BIOLOGY

2nd Year

First term

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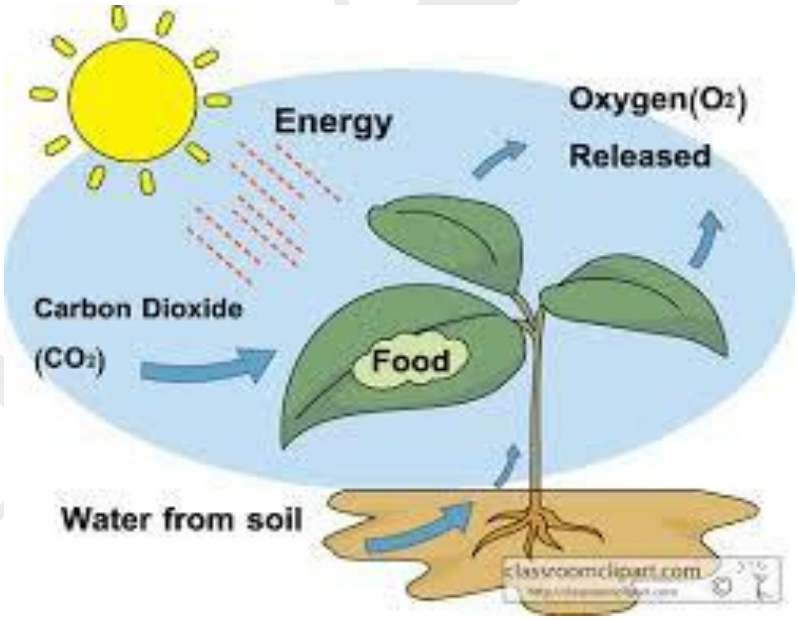
Unit (I)

NUTRITION and DIGESTION

in living organisms



Nutrition and digestion in living organisms

Nutrition:

It is the scientific study of food and various modes of nutrition of living organisms.

Importance of nutrition (food):

1- It provides the living organism with the energy needed for all the vital processes.

2- It constitutes the materials needed for growth and repair of worn-out tissues (الأنسجة التالفة).

Types of nutrition

1-Autotrophic nutrition

Autotrophs:- They are the organisms which can manufacture their own food by themselves.
e.g.) Green plants.

2- Heterotrophic nutrition

Heterotrophs:- They are the organisms that can obtain their food from other organisms.

They obtain their high energy food substances either from green plants or from animals that were previously feeding (سبق و تغذت) on plants.

Heterotrophic nutrition includes: Holozoic nutrition, Parasites and Saprophytes.

a) Holozoic nutrition Includes h**erbivores** (اكلات العشب)e.g. rabbits, c**arnivores (اكلات اللحوم) and omnivores (متنوعة الغذاء)** e.g. Man.

b) Parasites e.g. Bilharzia worms and Halok plant (**Orobanche)**

c) Saprophytes e.g. many fungi and saprophytic bacteria.

Autotrophic nutrition

Photosynthesis

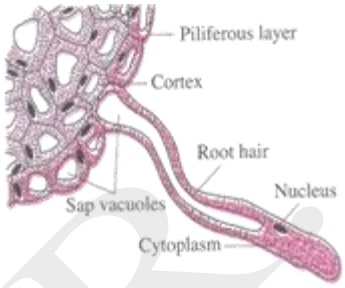
It is the process by which the plant can synthesize the high energy organic food substances from law energy simple inorganic compound, namely CO_2, H_2O and mineral salts.

• To study photosynthesis, you must know:

1- How does the plant get water and salts. 2- How do the reactions take place.

First: Absorption of water and salts

Higher green plants absorb water and mineral salts from the soil through **root hairs** present in the root system of the plant.



Characteristics of the root hair

Length	It may reach 4 mm
Structure	- Each root hair is an extension of one cell of the piliferous layer (epidermis). - It is lined internally with a thin layer of cytoplasm which contains nucleus and large cell vacuole.
Age	do not exist for more than a few days or weeks (G.R.) since the epidermal layer is lost from time to time and regenerated (تتجدد) continuously from the zone of elongation (منطقة الاستطالة).

The functions of the root hairs

1- Absorption of water and mineral salts from the soil.

2- Fixation of the plant to the soil.

(Functional suitability(Adaptation) of the root hair:

1- They have thin walls (G.R.)**:**

To permit the passage of water and salts through them.

2- They are large in number and protrude to the outside (G.R.)**:**

To increase the area of absorbing surface.

3- They secrete a viscous substance (G.R.)**:**

To help these hairs to find their ways easily among soil particles to stick to these particles and to help to fix the plant to the soil.

4- The solution inside the root hair vacuole is more concentrated than that of the soil (G.R.)**:**

To help the water to pass from the soil to the root hair by osmosis.

Mechanism of water absorption

Mechanism of water absorption depends on several physical phenomena (ظواهر طبيعية):

1- The phenomenon of diffusion **2- The phenomenon of permeability**

3- The phenomenon of Osmosis **4- The phenomenon of imbibition**

1- The phenomenon of diffusion (خاصية الانتشار)

It is the movement of molecules or ions from a high concentrated medium to a law concentrated medium.

- Diffusion phenomenon occurs because of the continuous free motion of the diffused substance .

e.g.) the diffusion of a drop of ink when it falls into a beaker containing water.

2- The phenomenon of permeability (خاصية النفاذية)

- Walls (الجدر) and membranes (الأغشية) are classified according to their permeability into three types:

Membrane	Ability of permeability	Example
Permeable	allow both water and mineral ions to pass through	Cellulose walls
Impermeable	does not allow water and mineral ions to pass through.	Walls covered by legnin, suberin or cutin
Semi-permeable	Allows passage of water controls the passage of salts Prevents the sugars and amino aciods due to their large sized molecules.	Plasma membrane

Plasma membrane:

it is semipermeable, has tiny pores that control the permeability of substances through it (has the selective permeability phenomenon)

Selective permeability phenomenon:

A phenomenon that controls the passage of substances through the plasma membranes , where:

- Some substances pass freely through it, such as water.
- Others pass slowly, such as salts.
- Other substances are not allowed to pass, such as sugars and amino acids because they are large-sized molecules.

3- The phenomenon of Osmosis (الخاصيه الاسموزيه)

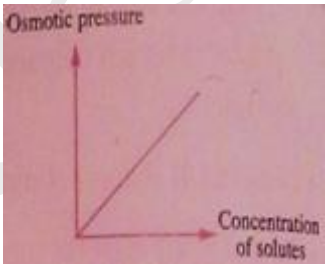
It is the diffusion of water from a medium with a high water concentration to another with a low water concentration through a semi-permeable membrane.

Osmotic pressure:

It is the pressure that causes the diffusion of water through semi-permeable membranes due to difference in concentration of the solutes in water across the 2 sides of the membrane.

The relation between the concentration of solutes in a solution and its osmotic pressure:

osmotic pressure increases as the concentration of the solutes in the solution increases, directely proportional relation.



e.g) - The root hairs of the of the desert plants (xerophytes) are characterized by high osmotic pressure to absorb water as much as possible from the soil.

- The normal plants have law osmotic pressure.

4- The phenomenon of imbibitions (خاصية التشرب)

- *It is the phenomenon by which the solid particles, especially the colloidal (الغروية), absorb water, swell and increases in size.*

- Plant cells contain colloidal substances such as cellulose, protoplasmic proteins and pectin substances so that they can imbibe water and liquids.

Mechanism of water absorption by the root

1- The outer surface of the root hairs imbibes water from soil solution; (G.R.) because the root hairs are covered with a colloidal layer which has a strong affinity (قابلية) for water that surrounds the adjacent soil particles.

2- The imbibed water is withdrawn (يتم سحبها) to the inside of the epidermal cells by osmosis; because the concentration of the sugar solution inside the cell sap is higher than the concentration in the soil solution (water concentration inside the cell sap is lower than that in the soil solution).

3- Water passes by the same method to the cortex cells until it reaches the xylem vessels in the center of the root.

Absorption of Mineral Salts

- **Essential nutrients for green plants:**

- Green plants need certain essential elements (other than Carbon, Hydrogen, and Oxygen).
- Plants absorb these elements through the root.

Deficiencies (نقص) of these elements lead to:

1. Disturbances in plant growth which may stop completely.
2. Flowers or fruits may not produce.

These elements are divided into 2 groups: Macro-nutrients and Micro-nutrients.

	Macro-nutrients	Micro-nutrients
	They are elements that needed by plants in considerable quantities.	They are needed by plants in very small quantities (Few mg/liter) so they are also called trace elements.
Elements	They are seven: Nitrogen, Phosphorous, Potassium, Calcium, Magnesium, Sulpher and Iron	They are eight: Manganese, Zinc, Boron, Aluminium, Chlorine, Copper, Molybdenum and Iodine.
Importance	**Phosphorous**: enters in nergy carriers compounds. **Iron**: enters in composition of coenzymes of photosynthesis. **Nitrates, sulphates and phosphates**: change carbohydrates into proteins.	Some of them act to activate enzymes.

Mechanism of absorption of minerals

Diffusion:

1- Ions diffuse independent of each other and of water in the form of:

- Positive ions: cations (K^+,Ca^{++}) - Negative ions: anions ($SO4^{--}$, $NO3^-$ and Cl^-, NO_2^-).

2- These solutes move **by diffusion** from the soil solution and pass through the wet cellulose wall.

3- Cations exchange may take place e.g. Na^+ may get out of the cell and is replaced by a K^+ ion.

Selective permeability:

4- When ions reach the plasma membrane (semi permeable), some of them are selected and allowed to pass inward while others are prevented, regardless to their size, concentration or charge, according to the plant's requirements.

Active transport:

5- Ions accumulate inside the cells against the concentration gradient i.e. the ions diffuse from the soil solution of low concentration to the inside of the cell of high concentration; this process needs energy and is called **active transport**.

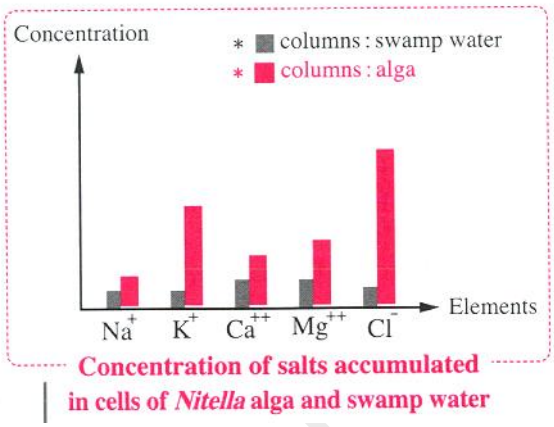
Active transport

It is the movement of any substance through the cell membrane by the help of chemical energy.

The energy required for active transport:

is supplied during the respiration of root tissues.

Experiment of Nitelle alga



Concentration of salts accumulated in cells of *Nitella* alga and swamp water

Target: To prove the active transport and selective permeability.

Experiment:

The concentration of some ions are measured in the cell sap of the Nitella alga and in the swamp water the alga live in.

Observations:

The following graph represents the results of an experiment.

Conclusions:

1. The concentration of ions in the cell sap of the algal cells **is higher** than their concentration in the swamp water.

☒ This proves that the cell must use up energy to absorb these ions. (**active transport**)

2. The concentration of some ions in the algal cells **is higher** than the concentration of other ions.

☒ This proves that ions are selectively absorbed according to the requirements of the plant.

(**Selective permeability**).

Lesson 2:

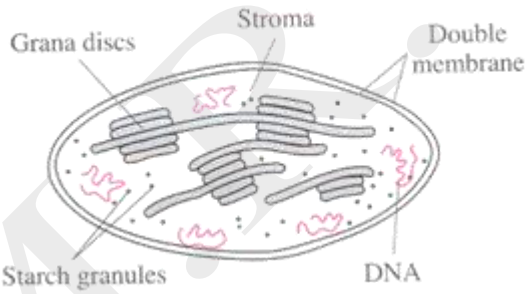
Photosynthesis in green plants

Places of occurrence of Photosynthesis:

- **Green leaves** are the main centers for photosynthesis (G.R) since they contain chloroplasts.

- **Green herbaceous stems**: perform photosynthesis (G.R), as they contain collenchyma's cells which have chloroplasts.

Chloroplast Structure:



- **Under the light microscope**:

It appears as a homogenous mass in the form of a convex lens.

- **By the electron microscope:**

It appears to be formed of:

- **Double thin membrane**: its thickness about 10 nm.
- **Stroma (Matrix):** colorless, proteinic substance, contains starch granules and Grana.
- **Starch granules:** large in number and minute in its size, they are decomposed into simple sugar to be translocated (تُنقل) to other organs of the plant under certain conditions.
- **Grana:**

- They are disc shaped granules embedded in the stroma.
- Each granum is about 0.5 micron in diameter and about 0.7 micron thick.
- Each granum (granule) consists of 15 or more discs arranged over each other.
- Each disc is hollow from the inside, while its margins (الحواف) extend (تمتد) outside the granum (G.R) to meet the margins of another disc in a neighboring granum (الحبيبة المجاورة), (G.R) to increase the exposed area of the granum to light.
- They contain pigments (الأصباغ) which absorb light energy needed for photosynthesis.

- **Pigments of the chloroplast:**

The pigment	The color	The percentage
Chlorophyll A	Blue green	**About** 70%
Chlorophyll B	Yellow green	
Xanthophylls	Lemon yellow	25%
Carotene	Orange yellow	5 %

N.B)

1- The green colour dominates the other colours of the chloroplast (G.R), due to high ratio of chlorophyll pigment (A) and (B) together 70%.

2- **Molecular formula of chlorophyll molecule**: $C_{55}H_{72}O_5N_4Mg$.

3- **It is believed that the ability of chlorophyll molecule to absorb light is due to:**

the presence of Mg atom in its centre.

Structure of the plant leaf

The dicotyledonous leaf consists of 3 tissues:

1-The upper and lower epidermis:

- Each of the 2 layers consists of :

one row of adjacent barrel shaped parenchyma cells with no chlorophyll.

- Stomata are present and abundant on the lower epidermis.

- The external wall of cells is covered by a thin layer of cutin (to prevent water loss) except stomata.

2- Mesophyll tissue:

- It lies between the upper and lower epidermis and transversed by veins.

- It consists of palisade tissue and spongy cells.

Palisade tissue:	Spongy layer:
- Perpendicular to the upper epidermis. - One row of cylindrical and elongated parenchyma cells. - Cells are filled with chloroplasts, especially its upper part, to receive the hieghest light intensity.	- It lies below the palisade tissue. - Several rows of irregularly shaped and loosely arranged parenchyma cells. - Cells have wide intercellular spaces. - Contain lower number of chloroplasts than the palisade tissue.

3- Vascular tissue:

- It contains vascular bundles that extend through the veins and venules , the main vascular bundle (الحزمة الوعائية) is found in the midrib (العرق الوسطى).

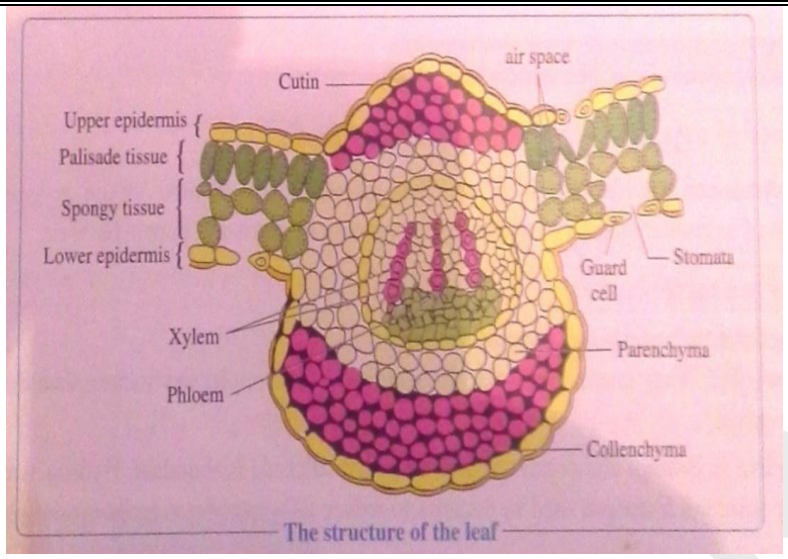
- **The vascular bundle consists of**:

* **Xylem vessels:**(toward the upper epidermis)

- Several rows that are separated by parenchyma cells called xylem parenchyma.

* **Phloem**: (toward the lower epidermis)

- Translocates the dissolved organic food from the mesophyll to other parts of plant.



Chemical equation of photosynthesis:

$$6CO_2 + 12H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light energy}} C_6H_{12}O_6 + 6\,O_2\uparrow + 6H_2O$$

What is the source of the produced oxygen?

1- Studies of Van Neil:(An American scientist)

He pointed to (أشار إلى) the role of light in photosynthesis by studying photosynthesis in green and purple bacteria.

*** The green and Purple bacteria:**

- live in swamps and ponds, where H_2S is abundant (يوجد بكثرة).
- Autotrophic, where they contain bacteriochlorophyll which is simpler in structure than normal chlorophyll.
- They use **H_2S** as a source of hydrogen to reduce CO_2 to form charbohydrates while sulpher is precipitated.

Assumption of Van Neil:

1- In green and purple bacteria:

-Light decomposes **H_2S** into hydrogen and sulpher in light reactions.

-Bacteria **hydrogen** to reduce CO_2 to form charbohydrates in dark reactions while sulpher is precipitated.

-General equation of photosynthesis in bacteria:

$$6CO_2 + 12H_2S \xrightarrow[\text{Simple chlorophyll}]{\text{Light energy}} C_6H_{12}O_6 + 12S\downarrow + 6H_2O$$

2- In green plants:

- Light decomposes **H_2O** into hydrogen and oxygen in light reactions.
- Bacteria **hydrogen** to reduce CO_2 to form charbohydrates in dark reactions while oxygen is liberated.
- General equation of photosynthesis in plants:

$$6CO_2 + 12H_2O \xrightarrow[\text{Normal chlorophyll}]{\text{Light energy}} C_6H_{12}O_6 + 6H_2O + 6O_2\uparrow$$

Van Neil assumed that:

(green plants use H_2O as a source of hydrogen while oxygen liberated.)

	green and purple bacteria	green plants
Type of chlorophyll	bacteriochlorophyll	**Normal** chlorophyll (A and B)
Source of hydrogen	H_2S	H_2O
Products of photosynthesis	**Glucose + Sulpher**	**Glucose + Oxygen**
General equation	$6CO_2 + 12H_2S \xrightarrow[\text{Simple chlorophyll}]{\text{Light energy}} C_6H_{12}O_6 + 12S\downarrow + 6H_2O$	$6CO_2 + 12H_2O \xrightarrow[\text{Normal chlorophyll}]{\text{Light energy}} C_6H_{12}O_6 + 6H_2O + 6O_2\uparrow$

2- A group of scientists of Kaliforina university 1941:

They carried out an experiment to verify Va Neil assumption:

- They used a green alga (*Chlorella*) and provided it with all conditions favourable for photosynthesis.

- The 1st experiment:

They used water contains an oxygen isotop O^{18} instead of the normal oxygen O^{16}.

Obseravation:

The released oxygen was O^{18}.

The general equation:

$$\mathbf{6\,C\,{}^{16}O_2 + 12\,H_2\,{}^{18}O \xrightarrow[\text{Chlorophyll}]{\text{Sun Light energy}} C_6H_{12}\,{}^{16}O_6 + 6\,H_2\,{}^{16}O + 6\,{}^{18}O_2}$$

- The 2nd experiment:

They used ordinary water with Carbon dioxide containing the isotope Oxygen (O^{18}).

Obseravation:

The released oxygen was O^{16} not O^{18}

The general equation:

$$6\,C\,^{18}O_2 + 12\,H_2\,^{16}O \xrightarrow[\text{Chlorophyll}]{\text{Sun Light energy}} C_6H_{12}\,^{18}O_6 + 6\,H_2\,^{18}O + 6\,^{16}O_2$$

Conclusion:

(The source of liberated oxygen is water not CO_2.)

Photosynthesis reactions:

The scientist Blackman:

- Studied the limiting factors of photosynthesis, such as light temperature and **CO_2**.
- He concluded that photosynthesis of two types of reactions, light reactions and dark reactions.

P.O.C.	Light reactions	Dark reactions
- Site of occurrence:	- in grana	- in stroma
- The time of reactions:	- Occur in light only	- Occur in light and dark
- The limiting factor:	- light	- temperature
- Enzymes:	- Enzymes do not share	- Enzymes share in the reactions
- What happens in the process:	- The kinetic light energy is converted into a potential chemical energy in the chlorophyll.	- CO_2 is fixed by hydrogen that is carried on $NADPH_2$ and by the help of energy stored in ATP molecules.
- Products:	- ATP (stored energy) - $NADPH_2$ (hydrogen carrier) - Oxygen (2nd product)	- PGAL (1st stable chemical compound) - Water.

Summary of light reactions

a. When light falls on chlorophyll of the grana inside the chloroplast, some electrons in the atoms of chlorophyll molecule gain light energy.

b. These electrons are shifted up from their low energy levels to higher ones. So, the kinetic light energy is stored as potential chemical energy in the chlorophyll. Molecules of chlorophyll are therefore said to be in an excited or activated state.

c. When the stored energy is released, the electrons fall once more to the lower energy levels. So, the chlorophyll returns to the stable state ready to receive another influx of light, to become excited once more.

d. **Part of the energy** stored in chlorophyll is used in **splitting up** water molecules into Hydrogen and Oxygen.

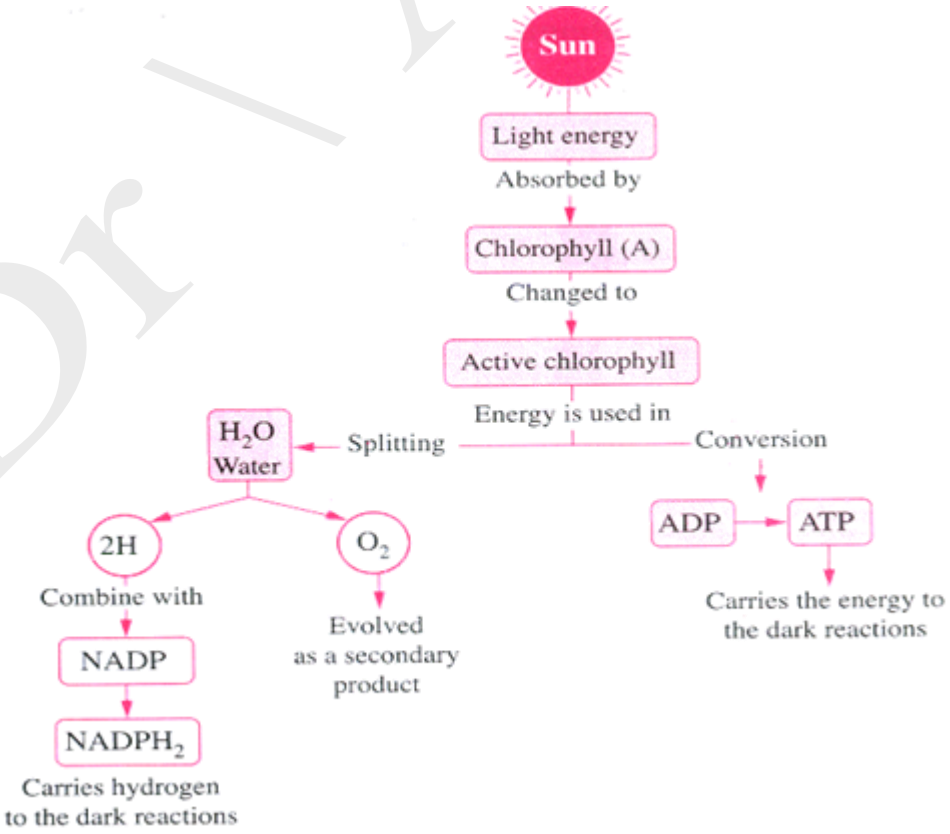
e. **Another part of the energy** of the excited chlorophyll is **stored in ATP** (Adenosine Tri-Phosphate) molecules which are called the energy currency in living cells {ATP is the result of combination of ADP (Adenosine Di-Phosphate) molecule, a phosphate group, and an amount of the released energy by means of high-energy bond, which is marked by a squiggle}:

$$ADP + P + energy \longrightarrow ATP$$

f. Hydrogen resulting from decomposition (انحلال) of the water molecules combines with a co-enzyme present in the chloroplast which is called NADP which is a Hydrogen receptor (Nicotinamide dinucleotide phosphate) to give $NADPH_2$. In this way Hydrogen will not escape or recombine with Oxygen once more.

$$NADP + H_2 \longrightarrow NADPH_2$$

g. Oxygen releases as a bi-product for the decomposition of water.



Summary of dark reactions

- A group of reactions that takes place in the stroma of the chloroplast outside the grana, **in which**: CO_2 gas is fixed bu Hydrogen carried on $NADPH_2$ into carbohydrates with the help of the energy stored in ATP molecules.

Experiment to prove the nature of the dark reactions:

Melvin Calvin and his associates in California University revealed together the nature of dark reactions by using the radio-active isotope C^{14}:

a. They placed the chlorella alga in the apparatus shown, and supplied it with CO_2 gas containing radio-active C^{14}

b. A lamp was lighted very briefly in order for photosynthesis to take place.

c. The chlorella alga is then immersed in a beaker containing hot alcohol (G.R)to kill the alga and to stop the biochemical reactions.

d. They separate the product of photosynthesis by special means, and they tested the presence of radio-active C^{14} in these products.

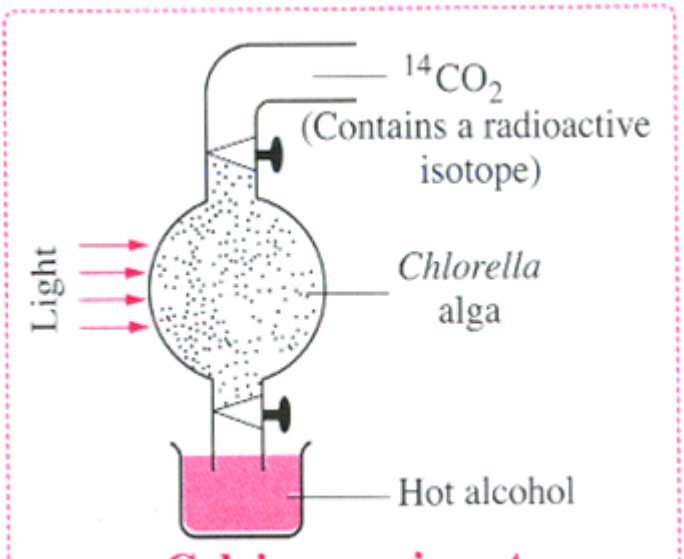
The results:

1- When photosynthesis is proceeded with the briefest flash possible of light, the 1st stable compound to be produced is PGAL (Phospho-glyceraldehyde).

2- The Hexose's sugar is formed throughout several enzymatic intermediate reactions.

PGAL

- *It is the 1st stable compound to be produced from photosynthesis.*
- It is a 3-carbon compound.
- It acts as crossroads (مركب وسطى) in the metabolic network, from which glucose, starch, proteins, and fats are formed.
- It can be utilized in the cellular respiration.



Calvin experiment

Heterotrophic nutrition

Digestion:

It is the conversion of the large food substances (polymers) into small ones (monomers) by hydrolysis, this process is catalyzed by enzymes.

Large and complex food substances **(starch, proteins and fats)** —**ENZYMES**→ simple and smaller molecules **(mono saccharides, amino acids, fatty acids and glycerol)**

Enzyme:

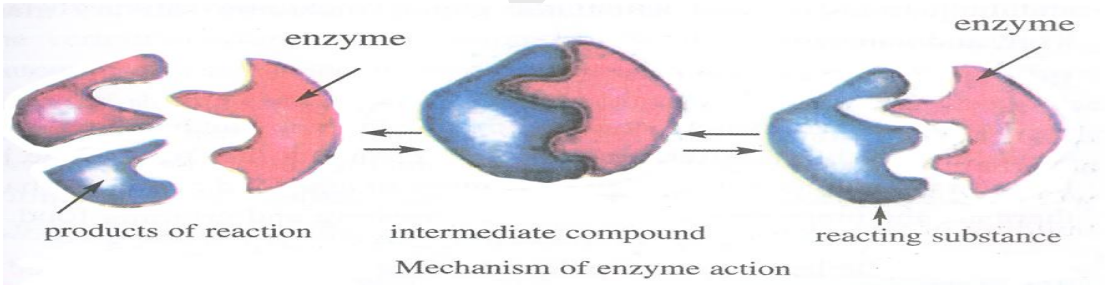
It is a protein substance which has the properties of a catalyst, as it has specific ability to activate a particular chemical reaction.

Mechanism of enzyme action:

1 - The catalytic chemical reaction depends on the structure of the reacting molecule and the nature of the enzyme.

2- The enzyme reacts with the reacting substance forming an intermediate compound (مركب وسطى).

3- When the reaction is completed, the resulting molecules break away (ينفصل) from the enzyme leaving it in the same form as it was before the reaction.



Mechanism of enzyme action

Properties of enzymes:

1- **They are specific** (متخصصة) (G.R.) because each enzyme accelerates only one type of reactions.

2- **They do not affect the products of the reaction** (explain) as they work as catalysts which increase the rate of the reaction until it reaches the equilibrium (الاتزان).

(Enzyme + reacting substance ⟶ unstable intermediate compound ⟶ Enzyme + products)

3- **Some enzymes have a reversible effect** (explain) as the same enzyme, that catalyzes the hydrolysis of a complex molecule into two simpler molecules, can rejoin the simpler molecules to form the complex one again.

4- **The activity of the enzyme is affected by**:

temperature and pH of the reaction.

5- **Some enzymes are secreted by the cells in an inactive state** (غير نشطة) so they need certain substances to activate them.

e.g.) Pepsin enzyme of the stomach is secreted in an inactive form, pepsinogen, and then it is activated by HCl.

Digestive system in Human

Digestive system in human consists of:

2- Digestive (alimentary) canal: consists of (mouth, pharynx, esophagus, small intestine and large intestine).

1- Accessory glands: which consists of (salivary glands, liver and pancreas).

Buccal digestion (Digestion in mouth)

- **The mouth contains:**

Many kinds of teeth	Incisors (القواطع): for cutting food, Canines: for tearing (تمزيق) food, Premolars and molars: for crushing (سحق) and grinding (طحن) food.
The tongue	It manipulates (يحرك) the food and serves as an organ for taste.
Three pairs of salivary glands	They secrete saliva (اللعاب) into the buccal cavity through canals, Saliva is formed of: - **Mucus**: it mixes with food and facilitates its movement through the digestive tract. - **Amylase enzyme (Ptyaline)**:- It catalyzes the hydrolysis of starch into disaccharide maltose. **Starch** (Polysaccharide) —Amylase (In a weak alkaline medium)→ **Maltose** (malt sugar) (Disaccharide)

Pharynx (البلعوم):

It is a cavity at the back of the buccal cavity. It is a common passage for air and food.

Swallowing: -

It is an organized reflex action, when food is pushed from the mouth to the oesophagus, the top of the trachea together with the larynx is elevated causing the epiglottis (لسان المزمار) to close over the glottis (entrance to the air passage).

The oesophagus (المرىء):

Lengh	It is a 25 Cm. long
Extention	- extend from the pharynx downward through the neck, parallel to the vertebral column into the chest cavity.
Secretion	- It is lined with glands secreting mucus. - It does not secrete enzymes.
Medium	***Alkaline***
Functions	- It is lined with glands secreting mucus which it mixes with food and facilitates its movement through the digestive tract. - Food is carried through the oesophagus to the stomach by a phenomenon called peristalsis.

Peristalsis (الحركة الدودية):-

- *It is a series of a rhythmical muscular contractions and relaxations that extends along the alimentary canal.*
- *It is responsible for pushing food through different parts of the alimentary canal and also it is responsible for churning (خض و عجن) the food and mixing it with the digestive juice.*

Digestion in the stomach (Gastric Digestion)


Peristaltic action of oesophagus

The stomach:

- It is a dilated muscular sac.
- It is joined to the lower part of the oesophagus by a circular muscle called **the cardiac sphincter.**
- It is joined to the small intestine by a circular muscle called **the pyloric sphincter**.
- It secretes the gastric juice.

The gastric juice:

It is a colourless, acidic liquid, 90% of which is water and the rest is HCl and pepsin enzymes.

Proteins: are the only food substances which are affected by the gastric guice.

G.R) why does the gastric juice not affect the epithelial cells of the stomach?

1- **The presence of mucus secretions** which protect the cells against the effect of the digestive enzymes.

2- **Pepsinogen** (inactive) will be activated only when it is mixed with HCl in the cavity of the stomach.

The functions of HCl in the stomach:

1- It creates an acidic medium (pH: 1.5 to 2.5) which stops the action of the ptyaline enzyme.

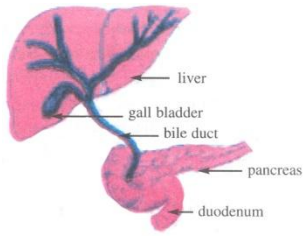
2- It activates the inactive pepsinogen into an active pepsin enzyme.

3- It kills the harmful bacteria that may enter with the food.

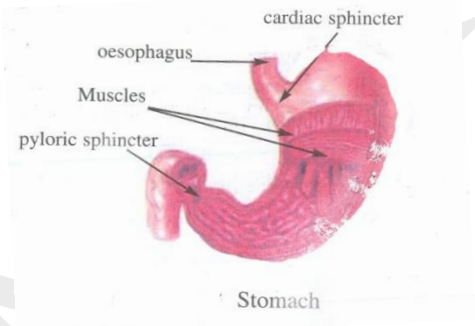
Action of pepsin enzyme:

It catalysis the hydrolysis of proteins by breaking certain peptide bonds in the protein to yield smaller polypeptides.

$$\text{Proteins + Water} \xrightarrow[\text{HCl}]{\text{Pepsin}} \text{Polypeptides}$$



The liver & Pancreas



Stomach

Digestion in the small intestine:

- **Its composition**: it is formed of two parts, **the duodenum** (الإثنى عشر) and **the ileum** (اللفائفى).
- **Its length**: 8 meters, its diameter: 3.5 cm. at its beginning and 1.25 cm. at the ending.
- **Its coils and loops**: are connected together by **the mesentry** (غشاء المساريقا).
- **Its juices**: three juices help to digest food in the small intestine (bile juice, pancreatic juice and intestinal juice)

I- The bile juice: (العصارة الصفراوية)

- It is secreted **by the liver** while the food passes through the duodenum.
- It emulsifies food i.e. dividing large masses of fats into small globules (G.R) to facilitate the enzymatic effect on fats which are insoluble in water.

N.B) The bile juice is the only juice that does not contain enzymes.

II- Pancreatic juice:

- It is secreted by **the pancreas**.
- It includes the following:

1- **Sod. Bicarbonate**:- it neutralizes HCl and renders (تعيد) the medium alkaline (pH= 8).

2- **Pancreatic amylase**: - it catalyzes the hydrolysis of starch and glycogen into maltose.

$$\text{Starch and glycogen + water (Polysaccharide)} \xrightarrow[\text{alkaline medium}]{\text{Pancreatic amylase}} \text{Maltose (Disaccharide)}$$

3- **Trypsinogen**:- it is inactive, when it reaches the duodenum it is activated to **trypsin** by co-enzyme **entrokinase** (secreted by the lining wall of the small intestine)

$$\text{Proteins} \xrightarrow[\text{Hydrolysis}]{\text{Trypsin}} \text{polypeptide}$$

N.B) Trypsin is stronger than pepsin.

4- **Lipase**: It catalyzes the hydrolysis of the emulsified fats into fatty acids and glycerols.

$$\text{Emulsified fats} \xrightarrow[\text{Hydrolysis}]{\text{Lipase}} \text{fatty acids and glycerols}$$

III- Intestinal juice:

- **It is secreted by**: certain cells in the wall of the small intestine.
- **It contains**: several enzymes that complete the process of digestion (Peptidases, Disaccharides and Interokinase).

1- Peptidases:

- A group of enzymes, each one of them is concerned with the hydrolysis of peptide linkage between certain kinds of amino acids in the polypeptide chains to give various amino acids.

$$\text{Polypeptides} \xrightarrow{\text{Peptidases}} \text{amino acids}$$

2- Disaccharides enzymes:

- A group of enzymes concerned with the hydrolysis of disaccharides into monosaccharides, they are 3 enzymes:

$$\text{Maltose} \xrightarrow[\text{(Malt sugar)}]{\text{Maltase enzyme}} \text{Glucose + Glucose}$$

$$\text{Sucrose} \xrightarrow[\text{(Cane sugar)}]{\text{Sucrase (invertase)}} \text{Glucose + Fructose}$$

$$\text{Lactose} \xrightarrow[\text{(Milk sugar)}]{\text{Lactase}} \text{Glucose + Galactose}$$

3- Interokinase:

- **It is not** a digestive enzyme.
- It acts only as a co-enzyme to activate the inactive trypsinogen enzyme into an active trypsin enzyme.

$$\text{Trypsinogen} \xrightarrow{\text{Entrokinase}} \text{Trypsin}$$

Absorption

Definition:

It is the transfer of digested food substances to the blood and lymph through the mucosa (epithelial lining) of the small intestine.

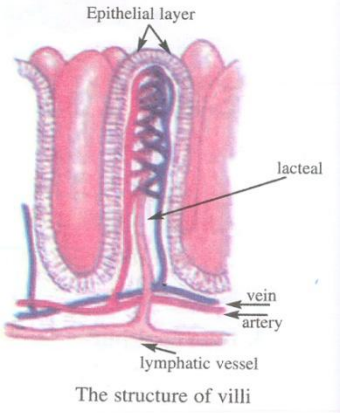
- It takes place by the inner epithelial lining of the ileum
- The inner epithelial lining of the ileum is folded to form villi.
- The villi increase the absorbing surface area of the inner lining wall of the ileum greatly to reach about 10 m^2 i.e. about 5 times as much as the surface area of the human body surface.

Structure of the villus:

- Each villus consists of :

an epithelial layer, inside it there is a lacteal (lymphatic) vessel, the lacteal vessel is surrounded by a network of both venous and arterial blood capillaries.

- There are tiny microscopic projections (زوائد ميكروسكوبية دقيقة) cells of the villi, they are called (Micro-villi) and they increase the area of the absorbing surface of villi.



The structure of villi

- The products of digestion are transferred through the villi by:

membranal diffusion and active transport.

- These absorbed substances pass through two routes:

Blood route and lymphatic route.

BLOOD ROUTE

- **It starts with** the blood capillaries inside the villi.
- **The absorbed substances:**

Water, mineral salts, monosaccharides, amino acids and vitamins which dissolve in water.

- These substances are carried to **the hepatic portal vein** to **the liver** and then to **the hepatic vein** then to **the inferior vena cava** then to **the right atrium** of the heart.

LYMPHATIC ROUTE

- **It starts with** the lacteal vessels inside the villi.
- **The absorbed substances:**

Fatty acids, glycerol and vitamins dissolved in it (A,D,E and K), some fats.

The fats are:

resulted from the recombination of some fatty acids with glycerol,

and some emulsified fats (tiny droplets)(which are not digested by lipase enzyme and absorbed directly by being engulfed **(Engulfment)** by the epithelial cells).

- These substances are carried to **the lymphatic system** which carries them slowly to **the superior vena cava** then to **the right atrium** of the heart.

Metabolism

It is the process by which the body can utilize the absorbed food.

It takes place by two opposite ways which are anabolism and catabolism.

Anabolism:	Catabolism:
It is the process of using simple molecules for building more complex substances throughout a chain of chemical reactions that consume energy. *e.g)* - Glucose can be changed into glycogen and stored in the liver and muscles. - Amino acids can be changed into different forms of polypeptides and proteins to build up new tissues. - Fatty acids and glycerols are converted into fats stored in the body under the skin.	*It is the process of producing energy required for the activity of the body from the absorbed food substances. especially the glucose.*

The large intestine and defecation:

The undigested food passes from the small intestine to the large intestine.

The epithelial wall of the large intestine has many convolutions (G.R) to help in the absorption.

Functions of the large intestine:

1- Absorption of water and salts.

2- The mucosa of the large intestine secretes mucus (G.R) that facilitates passage of faeces to outside.

Wastes become semi-solid faeces, has bad odour (G.R) due to the presence of certain types of bacteria in the large intestine.

Defecation:

Wastes are expelled as faeces by means of:

Strong muscular contractions of the rectum accompanied by the relaxation of two muscles of the anal sphincter situated on both sides of the anus.

SUMMARY OF ENZYMES

The juice	The enzyme and juice	Site of secretion	Site of action	The action
Saliva	Amylase (Ptyalin)	Salivary glands	The mouth	It catalyzes the hydrolysis of starch into disaccharide maltose.
Gastric juice	Pepsin	Stomach	Stomach	It catalysis the hydrolysis of proteins to polypeptides
Pancreatic juice	Pancreatic amylase	Pancreas	The duodenum	It catalyzes the hydrolysis of starch and glycogen into maltose.
	Trypsin			It catalysis the hydrolysis of proteins to polypeptides
	Lipase			It catalysis the hydrolysis of emulsified fats into glycerols andfatty acids.
Intestinal juice	Peptidases	Certain cells in the wall of the small intestine		Catalysis the hydrolysis of polypeptides to amino acids.
	Maltase			maltose to **Glucose + Glucose**.
	Sucrase			Sucrose to **Glucose + Fructose**
	Lactase			Lactose to **Glucose + Galactose**
	Interokinase			Activates trypsinogen to trypsin

BIOLOGY

2nd Year

First term

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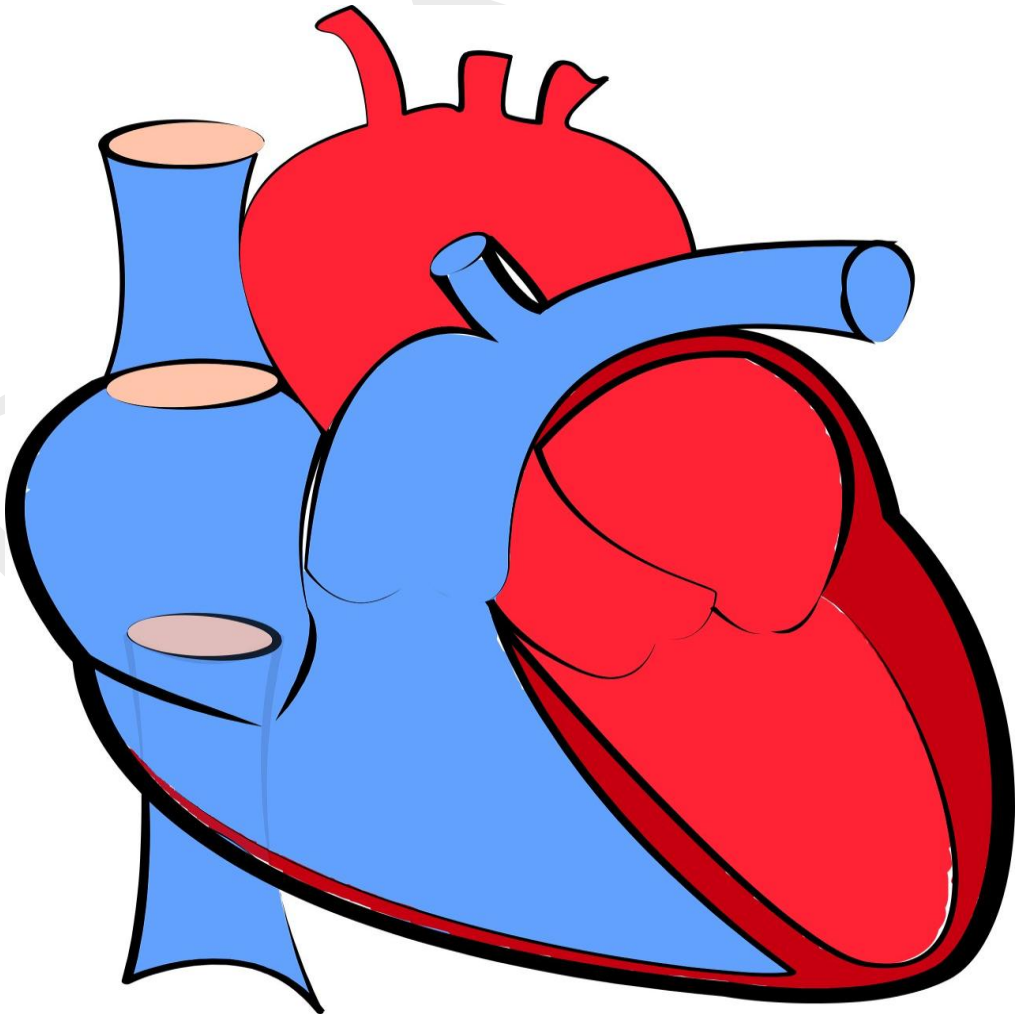
Unit (2)

TRANSPORT

in living organisms



Transport in living organisms

All living organisms need transport:

- In primitive plants like algae:

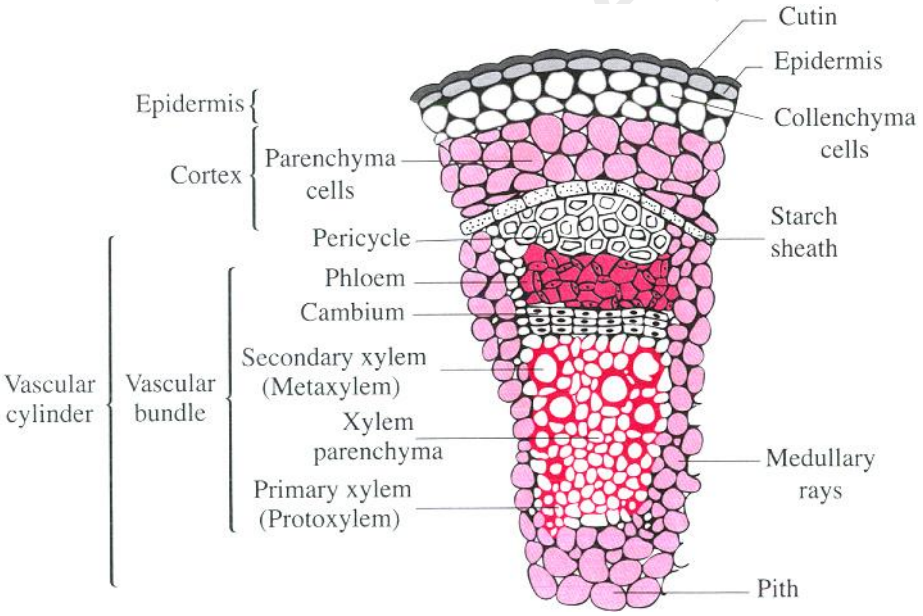
the raw materials and the products of photosynthesis move from one cell to another by diffusion and active transport.

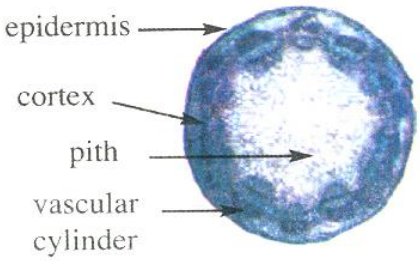
- In higher plants: gases move by diffusion while water, mineral salts and soluble products of photosynthesis need special systems for transport.
- In small animals (like protozoa and Hydra): gases and food substances move by diffusion.
- In higher animals: gases and food substances need special systems for transport.

Transport in higher plants

Water And Salts → Xylem vessels → LEAVES (Photosynthesis) → Sieve tubes of the phloem → Other parts of the plant

Structure of the stem





A detailed T.S. in a dicot stem to show its internal structure

1- Epidermis:

- It is one raw of adjacent, barrel-shapped, parenchyma cell.
- The outer walls are covered by a cuticle, to prevent water loss.

2- Cortex:

- It consists of:-

* External collenchyma cells:

Several rows, their corners are thickened by cellulose.

Functions: 1- Help as a mechanical support for the stem.

2- They contain chloroplasts so that they take part in photosynthesis.

* Internal parenchyma cells:

Several rows have intercellular spaces.

Function: Help in aeration of the stem.

- **The starch-sheath:**

It is the intermost row of cells of the cortex, it is used for storage of starch grains.

3- Vascular cylinder:

- It occupies much of the stem and consists of the following tissues:

a) Pericycle:

- It consists of alternative groups of parenchyma cells and fibres where each fiber group is in opposite to a vascular bundle.

Function: It supports the stem and gives it elasticity.

b) Vascular bundles:

- They are arranged in a cylinder, each bundle is triangular in shape with its base directed outwards.
- The bundle consists of the following tissues:

1- Phloem:

- It is the outer tissue of the bundle; it consists of sieve tubes, companion cells and phloem parenchyma.

Function: - Transport of organic food substances.

2- Xylem:

- It is the internal part of the bundle.
- It consists of xylem vessels and Tracheids.

Function: - Translocation of water and solutes and it also acts as a supporting tissue for the stem.

3- Cambium:

- It is one raw of meristematic cells; it lies between the phloem and the xylem of the vascular bundle.

Function: When its cells divide, they give rise externally to secondary phloem and internally to secondary xylem.

c) Pith:

- It consists of parenchyma cells and occupies the center of the stem.

- **Function**: It helps in the purpose of storage.

d) Medullary rays:

- They are rows of parenchyma cells that extend between the vascular bundles to join the cortex with the pith.

Mechanism of transport from the root to the leaf

Transport of water and solutes from the roots to the stem and leaves takes place by xylem vessels and tracheids.

1- VESSELS

The xylem vessel consists of elongated cylindrical cells joined end to end.

How were the vessels formed?

- The transverse walls have been completely dissolved and the cells become one tube.
- At the same time, the cellulose wall has become thickened by lignin, which is impermeable to water and solutes.
- The protoplasmic content has died leaving a hollow vessel.

Pits:

- They are certain placements all over the wall of xylem vessel, they are lift without thickening.
- **Functions of the pits**:

they permit water to pass from inside the vessel outward.

Thickening of vessels:

Lignin is laid down on the inner wall of the vessel in the form of strands taking various forms such as annular and spiral.

Function of lignin strands:

they help to support the vessel and prevent the collapse of its wall.

2- TRACHEIDS

- They are similar to the vessels except that:

1- They appear in a T.S. in a pentagonal or hexagonal form.

2- They are pitted and their ends are not open but pointed and closed.

Factors responsible for ascent of sap

Root pressure theory | **Imbibition theory** | **Capillary theory** | **Transpiration pull-Cohesion – Adhesion theory**

Root pressure theory

- It is the force that acts to raise water vertically through xylem vessels for a short distance to a certain level.

G.R) **Occurrence of root pressure**:

It is due to the presence of continuous and direct absorption of water from the soil by osmotic pressure.

G.R) **Raise of water by root pressure stops at a certain level:**

because the opposing pressure of the water column in xylem vessels has become **equal to** the root pressure.

What is the direct evidence for presence of the root pressure?

Guttation is the direct evidence for presence of the root pressure.

Guttation phenomenon:

- It is the exudation of water from the stump, when a plant stem is cut very near to the soil.

Disadvantage of the root pressure theory

The root pressure theory can not explain the ascent of water to high levels in tall trees (G.R):

because:

1- The maximum root pressure does not exceed 2 atmospheres.

2- Pinus and other conifers have no root pressure.

3- The force of root pressure is affected quickly by external factors.

Imbibition theory

Walls of xylem vessels imbibe water (G.R):

because of the colloidal nature of cellulose and lignin.

Imbibition has a very limited effect on the ascent of sap in xylem vessels (G.R):

because the sap ascends through the cavities of the xylem vessels and not along their walls.

The importance of imbibition is restricted to:

the transport of water along the cell walls until it reaches the walls of vessels and tracheids in the root, and from these vessels and tracheids to the neighboring cells in the leaves.

Capillary theory

It is the rising of water in tiny tubes.

Xylem vessels are considered as capillary tubes (G.R):

because their diameter ranging from 0.02mm to 0.5mm.

Capillarity is a weak secondary force for the ascent of sap (G.R):

because the finest capillary tube does not allow the rise of water more than a height of 150cm.

Transpiration pull - Cohesion - Adhesion theory: (H.H.Dixon and J.Joly in 1895)

This theory explains the forces that act to pull water upward to very high levels e.g. Approximately 100 meters.

This theory states that:

The water column ascends through the xylem vessels depending upon three forces: cohesive, adhesive and transpiration pull.

1- **Cohesive force:-** It is due to the strong mutual attraction between water molecules inside the xylem vessels and tracheids.

- This force explains the existence of a continuous column of water.

2- **Adhesive force:** It is the force between water molecules and the walls of xylem vessels.

- It helps the water column to be held against the effect of gravity.

3-Transpiration pull: This pull attracts the water column upwards due to the continuous process of transpiration in the leaves.

Dixon and Joly put three conditions required to pull water from xylem to leaves:-

1- The vessel must be like capillary tube.

2- The walls of the tube must possess an adhesive force to attract water.

3- The tubes must be free of any gas or air bubbles to avoid any breaking and therefore descent of the water column.

All these conditions are known to exist in xylem vessels.

G.R.) When some seedlings are transplanted from a nursery to an open soil, they fall to grow, if they remain exposed to the sun for a long time before they are transplanted in the new soil.

The answer:

Because heat of the sun causes a loss of water from the seedlings, air bubbles enter the xylem vessels and the water column is cut, so that water does not ascend in xylem vessels and the seedlings die.

The path of the sap during its ascent from the root to the leaves

1- **Transpiration** lessens (يقلل) the water concentration in the air chamber above the stoma in the leaf.

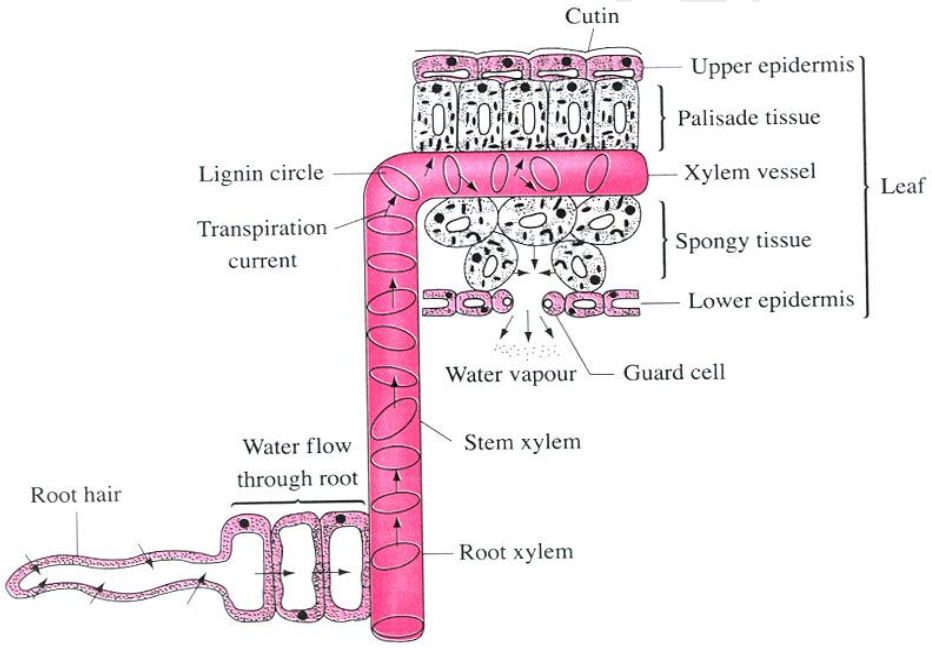
2- **Evaporation** increases from the cells of the mesophyll surrounding the stomatal chamber.

3- **Water content** of the cells of mesophyll **decreases**, therefore their concentration increases.

4- The increasing in cell concentration creates a **pulling force** (قوة شد) to attract water from the surrounding cells.

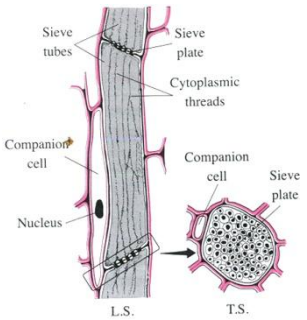
5- This will continue as far as (حتى يصل الى) the xylem elements in the venules and veins, then finally from the midrib of the leaf.

6- Transpiration pull **attracts water from xylem vessels and tracheids** of the stem and the root and also it will help in the lateral pull of water from the root hairs.



Transport of manufactured food from the leaf to other parts of the plant

The phloem consists of sieve tubes and companion cells.



1- Sieve tubes

- They appear in a longitudinal section as elongated cells, arranged end to end.
- They contain cytoplasm **without a nucleus**.
- They are separated from each other by **sieve plates** cross-walls which are perforated by **tiny pores** through which cytoplasmic strands extend from one tube to another.
- Each sieve tube has a nucleated companion cell.

2- Companion cells

- Nucleated cells.
- They organize the vital functions of the sieve tube by their **ribosomes** and **mitochondria**.

Mechanism of transport of ready-made food substances

Thain and Canny Scientists:

-They could see long cytoplasmic threads which contain organic substances inside the phloem tubes, these lines extend through tiny pores from one tube to another.

-They explain the transportation in the phloem on the basis of cytoplasmic streaming.

Cytoplasmic streaming:

-It is the cytoplasmic circular movement inside the sieve tubes.

Explanation of cytoplasmic streaming:

It needs more of ATP molecules which exist in the companion cells, **so that:**

- It is affected by temperature and oxygen in cells (G.R).

-It is **delayed** with the decrease of temperature or oxygen in cells which delayed the movement of cytoplasm in sieve tubes.

Human transport system

Transport in human body takes place through two systems:

a) Blood vascular system (Circulatory system) b) Lymphatic system.

I- Circulatory system

- It consists of the heart and the blood vessels through which the blood passes.
- The blood vessels form a complete circuit, so that the circulatory system is closed.

THE HEART

- It is a hollow muscular organ which lies nearly in the middle of the chest cavity.
- It is enclosed in **the pericardium** to protect the heart and facilitate its pumping action.

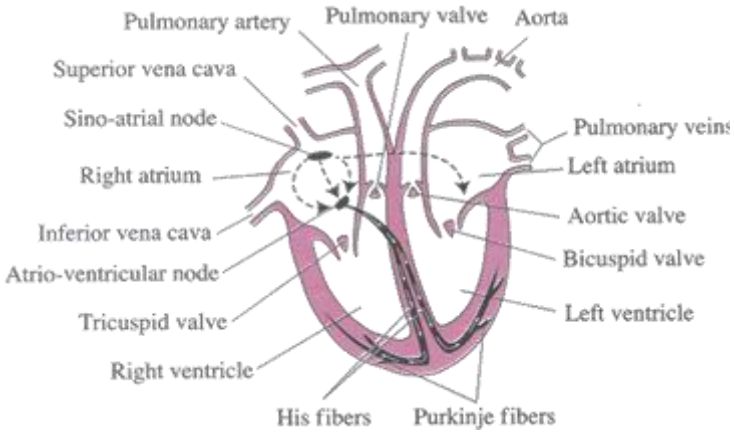
- It is divided into 4 chambers which can be divided:

Transversely			
Two atria	Upper	Thin walled	Receive blood from the veins.
Two ventricles	Lower	, thick walled	pumping blood through the arteries
Longitudinally by muscular wall			
The right side	Consists of **right atrium and right ventricle**	**Tricuspid valve** connects exists.	filled with a **deoxygenated blood**
The left side:	Consists of **left atrium and left ventricle**	**Bicuspid valve** exists (or mitral valve)	filled with **oxygenated blood.**

❖ Function of the valves:

Each valve permits the blood to flow from atrium to ventricle, but not in the reverse direction.

- There are also **semi-lunar valves** at the connection between the heart and both the pulmonary artery and the aorta to permit the blood to flow from the heart to the artries in one direction.
- The heart beats regularly throughout lifetime.



HEART BEATS

- The rhythmic heart beats are spontaneous as they originate from the cardiac tissue itself.
- It has been proved that the heart continues beating regularly even after it has been disconnected from the body and cardiac nerves.

* The sino-atrial node(The pace-maker):

It is a specialized bundle of thin cardiac muscular fibers buried in the right atrial wall near the connection between the right atrium and the large veins.

- It is considered as **pace maker** for the heart beats.
- It beats at a regular rate of 70 beats/minutes (it pumps 5 liters of blood every minute, this quantity nearly equal to the whole quantity of blood of the body)
- This rate changes according to the **physical and psychological state of the body** (G.R), this is because the sino-atrial node is connected to two nerves:

1- **The vagus nerve**: acts to **lower the rate of cardiac beats** e.g. during sleep and grief.

2- **The sympathetic nerve**: acts to **increase the rate of heart beats** e.g. in case of sever physical effort and joy also it gradually increases after waking up.

Mechanism of heart beats:

- **The sino-atrial node sends impulses** spontaneously to stimulate **the muscles of the two atria** to contract.
- The electrical impulse reaches **the atrio-ventricular node** (at the junction between the atria and the ventricles).
- The impulse transfers rapidly from the atrio-ventricular node through **Hess fibers** then spreads from **the inter-ventricular septum** to the wall of both ventricles through **Purkinje fibers** to stimulate them to contract.

The sino-atrial node
↓
The muscles of the two atria (contract)
↓
The atrio-ventricular node
↓
Hess fibers
↓
The inter-ventricular septum
↓
Purkinje fibers
↓
The wall of both ventricles (contract)

Heart beats:

*** We can distinguish two different sounds in the heart beat:**

One is long and low pitched (lubb):

It is due to closure of the two valves between the atria and ventricles during ventricular contraction.

The other is shorter and high-pitched (dupp):

It is due to closure of aortic and pulmonary valves during ventricular relaxation.

THE BLOOD VESSELS

Arteries | **Capillaries** | **Veins**

Comparison between artries and veins:

P.O.C.	Arteries	Veins
Blood direction	from the heart to other organs of the body	to the heart
Blood type	oxygenated blood, except the pulmonary artery which comes out from the right ventricle to the lung.	deoxygenated blood, except the pulmonary veins which opens into the left auricle.
Location	buried among the body muscles.	beneath the skin.
Wall	Thick, elastic and pulsate.	Thinner, less elastic not pulsate.
Valves	Not found except at the base of aorta and pulmonary artry.	Number of veins possesses a system of internal valves which prevent the backflow of blood.

The wall of artries and veins:

Both the walls of artries and veins are formed of three layers:

- **The outer layer**: consists of connective tissue with elastic fibers.
- **The middle layer**: consists of involuntary muscles which contract and relax under the control of nerve fibers.
- **The inner layer** (the endothelium): consists of one row of epithelial cells.

The difference between the wall of artries and veins:

The outer layer (connective tissue, elastic fibers): Thick in the artry and thin in the vein.

The middle layer (involuntary muscles): Thick in the artry and less thick in the vein.

The valves of veins:

The arm veins can be observed when the arm is tied tightly with a bandage above the elbow, this is done by **William Harvey**, English doctor, who discovered **the blood circulation** in the 17th century after **Ibn Elnafees** has discovered it in the **10th century**.

Capillaries

Definition: They are tiny, microscopic vessels which connect the arterioles with the venules.

Diameter: average diameter of (7:10) microns.

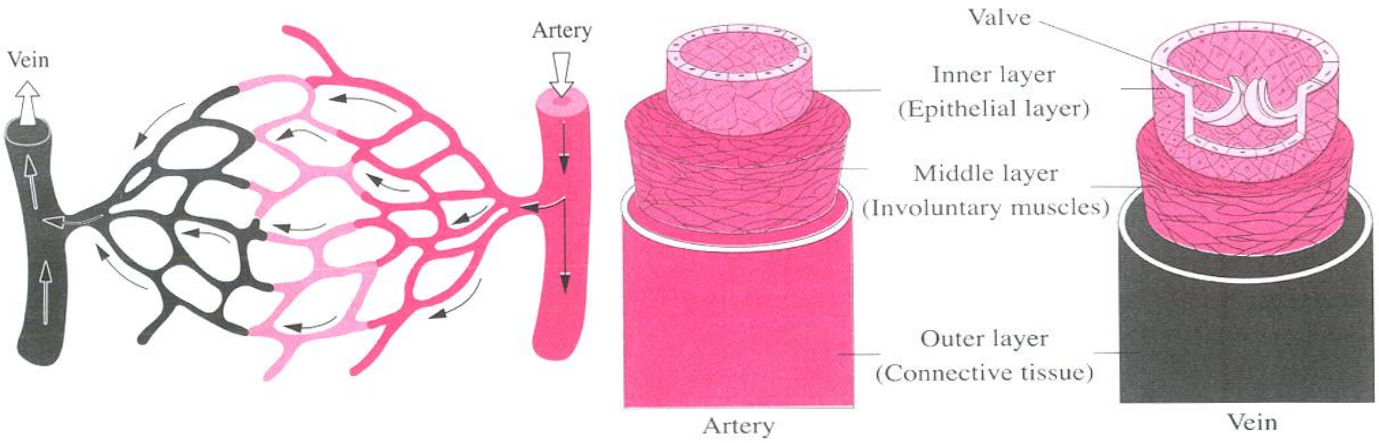
Walls: very thin and consist of one row of thin epithelial cells with tiny pores between them.

Lengh: about 80 .000 Km.(If the capillaries of the human body were put end to end).

Functional suitability:

- They spread in the spaces between cells all over the body tissues so that they reach all the cells of the body and supply them with all their requirements.
- The wall is about 0.1 micron thick so that it facilitates a quick exchange of substances between the blood and tissue cells.

They were discovered: by the Italian scientist **Malpighi** (at the end of the 17th century), he completed the work of **Harvey**.



THE BLOOD

Structure: It is a liquid connective tissue, contains red blood cells, white blood cells and platelets, and the tissue fluid part of it is called plasma.

- It is the principal medium in transport.

Colour: reddish in colour.

The medium: weakly alkaline (pH=7.4).

The volume: The human body contains from 5 to 6 litres of blood on average.

Functions of the blood:

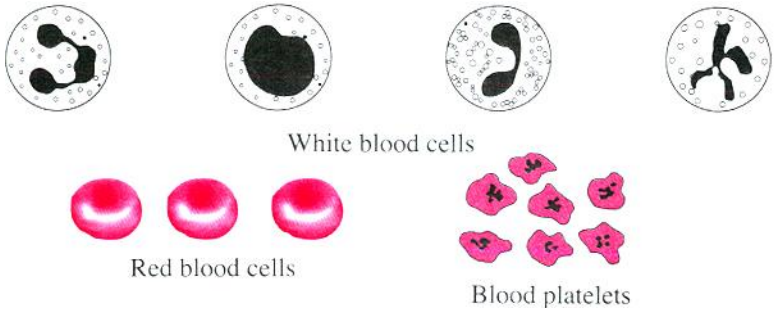
1- Transport of digested food substances, O_2, CO_2, wastes, hormones and some active and inactive enzymes.

2- Controlling processes of metabolism and keeping the body temperature at 37°C. In addition to the regulation of the internal environment (homeostasis) such as osmotic potential, pH value …etc.

3- Protection of the body against microbes and pathogens through immunity involving lymphatic system.

4- Protection of the blood itself against bleeding by formation of clots.

Components of human blood:



Plasma:

- It is 54% of blood volume.

• **It consists of** :-

- Water (90 %)
- Inorganic salts (1 %), such as Na^{+}, Cl^{-}, $(HCO)^{-}$, Ca^{++}
- Proteins (7%), such as albumin, globulin and fibrinogen.
- Other components, such as digestive products, hormones, enzymes, antibodies and wastes (urea).

Erythrocytes RBCs (Red blood corpuscles):

Origin:bone marrow where 100 million of RBCs are produced every minute.

Number: (4 : 5 million/mm^3) in males and (4 : 4.5 million/$mm^{3)}$ in females.

Description: circular and concave in both sides.

Colour: red due to the presence of hemoglobin.

Age: not more than 120 days, each one circulates within the blood circulation for 172.000 times, then they are broken down in liver, spleen and bone marrow and their proteins are reused to form the bile juice which plays an important role in digestion of fats.

Structure: have no nucleus (enucleated) but contain large amounts of hemoglobin.

Hemoglobin

- **Colour**: It has a red colour and it is the cause of the blood colour.
- **Components**: It is composed of proteins and iron.
- **Function**:

It is responsible for the transport of O_2 from lungs to cells and transport of CO_2 from cells to lungs as follow:

1- Hb combines with O_2 in lungs to produce **Oxyhemoglobin** substance of bright red colour (blood of arteries).

2- RBCs then transfer oxygen to the body cells where Oxyhemoglobin leaves oxygen for the cells and turns again to Hb.

3- Hb then combines with CO_2 to produce **Carbaminohemoglobin** substance of dark red colour (blood of veins).

4- RBCs return back to the lung Carbaminohemoglobin leaves CO_2 and and turns again to Hb and the cycle is repeated.

Leukocytes WBCs (White blood corpuscles):

Origin: Bone marrow, the spleen and the lymphatic system.

Number: (7000/ mm^3), the number increases during inflammation (diseases).

Description: Have no definite shape.

Colour: Colourless.

Age: (13-20 days).

Function: Have many types, each type has a special function, their main function is to Protect the body against infection, where they:

1- Attacking microbes (destroy and engulf them).

2- Removing of foreign substances in the blood (such as the products of microbes).

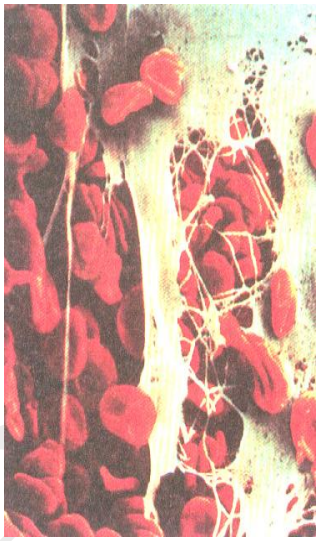
3- Removing of dead cells and other wastes.

4- Production of antibodies:

Platelets:

- **Origin**: Bone marrow.
- **Number**: (250 000/ mm^3).
- **Description:** small non-cellular particles.
- **Age**: About 10 days, they are regenerated continuously.
- **Size**: 1/4 the size of RBC.
- **Function**: Plays an important role in clotting.

BLOOD CLOT



When a blood vessel is cut, blood soon forms a clot.

Importance: to prevent bleeding before it leads to a shock followed by death.

Factors (Reasons) of blood clot:

1- Blood exposure to air.

2- Blood friction with a rough surface such as damaged vessels and cells.

Mechanism of blood clotting:

When the factors of blood clotting exist, a sequence of steps takes place:

1- Both the blood platelets and the damaged cells (at the site of wound) form a protein substance called **thromboplastin**.

2- In presence of Ca^{++} and blood clotting factors in the plasma, thromboplastin activates the conversion of **prothrombin** to the enzyme **thrombin**.

Prothrombin:

is a protein formed in the liver with the help of vitamin K and it is passed directly into the blood.

3- Thrombin catalyzes the conversion of **fibrinogen** (soluble protein in plasma) into **fibrin** (an insoluble protein).

4- Fibrin precipitates as a network of microscopic interlacing fibers. The blood aggregates and forms a clot which blocks the whole in the damaged blood vessel. In this way bleeding stops.

Summary of the mechanism of blood clotting:

1- Blood platelets + destroyed cells —(Factors of clotting in the blood)→ **Throboplastin**

2- Prothrombin —(Thromboplastin + Ca^{++}, Clotting factors)→ **Thrombin** (Active enzyme)

3- Fibrinogen (Soluble protein) —(Thrombin)→ **Fibrin** (Insoluble protein)

Why does blood not clot inside the blood vessels?

Blood never clots inside the blood vessels because:

1- It runs in a normal fashion in the blood vessels without slowing down.

2- The platelets slide easily and smoothly inside the blood vessels in order not to be broken.

3- The liver secretes **heparin** substance which prevents the conversion of prothrombin to thrombin.

THE BOOD PRESSURE

Blood is a viscous liquid that circulates because of the process of heart beats:

-Smoothly within the arteries and veins.

-But it needs pressure to pass within the microscopic blood capillaries due to their resistance to the viscous blood.

When the ventricles contract:

the blood pressure increases and the blood pressure is maximum in the arteries nearer to the heart.

When the ventricles Relax:

the blood pressure decreases and becomes minimum as we go away from the nearer artries to the heart to rach its minimum ratio in blood capillaries and veins (10 mm Hg).

- The return of blood in veins to the heart **depends on the valves** in it and the muscles surrounding them.

Measurment of blood pressure:

- The blood pressure is measured by means of mercuric instruments, **sphygmomanometers**.
- **Its reading consists of two numbers:**

The maximum number: is measured during contraction of ventricles (cystolic).

(The maximum blood pressure in the normal man is 120 mmHg.)

The minimum number: is measured during relaxation of ventricles (diastolic),

(The minimum blood pressure in the normal man is 80 mmHg.)

Example:

The blood pressure of the normal man is 120/80 mm Hg.

120: indicates the blood pressure during contraction of ventricles (cystolic).

80: indicates the blood pressure during relaxation of ventricles (diastolic).

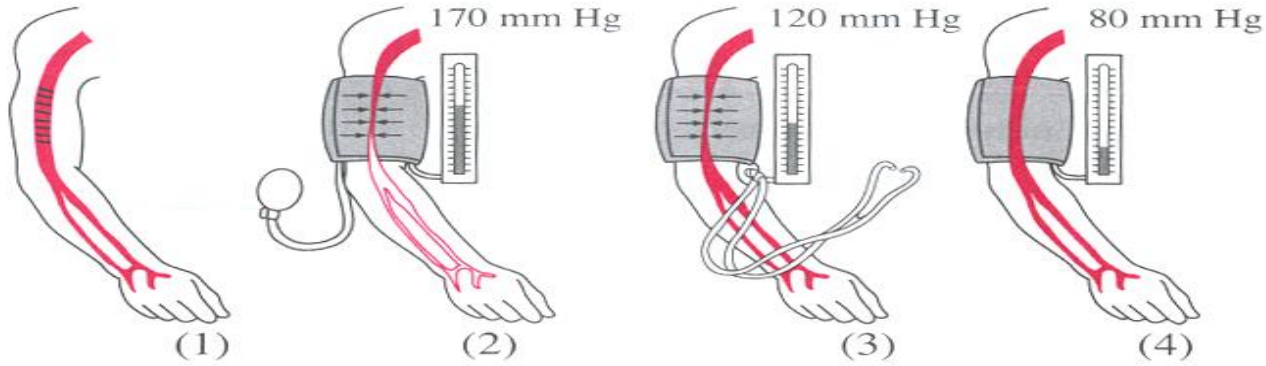
Method of measurement of the blood pressure:

- The values of blood pressure can be measured by listening to the heart beats and as well as between one beat and another, as follow:

On hearing the sound of heartbeat, the doctor can determine the maximum value of blood pressure, referring to the ventricles contraction (cystolic).

When the sound disappears, the doctor can determine the minimum value of blood pressure, referring to the ventricles relaxation (diastolic).

- There are some digital instruments to measure the blood pressure, but they are not accurate as mercury instruments.



N.B)

The blood pressure increases gradually by aging and it must be under medical control to avoid its harmful effects.

BLOOD CIRCULATION

Blood circulation in Man is divided into three main pathways:

Pulmonary circulation:

- It starts from the right ventricle and ends at the left atrium.

Mechanism

1- **The right ventricle** contracts, **the tricuspid valve** closes the opening of the right atrium.

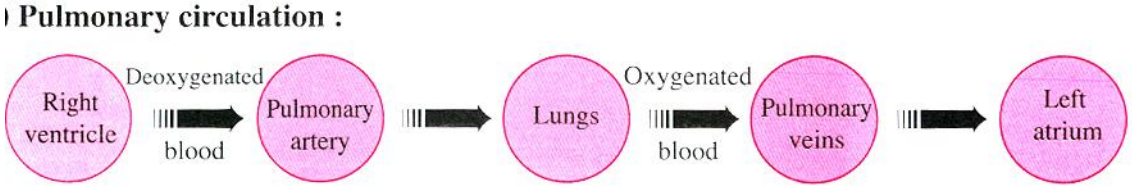
2- The deoxygenated blood will rush through **the pulmonary artery** through **the semi-lunar valve** which prevents the back flow of the blood to the right ventricle.

3- The pulmonary artery gives rise to two branches, each branch goes to **a lung** where it branches to form several arterioles which **terminate in blood capillaries which spread around the alveoli.**

4- **Gas exchange takes place** where CO_2 and H_2O vapour diffuse from the blood while O_2 will move toward it, the blood becomes **oxygenated**.

5- The oxygenated blood returns from the lungs through **four pulmonary veins** (two veins from each lung) to open into the left atrium.

6- When the left atrium contracts, blood passes to the left ventricle **through the bicuspid valve**.



Systematic circulation:

- It starts from the left ventricle and ends at the right atrium.

Mechanism:

1- When **the left ventricle** contracts, **the mitral valve** (bicuspid valve) closes.

2- The oxygenated blood will rush from the left ventricle to **the aorta** while **the semi-lunar valve** prevents the back flow of the blood to the left ventricle.

3- **The aorta** gives rise to several arteries, some of which move up-wards and others go downward.

4- Arteries then branch to form smaller and smaller arterioles which end by blood capillaries, these capillaries spread through the tissues in between the cells.

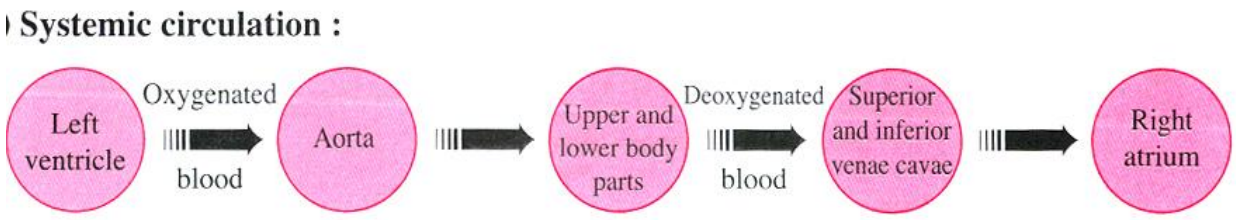
5- O_2, water and dissolved food substances are transported to the cells, on the other hand, products of catabolism, such as CO_2, diffuses to the blood in the capillaries, the colour of the blood changes from light red to dark red i.e. **it becomes deoxygenated.**

6- Blood capillaries collect to give rise to larger and larger venules and finally veins, which power their deoxygenated blood into the superior and inferior vena cava which carry blood to the right atrium.

7- The walls of the right atrium contract and so the blood is forced to the right ventricle which becomes filled with deoxygenated blood.

N.B.:

Contraction of the right side of the heart occurs at the same time as contraction of the left side, therefore, pumping of the deoxygenated blood from the right ventricle and pumping of the oxygenated blood from the left ventricle, both take place at the same time.



1- Hepatic Portal circulation:

After absorption of digested food substances, both glucose and amino acids are transported to the blood capillaries inside the villi.

1- The blood capillaries aggregate into small venules, then large venules and finally they pour their content into the hepatic portal vein, which receives veins from the pancreas, the spleen and the stomach.

2- The hepatic portal vein carries blood into the liver where it branches to end with minute blood capillaries.

3- Excess food substances which exceed the body needs filter through the capillary walls and pass through the liver where they undergo certain changes.

4- The blood capillaries unite into the hepatic vein which leaves the liver to pour its contents into the upper part of the inferior vena cava, just before it enters the right atrium.

2- The lymphatic system

- The lymphatic system is considered as the immune system of the body (G.R):
due to its ability for defense and the production of the antibodies that give the body its immunity.
- The spleen is considered one of the most important lymphatic organs in the body.
- The lymphatic system consists of:

1- **The lymph:** A fluid diffuses from plasma, it consists of all components of plasma, in addition to a large number of leucocytes (WBCs).

2- **Lymphatic vessels:** They collect the lymph and empty it into the circulatory system along the superior vena cava.

3- **The lymph nodes:** The lymph passes across the lymph nodes which are found at certain points along the lymph capillaries.

They trap microbes by white blood cells which they produce.

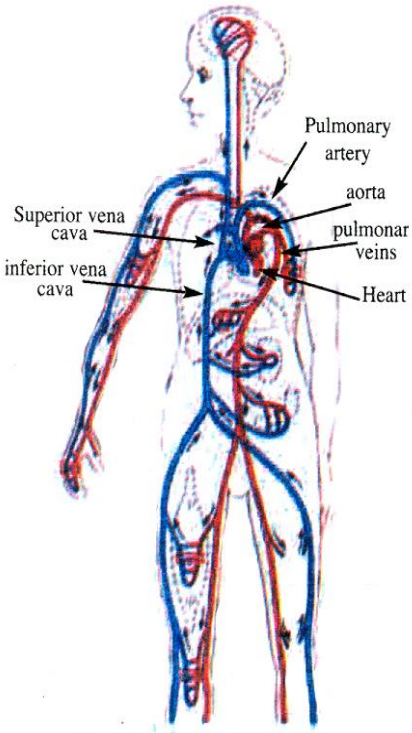
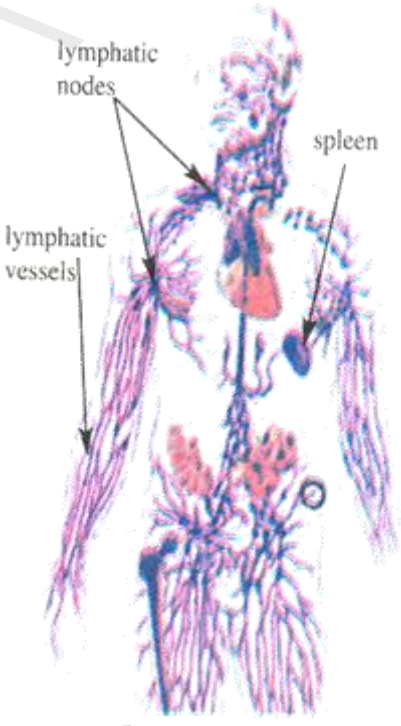
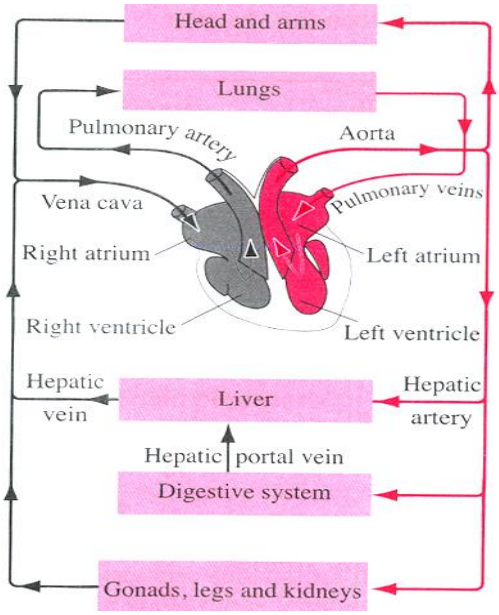
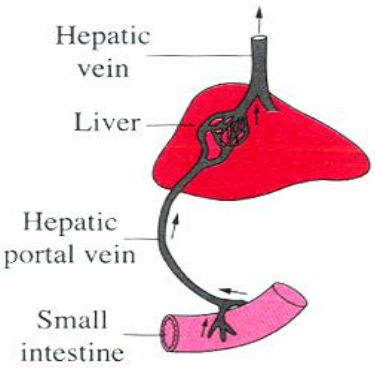


Fig. 10 Blood Circulation



Lymphatic system





Unit (3)

RE

SPIRATION

in living organisms

Respiration in living organisms

Gas exchange

It is the process by which the living organism **obtains oxygen**, directly in case of unicellulars or by a a respiratory system in case of multicellulars, and **releases CO_2** as a final poduct of respiration.

Cellular respiration

It is the process by which energy is extracted from bonds in the food molecules manufactured by the plant, or eaten by the animal.

- This energy is stored in the form of ATP molecules to be used in different activities.
- Glucose and other carbohydrate molecules are considered as energy-storing foods, and also they carry energy from one cell to another.
- The glucose molecule is used to study the steps of breakdown of food molecules (G.R): because it is the most commonly used by the majority of living organisms.

Structure of ATP

- ATP (Adenosine Tri Phosphate) molecule is built up of three sub-units:

1- **Nitrogenous base**: Adenine which has base properties.

2- **5-Carbon pentose sugar**: Ribose sugar.

3- **3 Phosphate groups**.

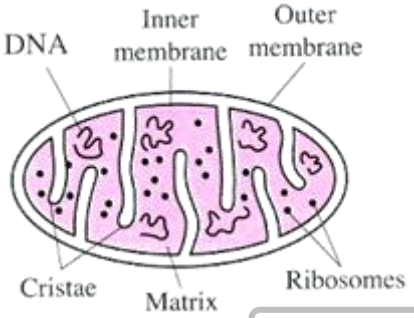
- **ATP is considered as the universal currency of energy in the cell (G.R)**

Because any energy required by the cell needs ATP and when ATP is converted into ADP ,by losing one phosphate group, energy is released (about 7 : 12 Kcal/mole).

ATP ⟶ ADP+ Energy (about 7-12 K cal/mole)

Structure of mitochondria

- It is surrounded by a double membrane; the outer membrane is smooth while from the inner one a group of folds known as (Cristae) extend into the matrix, the function of the matrix is to increase the surface area on which the chemical reactions of cellular respiration take place to produce energy.
- Most of the chemical reactions of cellular respiration occur in mitochondria, so that it is considered as **the center of energy production in the cell** (G.R).



Cellular respiration

- There are two types of cellular respiration:

a) Aerobic cellular respiration.

b) Anaerobic cellular respiration.

Aerobic cellular respiration

- **These reactions take place**: in presence of oxygen.
- **They take place in three steps:**

glycolysis, Krebs cycle and electron transport.

- **The majority of these reactions occur inside the mitochondria (G.R)**:

where there are respiratory enzymes, co-enzymes, water, phosphates and other molecules such as cytochromes.

- **The produced energy** is stored in ATP molecules.
- **Number of produced ATP molecules** from the oxidation of 1 mole of glucose:

38 molecules.

- **Equation of cellular respiration:**

$$C_6H_{12}O_6 + 6O_2 \xrightarrow{\text{(Oxidation)}} 6CO_2 + 6H_2O + 38ATP$$

- **During the reactions of glycolysis and Krebs cycle:**

hydrogen atoms are removed from the carbon skeleton of the glucose molecule (oxidation) to pass to the co-enzymes which act as **hydrogen-carriers**.

- **Of these co-enzymes are:**

NAD^+ (Nicotinamide adenine dinucleotide) and FAD (Flavin adenine dinucleotide), each one of them receives 2 electrons and reduced into NADH and $FADH_2$, respectively as follows:

$$NAD^+ + H_2 \xrightarrow{\text{(Reduction)}} NADH + H^+$$

$$FAD + H_2 \xrightarrow{\text{(Reduction)}} FADH_2$$

First: GLYCOLYSIS

- **It occurs in case of:**

aerobic (presence of O_2) and anaerobic (absence of O_2) cellular respiration so that it is called **anaerobic respiration**.

- **Site of reactions:**

in the cytosole of the cell.

Cytosole: it is the non-organelle part of cytoplasm.

- **Products glycolysis:**

2 molecules of pyruvic acid + two molecules of ATP + two molecules of NADH.

- **Steps:**

- Glucose molecule is converted into Glucose 6-phosphate (6 C) then Fructose 6-phosphate (6 C) then Fructose 1,6 -diphosphate (6 C).

- The Fructose 1,6 –diphosphate is splitted into 2 molecules of PGAL (phosphoglyceraldehyde) (3C)

- Each molecule of PGAL is oxididized into a molecule of pyruvic acid (3 C).

- **During these reactions:**

2 molecules of NAD^+ are reduced to NADH

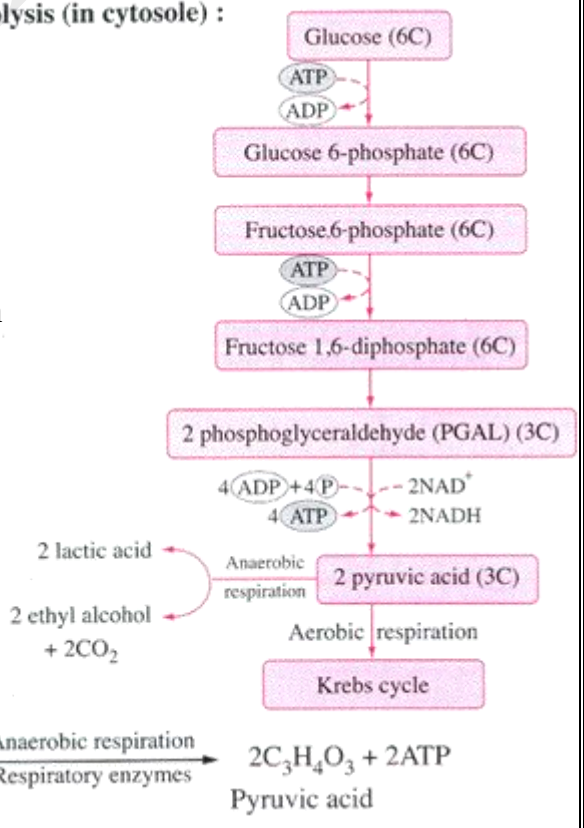
2 molecules of ATP are produced in cytosole.

The energy produced from glycolysis (2ATP):

is not sufficient for performing the biological functions,

so that the molecules of pyruvic acid pass from the cytoplasm to the mitochondria in presence of oxygen to produce greater amount of energy

Steps of glycolysis (in cytosole) :



General equation of glycolysis:

$$C_6H_{12}O_6 \xrightarrow[\text{Respiratory enzymes}]{\text{Anaerobic respiration}} 2C_3H_4O_3 + 2ATP$$

Importance of glycolysis:

1-Production of energy (2 ATP)

2-Production of 2 pyruvic acid molecules

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow[\text{Respiratory enzymes}]{\text{Anaerobic respiration}} \underset{\text{Pyruvic acid}}{2C_3H_4O_3} + 2ATP$$

The pyruvic acid molecules will be used in aerobic and anaerobic respiration.

Second: KREBS CYCLE

This cycle was first described by Sir **Hans Krebs in 1937**, for which he won the Nobel Prize in 1953.

Before Krebs Cycle and In presence of oxygen:

- Each pyruvic acid molecule, in the mitochondria, is oxidized into an acetyl group and each acetyl group then combines with a compound called co-enzyme A (Co-A) to give rise to acetyl coenzyme (A) (or acetyl Co-A).

Products of this reaction:

- 2 NADH molecules.
- 2 CO_2 molecules.

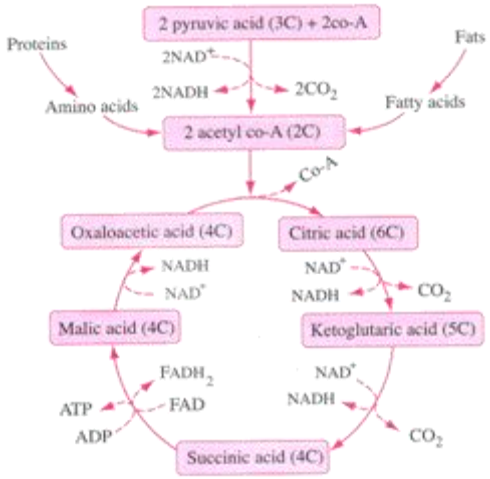
Reactions of Krebs cycle:

1- The **Co-A** of each **acetyl Co-A** molecule **splits off to** repeat its role while **the acetyl group** (2C) combines with a 4-carbon compound (**oxaloacetic acid**) to form a 6-C compound (**citric acid**).

2- In the pathway of the cycle, citric acid molecule passes by **three intermediate compounds**, starting with **ketoglutaric acid (5C)** then **succinic acid** (4C) and ending with **malic acid (4C)**.

3- The reactions of Krebs cycle **end with citric acid once more**, so that the cycle is known as the citric acid cycle (G.R).

4- Each cycle **consumes one acetyl group**, so that the cycle takes place **two times for the oxidation of the glucose molecule**.



Products of one Krebs cycle

1- 3 molecules of NADH.

2- 1 molecule of $FADH_2$.

3- 1 molecule of ATP.

4- 2 molecules of CO_2.

N.B.

- Krebs cycle does not need oxygen (G.R),

since all electrons and protons which are removed during oxidation of carbon atoms are received by NAD^+ and FAD.

- During the count of ATP molecules:

the products of Krebs cycle is multiplied by 2, because the cycle takes place two times.

N.B) Acetyl groups which are produced from breaking down of **glucose**, **proteins** and **fats** can enter the Krebs cycle reactions.

Third: ELECTRON TRANSPORT

Site of reactions: mitochondria.

Steps of electron transport:

After glycolysis and Krebs cycle, most of the energy is transferred to the hydrogen carriers (NAD^+ and FAD) in the form of high energy level electrons.

- These electrons and hydrogen descend step by step through energy levels of cytochromes molecules (electron carriers).

Cytochromes:

Co-enzymes; located in the inner wall of mitochondria and carry high-energy electrons at different energy levels.

- The energy liberated during this passage of electrons is used in the **oxidative phosphorylation** process to form ATP molecules from ADP and phosphate groups.
- Finally, the 2 electrons combine with 2 protons (H^+) and an oxygen atom to form water according to the equation:

$$2H^+ + 2e^- + 1/2\ O \longrightarrow H_2O$$

Role of oxygen in electron transport reactions:

Oxygen is considered as the last acceptor of electrons in electron transport series.

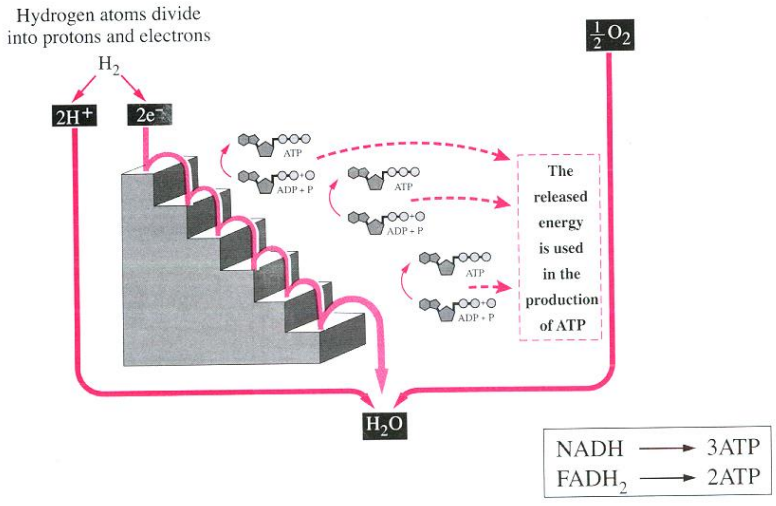
• During the electron transport reactions, molecules of NADH and $FADH_2$ are **oxidized** where:-

1- Oxidation of NADH gives 3 molecules of ATP.

2- Oxidation of $FADH_2$ gives 2 molecules of ATP.

Importance of electron transport series reactions:

Releasing the energy stored in NADH and FADH2 through the passage of electrons over a sequence of cytochromes and using the produced energy to form ATP from ADP and phosphate.

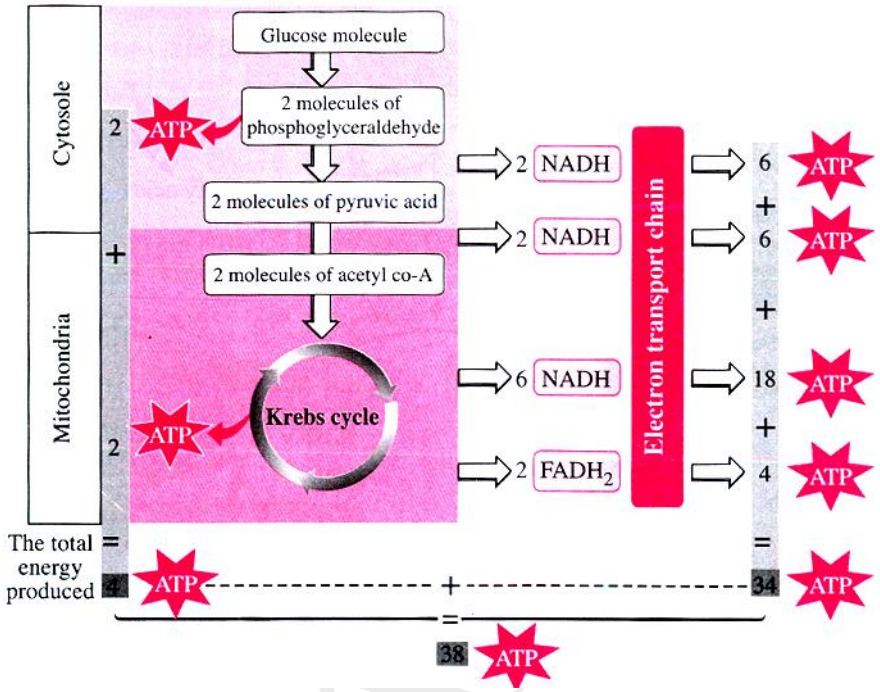


The total number of ATP molecules produced from the aerobic oxidation of glucose molecule:

38 molecules

- 2 molecules are produced in the cytoplasm (**during glycolisis**).
- 36 molecules inside mitochondria (**during respiration)**.

ATP molecules are calculated as follow:



Anaerobic cellular respiration (Fermentation)

It is the process in which the living organism gains energy in the absence, or in low quantities, of oxygen and by the help of some enzymes.

Steps of fermentation:

1- **It begins with glycolysis**, where:

2 molecules of pyruvic acid,

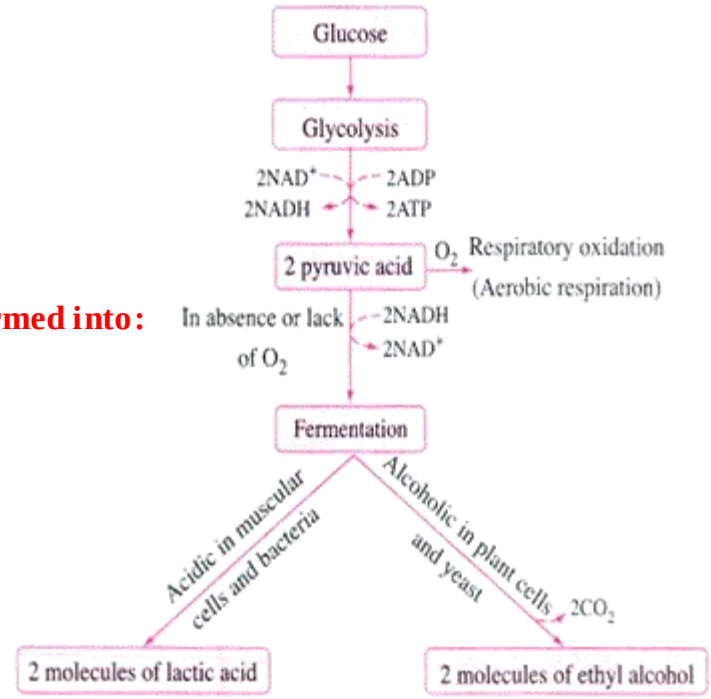
2 molecules of NADH

and 2 molecules of ATP are produced,

2- **The 2 molecules of pyruvic acid are transformed into:**

either ethyl alcohol and CO_2 or lactic acid

according to the type of the cell.



1) Acidic fermentation:

Site: It takes place in bacterial cells and animal tissues, especially muscle fibers, may have to perform some vigorous exercises.

Steps: If oxygen is insufficient in these cells, Pyruvic acid **is reduced** by the electrons of NADH into lactic acid.

- **In muscle cells:** accumulation of lactic acid causing muscle fatigue
- **In bacteria**: Many of **dairy industry** depend on this process (such as cheese, butter and yogurt).

$$\underset{\text{(Glucose)}}{C_6H_{12}O_6} \longrightarrow \underset{\text{(Lactic acid)}}{2\ C_3H_6O_3} + 2ATP\ \text{(energy)}$$

N.B) **When oxygen is present in these cells**, lactic acid is then **oxidized again into pyruvic acid**, then acetyl co-A and **no muscle fatigue is present**.

2) Alcoholic fermentation:

Site: in yeast and some plant tissues.

Steps: The pyruvic acid is reduced into ethyl alcohol and CO_2 is evolved.

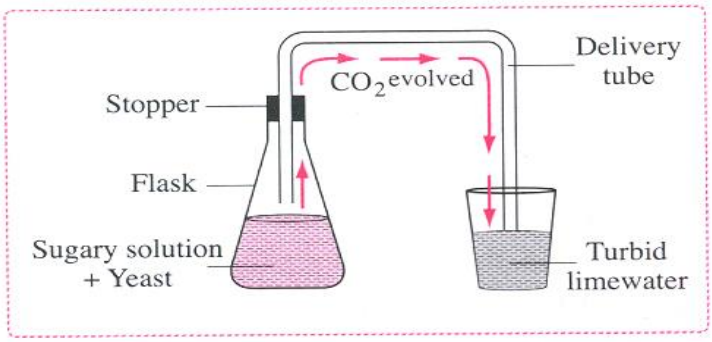
Importance: It is used in bread and alcohol industries.

$$\underset{\text{(Glucose)}}{C_6H_{12}O_6} \longrightarrow \underset{\text{(Ethanol)}}{2\ C_2H_5OH} + 2CO_2 + 2ATP\ \text{(energy)}$$

Experement to prove alcoholic fermentation:

Proof the anaerobic respiration (alcoholic fermentation) :

- **Procedures :**
  1. Put a sugary solution (or molasses diluted with water by a ratio of 1:2) in a conical flask.
  2. Add a piece of yeast and mix it thoroughly.
  3. Close the flask with a stopper of rubber through which a delivery tube passes and dip the free end of tube into a beaker containing limewater.
  4. Leave the apparatus in a warm place for several hours.



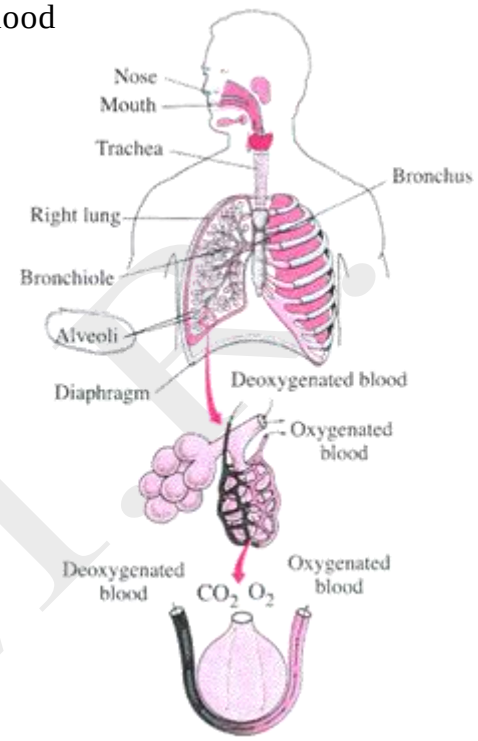
- **Observations :**
  1. Gas bubbles are seen on the surface of solution in the flask.
  2. The release of alcohol odour from the flask.
  3. Limewater has become turbid.
- **Conclusions :**
  1. Yeast makes an anaerobic respiration. So, CO_2 is produced that causes the turbidity of limewater and the sugary solution turns into alcohol.
  2. Yeast makes the anaerobic respiration in the absence of O_2 and this is called **alcoholic fermentation**.

The respiratory system in Man

Function of the respiratory system:

It extracts oxygen from the atmospheric air and transports it to the blood

Organs of respiratory system:



Mouth or nose

- The air enters the body through the nose or the mouth.
- **It is preferable for air to enter through the nose**, because:
  1- It is **warm**, as it is lined with numerous blood vessels.
  2- It is **moist**, as it secretes mucus.
  3- It also **serves as filter** as it contains hairs which act as a filter.

The pharynx

- Air the passes through the pharynx
- The pharynx is a common passageway for both air and food.

The larynx

- It enters the trachea through the larynx (which is also known as voice box).

The trachea

Functional suitability of trachea:

1- **Its wall contains a series of cartilage rings**, which maintain the trachea opens for air.

2- **It is lined with cilia which beat upwards**, to purify the air where it impedes the entry of small foreign bodies, and moves them to the pharynx, where they may be swallowed.

- The trachea is divided at its lower end into **two bronchi** which divide and subdivide into progressively smaller **bronchioles.**
- Each bronchiole finally opens into one of the many **alveoli** (air sacs).

The lungs

Composed of the alveoli, the bronchioles and the blood capillaries surrounding them.

Functional suitability of the alveoi

- **Number of them is about 600 million per lung:**

To increase the surface area of respiration.

- **Walls of them are considered as actual respiratory surface**, because:

They are thin to increase the speed of gas exchange.

They are surrounded by a large network of blood capillaries whose blood receives oxygen from the alveolar air and from the bronchioles surrounding them.

They are moistened by water vapour which is necessary for dissolving CO_2 and O_2 so that gas exchange between the air of alveoli and the surrounding blood in the blood capillaries occurs.

Role of respiratory system in excretion

- It serves to excrete CO_2 and also it has a role in the excretion of water with the expired air, as:

Man usually loses daily about 500 cm^3 of water through the lungs out of the 2500 cm^3 of water he loses daily. This is due to the evaporation of the water that moistens the alveoli.

- This water which moist the alveoli is necessary for dissolving O_2 and CO_2 so that the exchange of gases between the air of the alveoli and the surrounding blood in the capillaries occurs.

Respiration in plant

- **The plant cells have two types of respiration:**

Aerobic and anaerobic respiration

- In most plants, each living cell is in direct contact with the environment and therefore gaseous exchange is easy, and O_2 diffuses internally while CO_2 diffuses externally.

Gas exchange in plants

Methods of oxygen access to the vascular plant cells:

1- In most plants, each living cell is in direct contact with the environment and therefore gaseous exchange is easy, and O_2 diffuses internally while CO_2 diffuses externally.

2- In vascular plants (complicated structure) O_2 reaches cells through various passageways:

a) Stomata:

Where the air diffuses through the stomata to the air chambers, then to all the intercellular spaces in various parts of the plant. Oxygen then diffuses through the cell membranes and dissolves in the water of the cell.

b) **Phloem :**

Where some of oxygen is carried to the phloem dissolved in water, then it reaches the tissues of the stem and root.

c) Roots:

Oxygen enters the plant through the roots, soluble in water of the soil solution which is absorbed by root hairs or imbibed by cell wall.

d) If the stem is green:

oxygen diffuses to the stem tissues through the stomata which spread on its surface.

e) If the stem is woody:

oxygen diffuses to the stem tissues through Lenticels or any cracks in the bark**.**

act as an entry for oxygen.

Getting rid of carbon dioxide by plants:

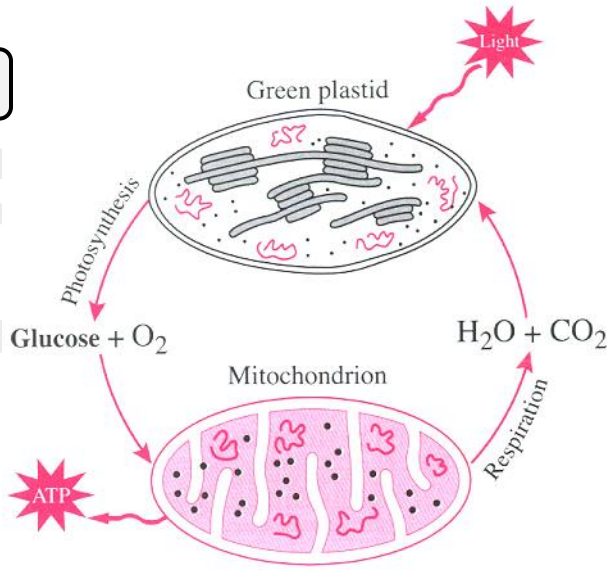
a) By direct diffusion:

By the plant cells which are directly exposed to the external environment where CO_2 diffuses to the air or the soil.

b) Cells that lie deep in the plant:

CO_2 is passed to the xylem or phloem tissues, then these tissues will carry CO_2 in their turn to the stomata and finally to outside.

Relation between photosynthesis and respiration

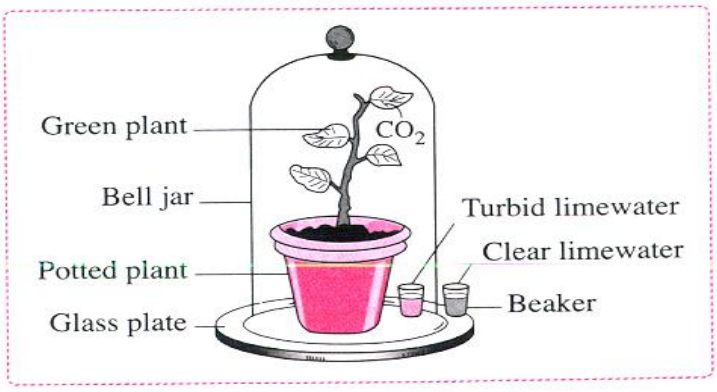


Experement

To prove the respiration in green plants :

- **Procedures :**

1. Take a green potted plant and place it on a glass plate together with a small beaker containing clear limewater. Invert a glass bell jar over the two, then cover the jar with a black piece of cloth.
2. Prepare a similar apparatus with a pot empty of any cultivated plant.



3. Put some clear limewater in a small beaker and leave it exposed to the atmospheric air.
4. Leave the three for some time.

- **Observation :** limewater becomes turbid in step one only and it doesn't become turbid in steps two and three.
- **Conclusion :** the green plant respires and produces CO_2 as a result of this process.