Nutrition

Concept of Nutrition:

Scientific study of food and various modes of nutrition of living organisms

Importance of Nutrition:

1- The living organism obtains the energy required for all the vital processes of the body.
2- food constitutes the materials needed for growth and repair of worn-out tissues

Types of nutrition: (2) types

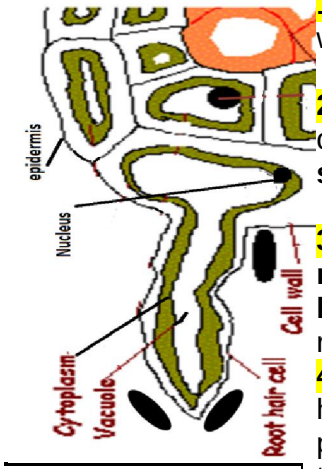
1) Autotrophic (auto = ذاتي)	2) Heterotrophic (hetero = اخر & troph = تغذية)		
Organisms which can **manufacture** their food by themselves.	Heterotrophs obtain **high energy food** from bodies of other organisms, either from green plants or from animals, previously feeding on plants. Heterophs organisms can be classifies into:		
E.g. *green plants* inside their cells, can **synthesize** the **high energy** food (Sugar - starch - fats and proteins) from **simple, low energy** materials (CO_2 – H_2O and Mineral Salts) through certain chemical reactions and with light energy in a process called the *photosynthesis*.	**Holozoic**	**Parasites**	**Saprophytes**
	1)Carnivores: feeds on animals' flesh 2)Herbivores: feeds on plants 3)Omnivores: feeds on both	As Bilharzia worms	As Fungi and Saprophytic bacteria

Autotrophic Nutrition

Autotrophic nutrition carried out by the green plant includes two important processes:

1) Absorption of water, salts and CO_2
2) Photosynthesis.

(1) THE PROCESS OF ABSORPTION OF WATER AND SALTS

Structure Of The Root Hair		Adaption Of The Root Hair To Its Function
1) Each root hair is an outgrowth of one cell of epidermal (pilifierous) layer **2)** May reach **4 mm**. **3**)lined internally with a thin layer of **cytoplasm** which contains the **nucleus**, and a large cell **vacuole** **4)** Root hairs do **not** exist for more than a **few days or weeks**, since the **epidermal** cells are **lost** from time to time and regenerated continuously from the *zone of elongation (video1)*		**1)** have **thin** walls to permit the passage of water and salt through them **2) Large** in number and **protruding** to the outside, to increase the area of the **absorbing surface.** **3)** The **solution** inside the root-hair vacuole is **more concentrated** than that of the soil **to help the water to pass** from the soil to the root hair. **4)** secrete a **viscous substance** to helps the hairs **to find** their way easily among soil particles, and **to stick** to these particles **to fix** the plant into the soil

MECHANISM OFWATER ABSORPTION: it depends on several physical phenomena

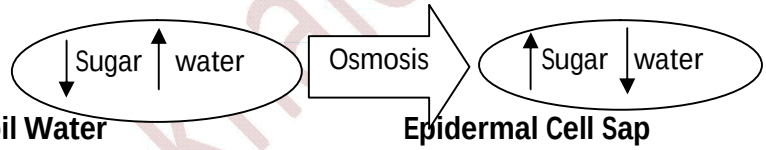
Diffusion	Permeability	Osmosis	Imbibition
It is the movement of **molecules** or **ions** from a **highly Concentrated** medium to a **low concentrated** one due to the **continuous free motion** of the molecules of the diffused substance. E.g. diffusion of a drop of ink when it falls into a beaker containing water.	It is the **ability** of some cell **walls** and cell **membranes** to allow the passage of **water** and **ions** through them. So the walls and membranes divided into: 1) *Permeable*: allow **both** water and salt ions to pass through them. e.g. **cellulose** walls 2)*Impermeable*: do **not** allow passage of water and salts.eg, walls covered with **Lignin, Subrin** and **Cutin** 3)*Semi- permeable*: allow passage of **some** substances and prevent others or make them pass slowly (**selective permeability**) e.g. **plasma** membranes have **tiny pores**, so they prevent passage of **sugars** and **amino acids** as they are **large sized molecules** (video 2)	It is the diffusion of **water** from a medium of high concentration of **water** to another with a low water concentration, through a semi-permeable membrane. **Osmotic Pressure**: The pressure that causes the diffusion of water through semi permeable membrane. It **increases** by the **increase** in the concentration of **solutes** in the solution	It is the ability of **solid particles** (especially **colloidal** ones) to **absorb** liquids, **swell** and increase in **volume**. Walls of plant cells absorb water by this phenomenon. e.g. cellulose, pectin and protein

ABSORPTION OF WATER BY ROOT:

1) Root hairs are covered by colloidal layer that will imbibe water from the soil solution by **Imbibition.**

2) The imbibed water is then withdrawn to the inside of epidermal cells by **osmosis**, due to the difference between the higher concentration of the sugar solution in the cell sap and the lower concentration of the soil solution. In other words, due to the higher water concentration in soil than in the cell sap.

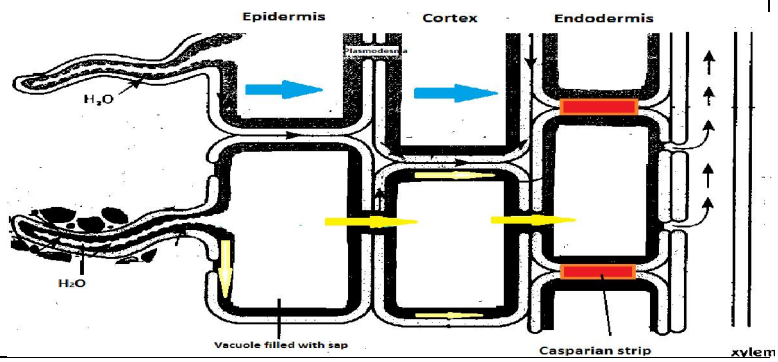
3) And so the water concentration in epidermal cells becomes higher than that of the cortex cells, so, the movement of water continues from one cell to another by osmosis until in reaches xylem vessels.



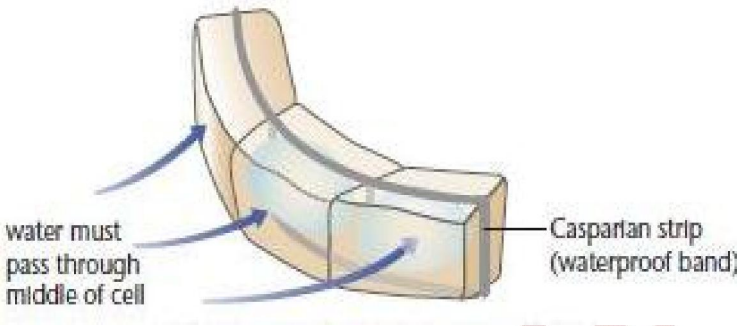
OP in root hairs of desert plants(xerophytes) & plants live in salt marshes (halophytes) is (50 -200 atmosphere) to absorb more water, while ordinary plants (mesophytes) have OP 5 -20 atmosphere

The water moves from the root to the Xylem in 3 pathways:
1) Through cell sap by *osmosis* that needs a gradual fall of osmotic pressure along the root cells.

2) Through the cytoplasm where water rushes from one cell to another through the plasmodesmata which connect the protoplasm of the plant cells together.



3) Through cell walls and through the small intercellular spaces by Imbibition.
(video 3)
Water pathway through the endodermis:
the walls of the endodermal cells are thickened with **Suberin**, which is called **Casprian strip** that prevents water from passing through walls and force it to pass inside the cells (**passage cells**).this passage is controlled by **osmosis & active transport** under the influence of the **protoplasm (video 4)**



ABSORPTION OF MINERALS SALTS

Plants need Oxygen, Hydrogen & Carbon in addition to other elements as follow:

A) Macro-nutrients:
- The plants need these elements in **considerable quantities**.
- They are(7) elements: **Nitrogen** - **Phosphorus** - **Potassium** - **Calcium**- **Magnesium** - **Sulphur** and **Iron.**

B) **Micro-nutrients**:
- The plants need these elements in **very small quantities** which do not exceed few milligrams/liter; therefore, they are called **trace elements**.
- They are (8) elements **Manganese, Zinc**, **Boron, Aluminum**, **Chlorine**, **Copper**, **Molybdenum** and **Iodine**.
- They help to activate enzymes.

Mechanism of absorption of Minerals:

Solutes in the soil are present as:

- **Positive** ions called (**Cations**) such as K+ and Ca++

- **Negative** ions called **(anions**) such as SO_4, NO_3 and Cl-

- These ions behave independently of each other and of water itself**.**

* This mechanism depends on different phenomena:

A) Diffusion:

The ions diffuse from high concentration to low concentration. These solutes move by diffusion from the soil solution and pass through the wet cellulose walls. Under certain conditions, Cations exchange may take place, e.g. Na+ ion may get out of the cell and is replaced by k+ ion

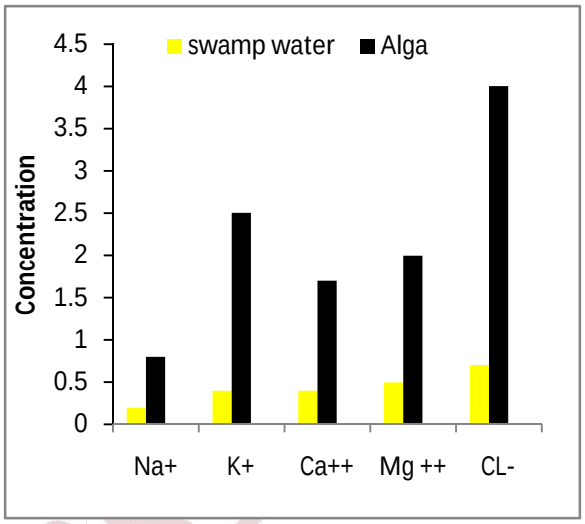
B) Selective permeability:

When ions reach a semi permeable plasma membrane, *some* ions are *allowed* to pass in according to the plants requirement, regardless of the **size, concentration** or **charges**, while others are not allowed.

C) Active Transport:

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

- Ions diffuse from the soil solution where the concentration of ions is low to inside the cell which is higher in concentration. So they need **energy** to force ions to move **against concentration gradient**.



- Energy is supplied during **aerobic** respiration of the root that needs presence of Oxygen and sugar.

Experiment 1:

- Done on **Nitella alga** that lives in Swamp water

- To show ions concentration in alga and in swamp water.

- Results:

- Ø The concentration of various ions accumulating in the **cell sap** of alga is comparatively **higher** than their concentration in the swamp water that necessitates energy to absorb these ions.
- Ø The ions are **selectively absorbed** according to the **cell requirements** as some ions are **higher** in concentration than others.

Experiment 2:

- Done on **barely** plant.

- To show the absorption of sulphate ions (SO4)--when the plant was deprived of oxygen.

Steps:

-the barley plant was supplied with sulphate salts containing radioactive sulphur (S35).

-The quantity of absorbed salt was estimated using a Geiger counter.

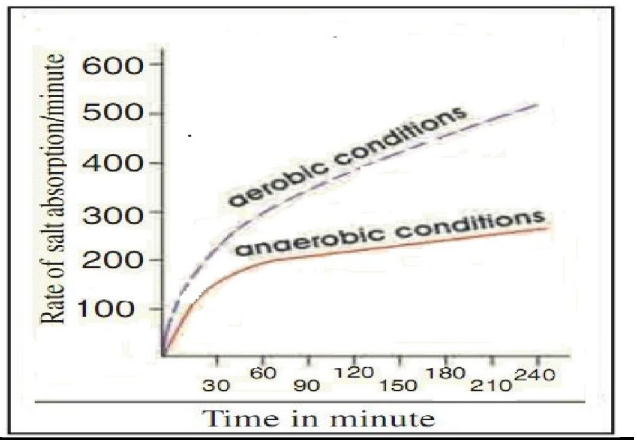
- Performed twice: 1st the root is exposed to **aerobic** conditions.

2nd root is exposed to **anaerobic** conditions.

-Results:

A) Absorption of the sulphate ion was **less** in the case of anaerobic conditions which proves the importance of active transport.

B) ions accumulate in plant cells using the energy released during aerobic respiration
(video 5)



(2)PHOTOSYNTHESIS

Importance Of Photosynthesis:

The photosynthesis is one of the most important chemical processes to Man and also it is the principal foundation of life on earth because:

1. It produces Man's food which contains carbohydrates, proteins, fats and vitamins.

2. It is the source of oxygen which is about 2l % of atmospheric air which accumulated through ages.

3. It produces plant and animal fibers that are used as textile fabrics

4. It is the source of industrial products such as fats, alcohol and vinegar.

5. It is the source of chemical energy stored in food which is required for all organisms

6. It is the source of fuels such as coal, petroleum and natural gas for engines and various means of transport.

Raw Materials Required For Photosynthesis:

1) **Water** is the only source of hydrogen needed by green plants to reduce CO_2. This is the first step in the synthesis of carbohydrates.
2) **CO_2**: is the only source from which the plant obtains carbon.
3) **Mineral salts**:
   i. **Nitrates**, **phosphates** and **sulphates** are required to convert carbohydrates into proteins.
   ii. **Phosphorus** is an important element in the structure of compounds which carry energy during photosynthesis.
   iii. **Magnesium** is required in the synthesis of chlorophyll.
   iv. **Iron** is important for the building up of some enzymes which help to complete the process

Products of photosynthesis:

A) **Monosaccharide:** is the main product and can be used in:
   - the manufacture of proteins required for growth, or
   - broken down during the process of respiration to produce energy, or
   - may be converted into starch in order to be stored

B) **Oxygen**: is a secondary product.

Where does photosynthesis take place?:

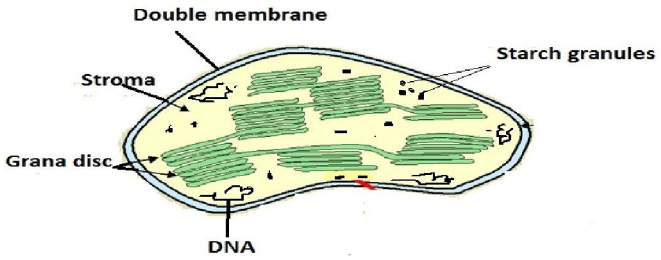
- Green leaves are the **main** centers for photosynthesis because they contain chloroplasts.

- **Green herbaceous stems** may participate, in this process as they contain chlorenchymatous tissues with chloroplasts.

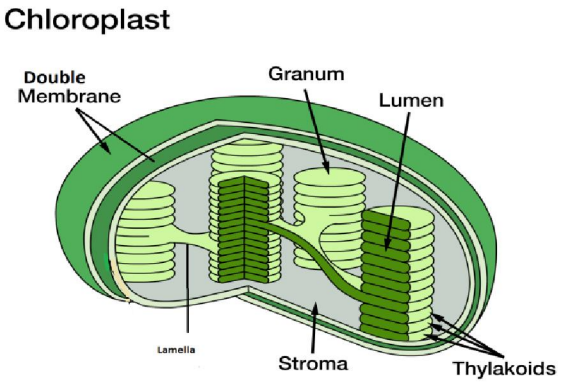
STRUCTURE OF THE CHLOROPLAST:

1. **Double thin membrane** (about 10 nanometers)

2. Matrix **or "Stroma"**: a colourless and proteinic substance inside the membrane.



3. **Grana**: embedded in the stroma, disc shaped, are linked together by thin membrane called "grana lamellae
Each **granum** is:
- About 0.5 micron diameter - about 0.7 micron thick.
- A pile of 15 or more disc arranged over each other.
Each **disc** is:
- Hollow from the inside.
- its margin extends outside to meet the margin of another disc that increase the exposed surface area of the disc
- carrying the pigments that absorb light energy.



The chloroplast contains four main pigments which can be separated, as follows:

Pigment	*Colour*	*Percentage*
Chlorophyll A	**Blue-green**	**70%**
Chlorophyll B	**Yellow-green**	
Xanthophyll	**Lemon-Yellow**	**25%**
Carotene	**Orange-Yellow**	**5%**

- Green colour dominates the colours of other pigments in the plastid due to the high percentage of the Chlorophyll.
- The chlorophyll is concerned with absorption of light energy required for photosynthesis.
- The chlorophyll molecule is complex in structure, Chlorophyll A formula is C_{55} H_{72} O_5 N_4 Mg.
- The **magnesium** atom occupies the centre of the molecule. It is believed that there is a relationship between the presence of Mg in the chlorophyll molecule, and the ability of chlorophyll to absorb light.

- Numerous **starch** grains are produced inside the chloroplast as temporary products of photosynthesis. They will soon change back to soluble sugar in order to be translocated, under certain conditions, to other organs of the plant. (video 6)

STRUCTURE OF THE LEAF AND ITS ADAPTATION TO PHOTOSYNTHESIS:

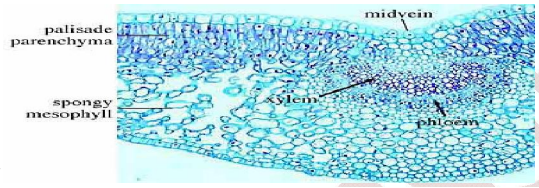
Structure	Function adaptation
1- Leaves are **flattened**, its blade Is **thin**, arranged on stem in a certain manner.	1- in order to be **exposed** to receive the largest amount of sun light
2. The leaf blade is supported by **midrib** which is branched into smaller veins forming a **net** which spread over the leaf blade.	2. To **supply** the leaf with **water** and salts from the soil, also helps to translocate high energy food from leaf to any part of the Plant.
3. The leaf surface is covered with cutin.	3- to prevent water evaporation from plant
4. Has stomata that mostly open in the light and closed in the dark, also affected by the degree of humidity of the environment.	4. For gaseous exchange between atmosphere and the interior of the plant. Control the rate of water evaporation from plant

The leaf consists of three main tissues

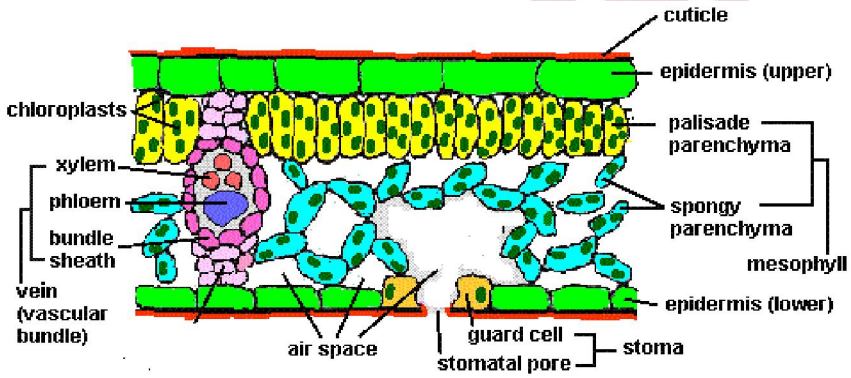
1) Epidermis (Upper, lower) 2) Mesophyll (palisade, spongy) 3) Vascular tissue (xylem, phloem)

1)Epidermis:

- Each of the **upper** and **lower** epidermis layers consists of one row of adjacent barrel-shaped parenchyma cells with **no** chlorophyll.
- **Stomata** spread throughout the epidermal layers.
- The external wall of the epidermis is coated with a layer of **cutin**.



TS in a dicot plant



2) The mesophyll:

- It lies **between** the upper and lower epidermal layers, and transverse by veins.

-consists of two layers:

a) *Palisade layer:*

1. One row of cylindrical, elongated, parenchymatous cells aranged in a columnar form and perpendicular to the leaf surface.

2. has many chloroplast which tend to arrange them selves in the upper part of the cell to receive the highest light intensity from the sun.

b) *Spongy layer:*

1. lies below the Palisade tissue.

2. Consists of irregular, loosely- arranged parenchyma cells

3. has wide intercellular spaces.

4. Has less number of chloroplasts than that of the palisade tissue

C) Vascular Tissue:

- It consists of numerous vascular bundles which extend through the veins and veinules. The midrib contains the main vascular bundle of the leaf.,

- **Xylem** vessels are several vertical rows, inside the vascular bundle, separated from each other by thin-walled cells called xylem parenchyma.

- The **Phloem** lies toward the lower epidermis; it translocates dissolved organic food from the Mesophyll, where it has been manufactured, to other parts of the plant. (video 7)

The Mechanism of Photosynthesis

- The American scientist "**Van Neil**" was the first person who pointed out that oxygen is evolved (produced) in photosynthesis.
- He studied photosynthesis on both **green** and **purple** bacteria
- These bacteria are **autotrophic** as they contain *bacteriochlorophyll* (simpler in structure than ordinary chlorophyll).
- They live in *swamps* and *ponds* where hydrogensulphide is abundant.
- These bacteria used **Hydrogen sulphide** as the source of hydrogen to reduce CO_2 in order to build up **carbohydrates** and Sulphur is released.

1) Assumptions of Van Neil:

A) In green and purple bacteria: He assumed that light decomposed hydrogen sulphide into hydrogen and sulphur, then, hydrogen was used in certain dark reactions to reduce CO2 into carbohydrates.

$$6CO_2 + 12\ H_2S \xrightarrow[\text{Bacteriochlorophyll}]{\text{Light Energy}} C_6H_{12}O_6 + 6H_2O + 12S \downarrow$$

B) In green plants, he assumed that light reactions in green plants are similar to those of Sulphur bacteria, except that in green plants, it is water which is decomposed by light into hydrogen and oxygen. Hydrogen is then used in the reduction of CO_2 in the dark reaction to produce carbohydrates.

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

Consequently, Van Neil proposed that the **release of oxygen comes from water**, which is similar to sulphur released from hydrogen sulphide by sulphur bacteria.

2) scientists at California University :

Verified the theory of Van Neil experimentally by using a **green alga** called **Chlorella** and provided it with all conditions favourable for photosynthesis. They made two experiments:

Experiment (1):

The water used contained the oxygen isotope ^{18}O (instead of ^{16}O), and CO2 contained ordinary oxygen (^{16}O).

The result: the oxygen evolved during photosynthesis of the alga was the isotope ^{18}O and not ^{16}O this proved that the source of liberated oxygen is water and not CO_2.

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

Experiment (2):

They repeated the experiment using ordinary water while CO_2 contained ^{18}O. This time ordinary oxygen was released, i.e. ^{16}O coming out from water.

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

THE LIGHT AND DARK REACTIONS

Blackman concluded that photosynthesis consists of two kinds of reactions;

1**) Light reactions: light** acts as the limiting factor of the rate of photosynthesis.

2) **Dark reactions** (or **enzymatic** reactions): **temperature** is the limiting factor of the rate of photosynthesis. It can take place in light and darkness.

Light reactions (occur in Grana)

1-When light falls on chlorophyll of the grana inside the chloroplast, some electrons in the atoms of the chlorophyll molecule will **gain energy**

2- These electrons are **shifted up** from their low energy levels to higher ones, and its molecules are said to be in an "**exited state**" (or **activated state**)

3-In this way, the **kinetic** light energy is stored as potential **chemical** energy in the chlorophyll.

4-When the stored energy is **released**, the electrons fall to the lower energy levels. The chlorophyll returns to the stable state, ready for another influence of light to become excited again.

5- Part of the energy of the excited chlorophyll is **stored** in ATP molecule, (*as a result of combination of ADP molecule in the chloroplast with a phosphate group (P) by means of high energy bond which is marked by a squiggle (~).*

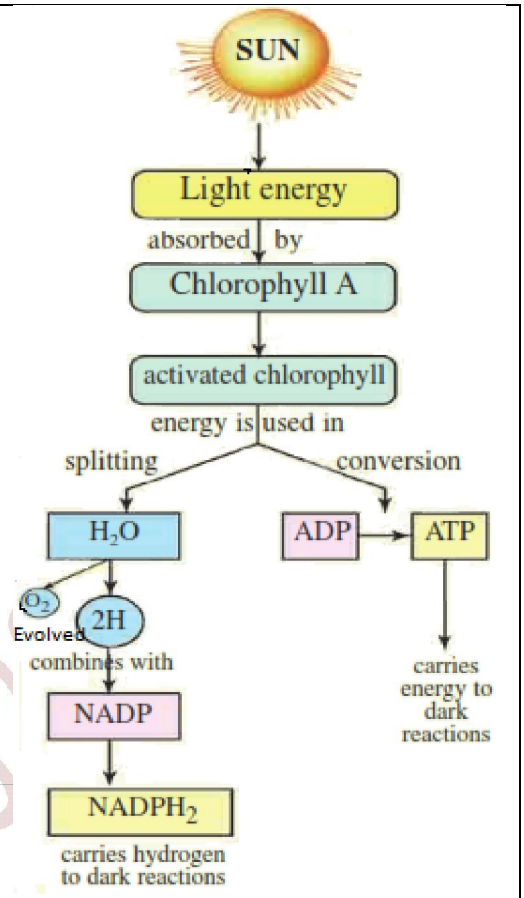
ADP + P ⟶ ATP

Adenosine - P ~ P + P ⟶ Adenosine - P ~ P ~ P

6- Part of the energy stored in chlorophyll is used in **splitting** up the water molecule into hydrogen and oxygen ions.

7- **Hydrogen** resulting from decomposition of the water molecule combines with a co-enzyme present in the chloroplast (**NADP**) to give **NADPH2**. In this way, hydrogen will **not** escape or recombine with oxygen.

8- **Oxygen** released as a product. (video 8)



N.B.:(*) **ATP**: is **Adenosine Triphosphate**. It consists of two organic compounds (*adenine and a sugar called ribose*) joined to a chain of 3 phosphate groups, which are linked together by two high-energy bonds. ATP as a compound acts as the energy currency of living cells.

(**) **NADP**: It is **Nicotinamide Adenine Dinucleotide Phosphate** which acts as a hydrogen receptor.

Dark reactions occur in stroma

A) **Hydrogen** carried on NADPH2 is used to fix CO2 gas into carbohydrates with the help of energy stored in the ATP molecule.

B) **Melvin Calvin Experiment**:

1-Revealed the **nature** of the dark reactions by using the radioactive isotope of carbon (**^{14}C).**

2-They placed the **Chlorella alga** in the apparatus shown in figure. And supplied it with CO_2 gas containing radioactive carbon (^{14}C).

3-A lamp was lighted very briefly to allow photosynthesis to take place.

4- Chlorella was then immersed in a beaker containing **hot alcohol** to kill the protoplasm by stopping its biochemical reactions.

5-They separated the products of photosynthesis by special means and tested for radioactive carbon in these compounds.

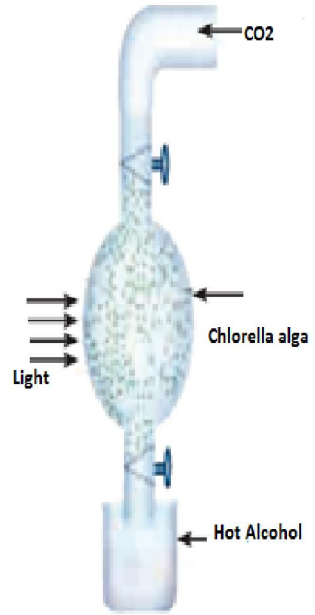
6-**Results**: showed that when photosynthesis proceeded with the briefest flash possible, a 3-carbon compound was formed **Phosphoglyceraldehyde** (PGAL). This is the **first stable compound** to be produced in photosynthesis.

Uses of PGAL:

-**Production** of **all** other products in plant cells, such as **glucose**, **starch**, **proteins** and **fats**.

- **utilized** in cellular respiration as a high-energy compound

7-Calvin pointed out that hexose sugar synthesis is not completed in one step, but throughout several intermediate reactions catalyzed by specific enzymes.



HETEROTROPHIC NUTRITION

Concept and Importance:

The living organisms obtain their food in the form of large and complex particles of proteins, carbohydrates and fats, which can not diffuse through the cell membrane unless it is broken down into molecules of smaller size and simpler structure (amino acids, glucose, fatty acids and glycerol). As these molecules are **small** and **soluble in water**, they are easily absorbed by the cells, either by **diffusion** or by **active transport** to be used as a source of energy in the building of new tissues.

Digestion:

Digestion is the conversion of large food molecules, (polymers) into smaller ones (monomers) by means of hydrolysis. This process is catalyzed by enzymatic action.

Enzymes:

- The enzyme is a **protein substance** which has the properties of a **catalyst** (it has the ability to activate a particular chemical reaction).
- The **reaction** which is catalyzed by a certain enzyme depends on:
  1) The **structure** of the reacting molecules 2) the **nature** of the enzyme.
- When the reaction is completed, the resulting molecules break away from the enzyme, leaving it in the same form as it was before the reaction.

Enzyme + reacting substance ⇌ unstable intermediate comp ⟷ enzyme + products of reaction

- Most enzymes have a **reversible** effect i.e. enzyme may catalyze the decomposition of a complex molecule into two simpler ones, and may recombine the two small molecules to give rise to the same complex molecule once more. (video 9)
- Enzymes only **accelerate** the rate of the reaction until it reaches a state of equilibrium.
- Some enzymes are secreted by the cells in an inactive state. Therefore, they need certain substances to activate them e.g. Pepsin enzyme is secreted by the stomach as pepsinogen is changed to active pepsin in the presence of HCl in the stomach.
- The **activity of the enzyme** depends upon the **temperature** and the **pH** of the medium.

Digestion in Man

The human digestive system is built up of alimentary canal extending from the mouth to the anus. This canal starts with the mouth which is followed by the pharynx, oesophagus, stomach, small and large intestine and associated glands including salivary glands, liver, and pancreas.

Buccal Digestion:

The digestive system starts with the mouth which contains:

A) **The teeth**:

1) incisors, at the front of the jaw for cutting food, 2) canines to tear food
3) premolars and molars for crushing and grinding food.

B) **The tongue**

1) Helps to manipulate the food to be chewed by the teeth. 2) Serves as an organ of taste.

C) **Three pairs of salivary glands**:

which open into the mouth cavity through Ducts and secretes **Saliva** that contains:

1) mucous that soften the food to be easily swallowed.
2) the enzyme **amylase (ptyalin)** which acts in a weak alkaline medium, it catalyses the hydrolysis of starch to the disaccharide maltose.

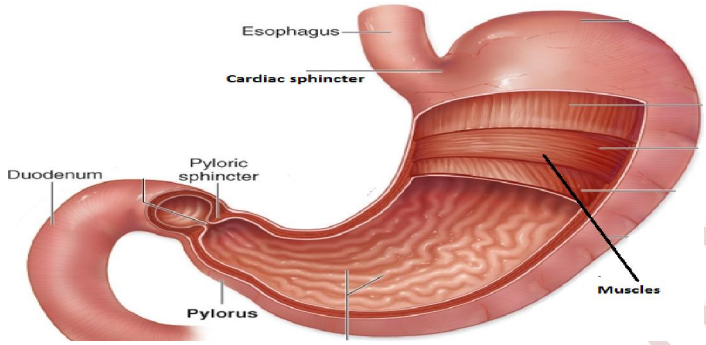
Swallowing:

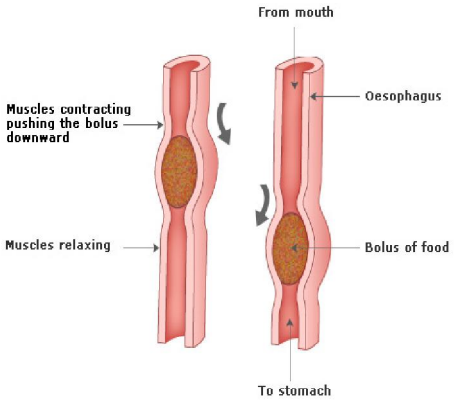
The **pharynx** is a cavity at the back of the mouth which leads to two tubes: the oesophagus and the trachea which is a part of the respiratory system.

Swallowing 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 to close over the glottis (entrance to the air passage).(video 10)

The oesophagus which is 25 cm long extends from the pharynx downward through the neck and into the chest cavity . It lies parallel to the vertebral column.

The oesophagus is lined with glands secreting mucus. Food is carried through the oesophagus to the stomach by a series of rhythmical muscular contractions and relaxations of circular muscles known as **peristalsis**. This movement extends downward along the alimentary canal and sweeps any food within the canal. It is also responsible for churning the food and mixing it with the digestive juice.





Gastric Digestion:

The stomach is a dilated muscular sac which lies in the abdominal cavity. It is joined to the lower part of the oesophagus by a constricted circular muscle(**cardiac sphincter**).The stomach is connected to the small intestine by a muscular valve of circular smooth muscle (**pyloric sphincter**). **Proteins** are the only food substances which are affected by the gastric juice. The gastric juice is colourless acidic liquid. It contains:

1) 90% water.
2) HCl: It creates an **acidic** medium (1.5 - 2.5 pH) which *stops* the action of the ptyalin enzyme and kills harmful bacteria that may enter with the food.
3) The enzyme pepsin: It is secreted in an inactive form called pepsinogen. It becomes active by the action of HCl.

Pepsinogen (inactive) $\xrightarrow{HCl}$ Pepsin (active)

Protein digestion:

Pepsin catalyzes the hydrolysis of protein by breaking certain peptide linkage in the long chain of the protein to yield smaller fragments called polypeptides.

Protein + water $\xrightarrow[Pepsin]{HCl}$ Polypeptides

Chyme:

The muscular contractions of the stomach wall help in churning and mixing up food with the gastric juice. The food becomes a heavy, semi fluid called chyme and is stored in the stomach to be digested. The chyme is then discharged into the small intestine by relaxation of the pyloric sphincter.

Q: Since the stomach is made up of protein, why does it not digest itself?

A:1)presence of mucus secretions that protect the cells against the effect of the digestive enzymes.
2) pepsinogen will be activated only when it is mixed with the acid in the cavity of the stomach.

Intestinal Digestion:

The small intestine consists of duodenum and ileum.
It is about 8 meters long and about 3.5 cm in diameter at its beginning to 1.25 cm at its end.
Coils and loops of the small intestine are connected by membranous structure called **mesentery**.
The juices that help to digest food in the small intestine are:

1. The Bile:

The bile is secreted from the liver on the food during its passage in the duodenum. It emulsifies fats, i.e. dividing large masses of fats into small globules to facilitate and accelerate the enzymatic action on fats that don't dissolve in water.

2. Pancreatic Juice: It includes the following:

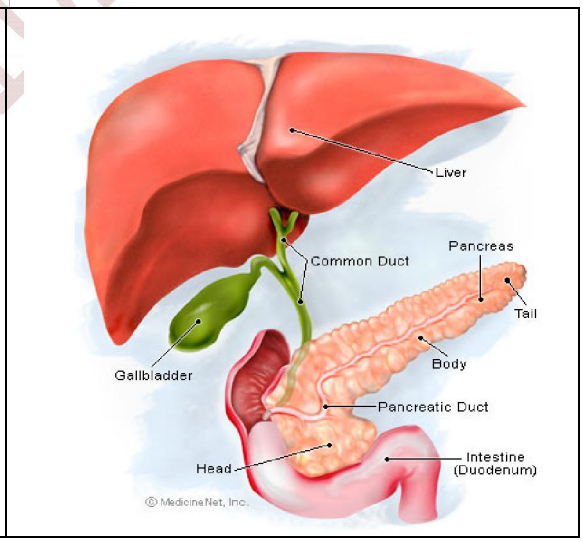
a) **Sodium bicarbonate** to neutralize HCl and renders the medium alkaline (pH = 8).
b) **Pancreatic amylase**: It catalyzes the hydrolysis of glycogen and starch into maltose.
c)**Trypsinogen**: It is an inactive enzyme. It becomes active trypsin in the duodenum by the co-enzyme **enterokinase** secreted by the intestinal glands in the lining of the small intestine. Trypsin catalyzes the hydrolysis of protein to polypeptides.
d) **Lipase**: It catalyzes the hydrolysis of the emulsified fats into fatty acids and glycerol.

3. Intestinal juice:

This juice which is secreted by certain cells in the wall of the small intestine contains a mixture of enzymes. These enzymes complete the action of the previous enzymes and end the action of digestion of all food constituents.
These enzymes are:

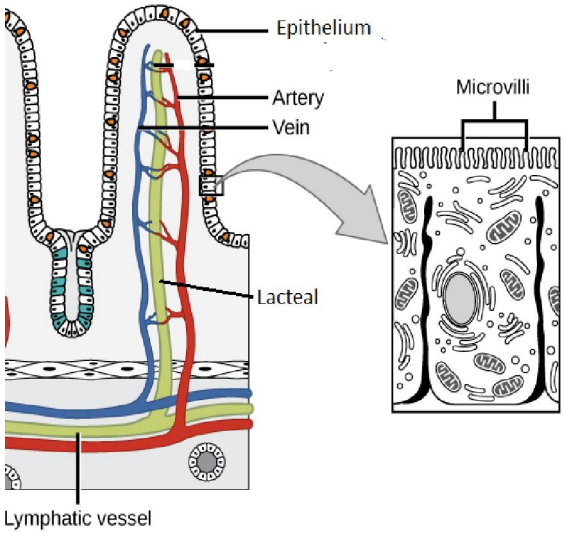
a) **Peptidases**: It is a number of enzymes. Each one is concerned with hydrolysis of peptide linkage between certain kinds of amino acids in the polypeptide chains, to give various amino acids.
b) Enzymes hydrolyse disaccharides to monosaccharides, these are:
- **Maltase**, which hydrolyze maltose to two molecules of glucose.
- **Sucrase**, which hydrolyze sucrose (cane sugar) to glucose and fructose.
- **Lactase**, which hydrolyze lactose (milk sugar) to glucose and galactose.

c) **Enterokinase**: It acts only as a co-enzyme to activate trypsinogen.



Absorption:

- It is the transfer of digested food to the blood and lymph through the mucosa of the ileum.
-The inner epithelial lining of the ileum is folded to form villi, therefore,The surface area increases enormously to about 10 m, i.e. about 5 times as much as the surface area of the human being.
- Each villus consists of an outer covering of a single layer of epithelial cells which enclose a lacteal surrounded by a network of venous and arterial blood capillaries.
-The electron microscope has revealed the presence of tiny projections from the epithelial cells of the villi called micro-villi that increase the area of the absorbing surface.
- Products of digestion are transferred to the blood and lymph by absorption through the villi by active transport and membranal diffusion



a) Blood route:

It starts with the blood capillaries inside villus, where blood carries water, mineral salts, glucose and amino acids together with some water soluble vitamins. These substances are carried to the hepatic portal vein to the liver and then through the hepatic vein to be emptied into the inferior vena cava, then to the heart.

b) Lymphatic route:

Where fatty acids and glycerol pass together through with their contents of vitamins A, D, H and K. However, some of these fatty acids and glycerol may recombine in the epithelial cells of the villi to form fats again.

some of the finely emulsified fats are absorbed directly by being engulfed by the epithelial cells.

All fats pass into the lacteals inside the villi to lymphatic system which carries them slowly and empties them into the superior vena cava, then to the heart.

Metabolism:

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

This process takes place by two ways:

1. Anabolism:

The simple and small-sized food particles can be changed into complex compounds.

Glucose can be changed into glycogen and stored in the liver and muscles.

Amino acids can be changed into different forms of polypeptides to build up new tissues. Fatty acids and glycerol can be changed into fats and stored mainly under the skin.

2. Catabolism:

The absorbed food, especially the glucose can be oxidized to produce the energy required for the activity of the body

Large intestine and defecation:

Undigested food passes to the large intestine. One of the most important functions of the large intestine is the absorption of water and salts from the undigested residue to leave semi-solid feaces. The lining of epithelial wall has many convolutions to help in the absorption. Presence of bacteria in the large intestine is responsible for the bad odour and breakdown of these remains into simple substances.Waste remains are expelled as feaces through the anus by means of strong muscular contractions of the rectum accompanied by relaxation of the two muscles of the anal sphincter situated on both sides of the anus. The mucosa of large intestine secrets mucus to facilitate the passage of feaces to outside.