln. to the tube 2

Observation

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Comment

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4-Diffusion of ions through gelatinous membrane

Tools:

Gelatin- NaOH soln.- ph.ph. Indicator- $FeCl_3$ soln.-potassium Ferro cyanide- test tubes –beaker

Procedures:

1- Prepare 10 ml of gelatin soln. in a test tube.
2- Add 1ml of potassium Ferro cyanide and 1ml of NaOH soln
3- Add drops of ph.ph Indicator and shake the test tube well .
4- Leave the test tube in a refrigerator until it freeze.
5- Add 2ml of $FeCl_3$ soln. on the mix. and leave the test tube in a refrigerator

Observation

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Determination the osmotic suction force by curvature the Ricinus petioles

Tools:

Ricinus petioles- knife or scalpel, NaCl solution (concentrated), distilled water, petri-dishes, different concentrations.

Procedures:

3- Cut the Ricinus petioles with knife

4- Put some of these petioles in 3 petri dishes

5- One of the petri dish contain distilled water , the second contain concentrated solution of NaCl

6- Put different concentrations of NaCl in petri dishes

7- Observe the curvature of Ricinus petioles in each petri dish.

Observation

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plasmolysis and deplasmolysis

Tools:

NaCl solution-distilled water- petri-dishes- slide – cover- onion skin leaves.

Procedures:

1-examine the onion cells under microscope

2-immerse the onion cells in concentrated NaCl soln. and leave it for 30 min.

3- examine the onion cells under microscope.

4- Immerse the shrinked onion cells in distilled water and leave it for 30 min. then examine it under microscope

Observation

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Osmotic tree

Tools:

$CuSO_4$ soln.(5%)- potassium Ferro cyanide- test tubes –holder.

Procedures:

1- Take 5ml of $CuSO_4$ soln.(5%) in a test tube and tie it in a holder.

2- Add crystals of potassium Ferro cyanide

3- Leave the test tube for 5 min.

Observation

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Enzymes

Hydrolases enzymes

A- Carbohydrase.

1- Detection of the invertase enzyme

Tools:

Sucrose soln.- Fehling reagent – test tubes – water bath 100℃ , 40℃- invertase

Procedures:

1- Take 5ml of sucrose soln.in two clean test tubes.

2-Add 2ml of invertase in one tube and let the other tube without addition

3-Put the tubes in water bath at 38-40℃ for 30 min.

4-Add 5ml of Fehling reagent in the two test tubes.

5- Put the tubes in water bath at 100℃ for 15 min.

Observation

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Comment

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2-Detection of diastase

Tools:

Starch soln.- Fehling reagent – chines plate – water bath 100℃ , 40℃- diastase- iodine soln. -

Procedures:

1- Take 2 test tubes and add 5ml of starch soln.

2-Add 2ml of diastase in two tubes .

3-Put the tubes in water bath at 38-40℃ for 30 min.

4- After 15 min. take drops of the mix. inn the chines plate which contain iodine soln. to detect the complete conversion of starch to simple sugar.

4-Add 5ml of Fehling reagent .

5- Put the tube in water bath at 100℃ for 15 min.

Observation

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B- Proteases enzymes

1-Detection of pepsin

Tools:

Egg albumin (protein sample)- HCl (0.4%) – test tube - pepsin

Procedures:

1-Take 5ml of egg albumin in clean test tube.

2-Add 5ml of HCl (0.4%) and 1ml of pepsin

3-Heat in water bath at 38-40°C for 30 min.

Observation

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Comment

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2-Detection of trypsin

Tools:

Egg albumin- NaOH (0.4%)– test tube – trypsin

Procedures:

1-Take 5ml of egg albumin in clean test tube.

2-Add 5ml of NaOH (0.4%) and 1ml of trypsin

3-Heat in water bath at 38-40°C for 30 min.

Observation

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Oxidation reduction enzymes
A-Dehydrogeneses
1-Detection of Schardinger enzyme

Tools:

Fresh milk- formaldehyde– test tubes – M.B.- paraffin oil

Procedures:

1-Take 5ml of Fresh milk in a clean test tube and 5ml of boiled milk in another test tube.

2-Add 1ml of formaldehyde in each tube followed by drops of M.B

3-cover the test tubes with paraffin oil

4-Heat in water bath at 38-40°C.

Observation

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Comment

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B- oxidases

1- Detection of catechol oxidase

Tools:

Potato tubers – guiacol

Procedures:

1-prepare discs of potato tubers .

2-Add drops of guiacol on its surface.

Observation

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Comment

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C- peroxidase
Detection of peroxidase enzyme

Tools:

Radish roots – guiacol- H_2O_2

Procedures:

1-Prepare discs of Radish roots and grind them.

2-Take 5ml of guiacol on these discs.

3-Add 1ml of H_2O_2

Observation

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Detection of catalase enzyme

Tools:

Yeast suspension – test tube– H_2O_2

Procedures:

1-Take 5ml of Yeast suspension in a test tube.

2-Add 2ml of H_2O_2 and cover the tube.

3- Put the tube in water bath at 38-40°C.

Observation

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Comment

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Transpiration

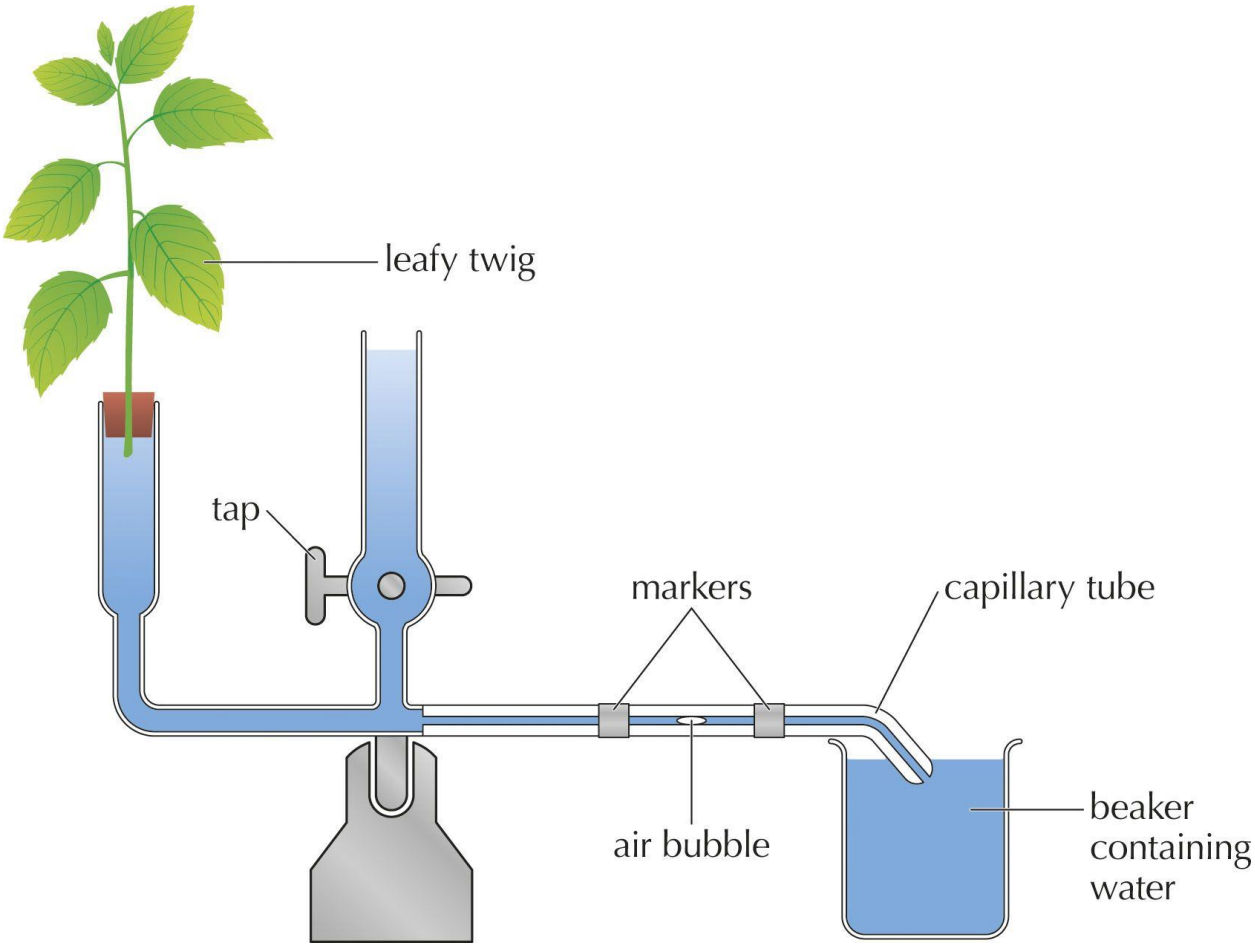
3-Potometer

- **Uses**

It is used to measure the rate of transpiration

- **The idea of its work**

It is based on the idea that the rate of absorption (the rate at which water plants acquire) almost equals the rate of transpiration (the rate at which water is lost)



Mechanism of work and the law

The plant that we want to measure transpiration rate for it is fixed in part designated for it inside the device, and the leaf surface area for this plant is estimated

There are two ways to measure the rate of transpiration

1-The gravimetric method for estimating the rate of transpiration

The apparatus is filled with water and branch of plant is fixed in its appropriate place, then the apparatus is weighted before beginning the experiment and weighted after the end of the experiment, the amount of lost water is calculated as the difference between the two weights

W1 = weight before beginning the experiment

W 2 = weight of the apparatus after the end of the experiment

$$\text{Transpiration rate} = \frac{\text{Weight of water lost (W1-W2)}}{\text{Leaf area (cm) x time (hours)}}$$

g / cm2 / hour

Methods for determining leaf area

1-By graphing

The paper is placed on a graph paper, then its dimensions are drawn with bullets and the number of squares taken is calculated, where each square represents 1 cm through the number of squares The area of the paper is approximately calculated

1- Weighted method

Draws a square with known dimensions, length and width, on a filter paper, and let its area be (A 1), then cut it and weight it (W1) .on the same type of filter paper draw the leave that you want to find its area and let its area A2 and weight it lets its weight W2

W1/ A1= W 2 /A 2

A2 = A1 x W2/W1

Leaf area = number of leaves x area of one leaves

If the stomata are found on two surfaces, the area of the leaves *2