

BIOLOGY

**FOR
GENERAL SECONDARY CERTIFICATE**

**Unit (I)
Chapter (I)
Nutrition and Digestion
In Living Organisms**

Nutrition and Digestion in Livings

Nutrition:

Nutrition is the scientific study of food and various modes of feeding in living organisms.

The need for nutrition:

1. The source from which the living organism obtains the energy required for all the vital processes.
2. Food contains the material needed for growth.
3. Food contains the material needed to repair the worn out tissues.

Types of nutrition in living organisms:

I. Autotrophic Nutrition:

1. Photosynthesis:

Green plants are considered autotrophs because they manufacture their own food by themselves. They can manufacture the high-energy types of food as carbohydrates (as sugars and starch), fats, and proteins out of simple, raw, and low-energy materials (carbon dioxide, water, and mineral salts). These materials are obtained from the surrounding habitat. By using these materials together with light energy that is absorbed by chlorophyll, green plants can carry out certain chemical reactions which are collectively called photosynthesis.

2. Chemosynthesis:

Some bacteria use chemical energy to manufacture its food.

II. Heterotrophic Nutrition:

Heterotrophs:

Heterotrophs are Living organisms that obtain food from bodies of other organisms. They obtain high-energy food substances either from green plants or from animals that were feeding on plants.

Types of heterotrophic nutrition:

1. Holozoic(organic) nutrition:

a. Carnivores: That feed on animal's flesh. Ex.: cats, dogs, and eagles.

b. Herbivores: That feed on plants. Ex.: rabbits, cattle, and horses.

c. Omnivores: That feed on plants and animals. Ex.: Man.

2. Parasitic nutrition:

Parasites are livings that live either as ectoparasites or as endoparasites on or in other living organisms (which are called hosts). Parasites obtain their food either ready-made or partially prepared from their hosts that will be harmed.

Examples for parasites: fleas, mosquitoes, bilharzias worms, tape worms, and some kinds of bacteria and fungi.

3. Saprophytic nutrition:

Saprophytes are living organisms that obtain their food in a liquid form from decayed remains of dead organisms.

Examples for saprophytes: many kinds of fungi and saprophytic bacteria.

Autotrophic Nutrition – Nutrition in green plants.

Autotrophic nutrition carried out by green plants includes 2 main steps:

1. Absorption of water, mineral salts, and carbon dioxide.
2. The process of photosynthesis.

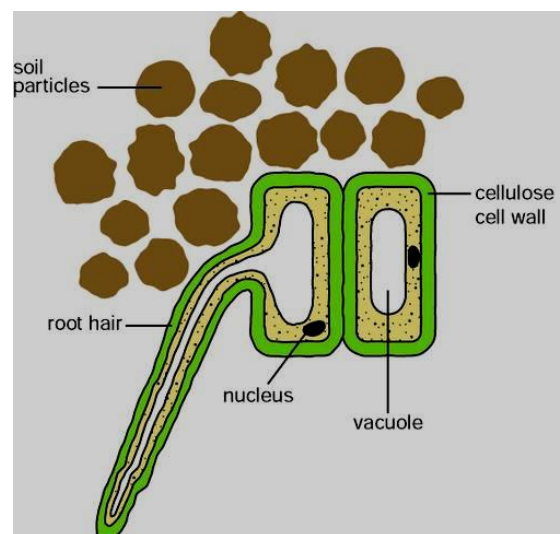
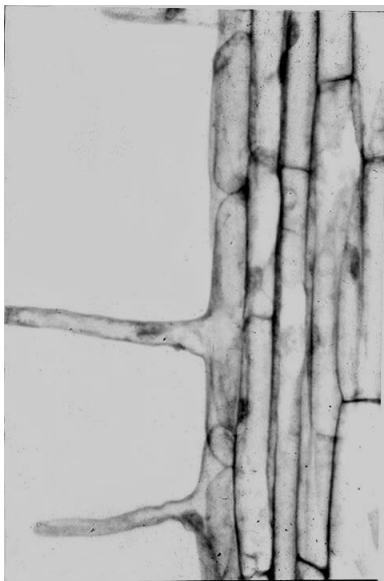
1. Absorption of water and salts.

The outermost layer of the root is the epidermis that consists of a single row of adjacent, flattened, thin-walled parenchyma cells that surround the root and give off root hairs. The root hair is a tubular outgrowth of an epidermal cell and may reach 4mm long. It is lined internally with a thin layer of cytoplasm that contains the nucleus. There is a large cell (sap) vacuole as well.

Root hairs do not exist for more than a few days or weeks, since the epidermal cells are ruptured and lost and regenerated continuously from the zone of elongation.

Adaptation of root hairs to their function:

1. **They have thin walls:** So as to allow the passage of water and salts through them.
2. **They are large in number, and protruding to the outside:** So as 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 water to pass from the soil to the root hair.
4. **Root hairs secrete a viscous substance:** So as to help these root hairs to find their way easily among soil particles, and to stick to these particles, so they help to fix the plant to the soil.



Mechanism of water absorption:

Mechanism of water absorption depends on several physical phenomena:

1. Diffusion:

Diffusion is the movement of molecules or ions from a highly concentrated medium to a low concentrated one. Diffusion is due to the continuous free motion of the molecules of the diffused substance in the medium of diffusion.

Example: Diffusion of a drop of ink when it falls into a beaker containing water.

2. Permeability:

Walls and cell membranes differ in their permeability:

- a. **Cellulosic cell walls:** They are permeable, as they allow both water and mineral ions to pass through.
- b. **Cell walls covered with lignin, suberin, or cutin:** they are impermeable to water and salts.
- c. **Plasma membranes:** they are semi-permeable (selectively permeable). They are thin with tiny pores that can control the passage of substances through them:
 1. Some substances: May be allowed to pass freely.
 2. Some other substances: May pass but slowly.
 3. Other substances: Are not allowed to pass at all.

So, the semi-permeable plasma membranes allow the passage of water, and control the permeability of many salts, but it prevents the permeability of sugars and amino acids because they are of large-sized molecules.

3. Osmosis:

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

Osmotic pressure:

Osmotic pressure is the pressure that causes the diffusion of water through semi-permeable membranes. It increases by an increase in the concentration of solutes in the solution.

4. Imbibition:

Solid particles especially colloidal ones have the ability to absorb liquids, swell, and increase in volume.

Example: When a piece of wood is placed in water, it imbibes water. Imbibition extends through the piece of wood till it reaches the parts which are not submerged in water.

How does absorption of water take place by the root?

- a. Root hairs are covered with a thin colloidal layer (the cell wall that is made up of cellulose), so they possess strong affinity for water that surrounds the adjacent soil particles. So, the outer surface of root hairs will imbibe water from the soil solution.
- b. The imbibed water is then withdrawn to the inside of epidermal cells by osmosis due to the difference between the higher concentration of sugar solution in the cell sap, and the lower concentration of the soil solution (i.e. due to the difference in water concentration which is higher in soil solution than its concentration in the cell sap).
- c. The water concentration in the epidermal cells becomes higher than that in the neighboring cells of the cortex.
- d. Absorption and movement of water continues from one cell to another inwards until it reaches the xylem vessels in the center of the root.

N.B. 1: Root hairs of desert plants (Xerophytes) and those of plants living in salt marshes (Halophytes) are characterized by their high osmotic pressure (ranges from 50 up to 200 atmosphere) compared to the osmotic pressure of root hairs of ordinary plants (Mesophytes) (that ranges from 5 up to 20 atmosphere). This is to help to absorb as much water as possible from the very difficult surrounding medium.

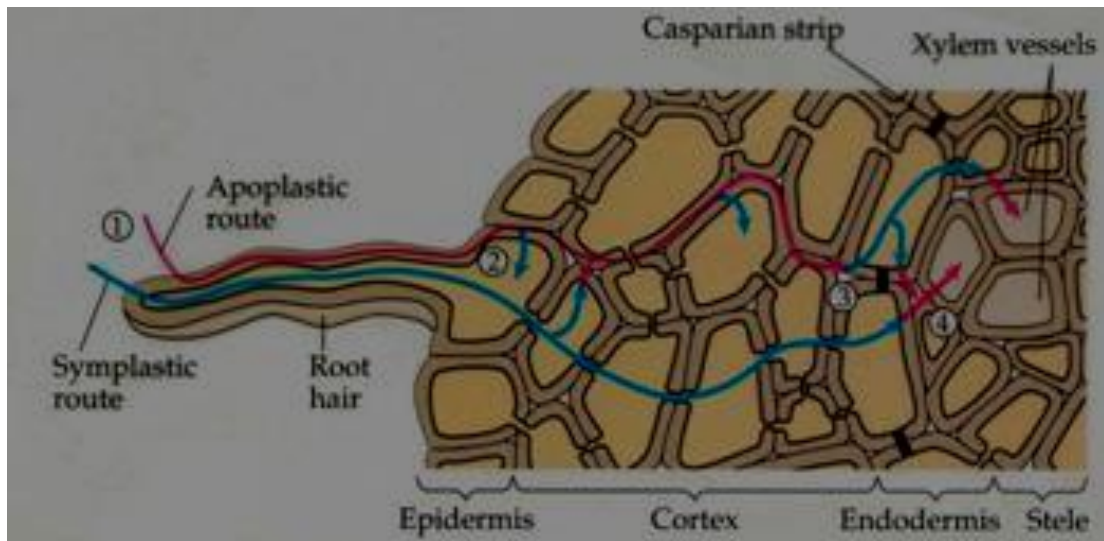
N.B. 2: The endodermal cells (the innermost row of cells of the cortex) control the passage of water inwards to xylem vessels as:

The endodermal cells facing phloem: having their cell walls completely thickened with suberin. So these cells prevent the passage of water inwards by imbibition which is not under the control of the cell.

While the endodermal cells facing xylem strands: having their cell walls thickened with suberin only as a strip called Caspian Strip that runs as a ribbon around the middle region of both the radial walls and the transverse walls. So, water is allowed to pass inwards only by osmosis and active transport under the control of the protoplasm of these cells. Passage of water by imbibition is prevented because suberin is impermeable for water. The endodermal cells facing xylem strands are called the passage cells.

The pathways through which water passes across root cells:

1. **Through the cell sap:** by osmosis that necessitates a gradual fall in the osmotic pressure along the root cells.
2. **Through the cytoplasm:** Where water rushes from one cell to another through the plasmodesmata that connect the protoplasm of plant cells together.
3. **Through the cell walls** by imbibition and **the small intercellular spaces** where the imbibed water flows.



Revision I

1. Mention the scientific term that represents:

- a. Movement of molecules of ions from a highly concentrated medium to a low concentrated one. (-----)
- b. Living organisms that obtain their food in a liquid form from decayed remains of dead organisms. (-----)
- c. An impermeable suberized ribbon that runs around the middle region of both the radial and the transverse walls of the endodermal cells. (-----)
- d. Plants living in salt marshes. (-----)
- e. The pressure that causes the diffusion of water from through semipermeable membranes. (-----)
- f. The phenomenon that causes colloidal solids to absorb water and swell. (-----)
- g. The endodermal cells that face xylem strands in the root. (-----)
- h. Plants that are grown in deserts. (-----)

2. Mention the biological function (s) of each of the following:

- | | | |
|---------------|----------------|-------------------------|
| a. Nutrition. | b. Root hairs. | c. The casparian strip. |
|---------------|----------------|-------------------------|

3. Define:

- | | |
|----------------|----------------------|
| a. Nutrition. | b. Osmosis. |
| c. Imbibition. | d. diffusion. |
| | e. osmotic pressure. |

4. Give reasons for:

- a. Water never passes through the endodermal cells by imbibition.
- b. Root hairs are large in number and protruding to the outside.
- c. Diffusion.
- d. Halophytes and Xerophytes have their root hairs with high osmotic pressure.
- e. Root hairs secrete a viscous substance.

5. Describe the adaptation features of each of the following to their function:

- | | |
|-----------------------|--------------------|
| a. The passage cells. | b. The root hairs. |
|-----------------------|--------------------|

6. Describe the three pathways through which water passes through the root cells till it reaches xylem vessels.

7. Explain how absorption of water takes place.

8. Give examples for:

a. Colloidal substances that imbibe water.

b. Molecules that never pass through the semi permeable membranes.

c. Impermeable walls.

d. Permeable walls.

9. Give an account for:

a. The endodermis in the root.

b. Parasites.

c. Holozoic nutrition.

d. Autotrophic nutrition.

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 of these elements lead to:

1. Disturbances in plant growth.

2. The growth may stop completely.

3. Flowers or fruits may not produce.

These elements are divided into 2 groups:

1. Macro-nutrients:

These elements are needed by the plant in considerable quantities:

Nitrogen – Phosphorus – Sulphur - Potassium – Calcium – Magnesium – Iron.

2. Micro-nutrients:

They are also called the trace elements, because they are needed by the plant in very small quantities. (Few milligrams/liter). These elements help to activate enzymes:

Manganese – Zinc – Boron – Aluminum – Copper – Chlorine – Iodine – Molybdenum.

Mechanism of Salts Absorption

It depends on the following phenomena:

1. Diffusion:

Some salt ions move by diffusion from the soil solution where the concentration is higher and pass through the wet cellulosic walls to the less concentrated medium.

Where the salt ions behave independently of each other and of water itself as:

a. Positive ions (cations) as K^+ and Ca^{++}

b. Negative ions (anions) as Cl^- , NO_2^- , and SO_4^{2-} .

Cation exchange may take place. A Na^+ may get out of the cell and is replaced by a K^+ ion.

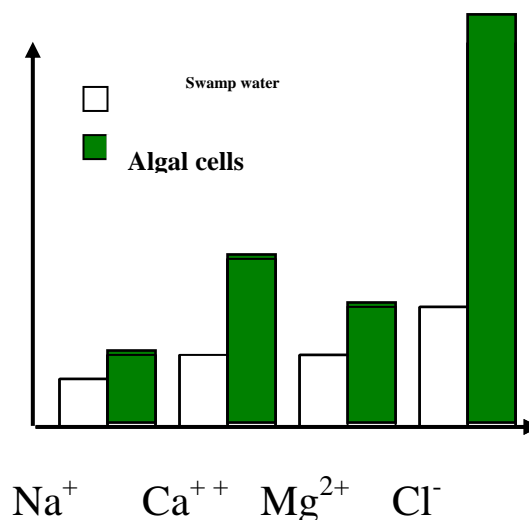
2. Selective permeability:

When ions reach a semi permeable plasma membrane, some of them are selected to pass inwards according to the plant's requirements. Some other ions are not permitted in regardless their size, concentration, or charge.

3. Active transport:

Sometimes ions move from the salt solution where the concentration is low to the inside of the cell where the concentration is high. Energy is needed to force these ions to move against the concentration gradient.

The following graph represents the results of an experiment carried out on *Nitella* alga that lives in swamp water:

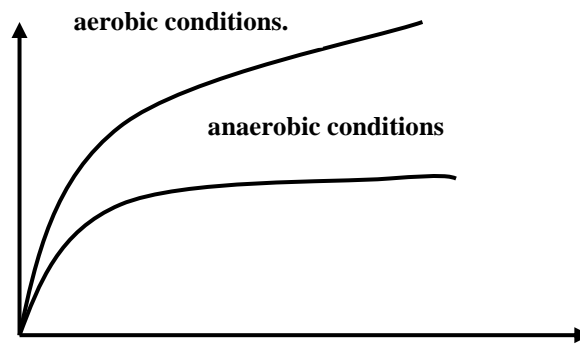


1. The concentration of different ions accumulated in the cell sap of the algal cells is higher than their concentration in the swamp water. This proves that the cell must use up energy to absorb these ions.

2. The concentration of some ions accumulated 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. **Movement of any substance through the plasma membrane of the cell by the help of chemical energy** is called active transport. This energy is supplied during respiration of root tissues. Since the process of aerobic respiration demands the presence of sugar and Oxygen, both of them are essential for absorption of salts by the plant.

The following graph represents the results of an experiment carried out on Barley plant to show the effect of Oxygen presence (aerobic respiration) on the absorption of sulphate ions (SO_4^{2-}) ions by the plant:



The Barley plant was supplied with sulphate ions containing radioactive S_{35} . The quantity of absorbed salt was estimated using Geiger counter. The experiment was carried out twice:

1st: When the root is exposed to aerobic conditions.

2nd: When the root is exposed to anaerobic conditions.

The results:

1. Absorption of sulfate ions was less in the case of anaerobic conditions. So, occurrence of aerobic respiration is essential for absorption of salts to take place.
2. Salt ions accumulate in the plant cells due to energy that is released during aerobic respiration.

2. Photosynthesis in Green Plants.

Importance of Photosynthesis:

1. Living organisms require energy in order to grow, reproduce, and survive.
2. Photosynthesis is the most important chemical process to Man, as it produces Man's food (carbohydrates, proteins, fats, and vitamins)
3. Man's economic life depends on photosynthesis, as it produces plant and animal fibers that are used as textile fabrics as well as wood, paper, and other products as fats, alcohol, vinegar being very important direct and indirect products for photosynthesis.
4. Fuels of engines and means of transport as coal, petroleum, and natural gas have originated from plants that stored the solar energy inside their tissues as fuels while they were performing photosynthesis in the ancient geological ages.
5. Oxygen which is 21% of volume of the atmospheric air that surrounds Earth is a product of photosynthesis process, that accumulates during the past ages.

Raw materials required for Photosynthesis:

1. Water: The source of Hydrogen needed by green plants to reduce Carbon dioxide, which is the first step in the production of carbohydrates.
2. Carbon dioxide: The only source from which green plants obtain Carbon.
3. Mineral salts:
 - a. Nitrates, Phosphates, and sulfates: Are required to convert carbohydrates into proteins.
 - b. Phosphorus: An important element in the structure of compounds that carry energy during photosynthesis.

- c. **Magnesium**: An important element in the synthesis of chlorophyll.
- d. **Iron**: An important element in building up some enzymes that help to Complete photosynthesis.

Products of Photosynthesis:

1. The main product of Photosynthesis is a monosaccharide. This sugar can be used in:
 - a. Building up of proteins needed for growth.
 - b. The production of energy during the respiration process.
 - c. Formation of starch in order to be stored.
2. The bi-product of Photosynthesis is Oxygen.

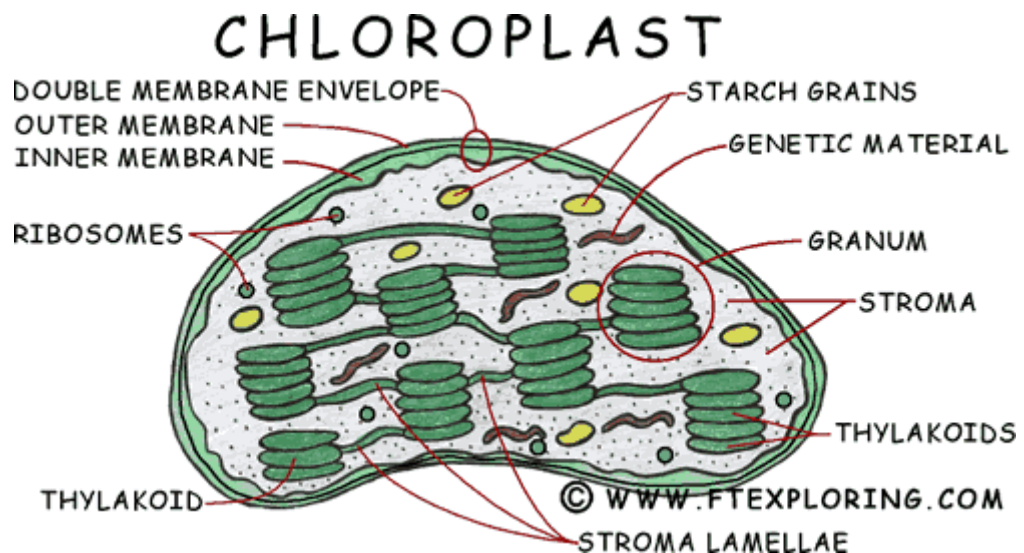
Rate of Photosynthesis:

Rate of Photosynthesis can be determined by

1. Estimating the amount of carbohydrates formed in time unit. Under good conditions of illumination, the rate of Photosynthesis would be 1 gm of carbohydrates in an hour per each meter square of the leaf surface. (1gm/hr/m²)
2. Measuring Oxygen bubbles evolved in the time unit. Or measuring the volume of Oxygen gas formed in the time unit.

Where does Photosynthesis take place?

1. Green leaves: The main sites for Photosynthesis as they contain chloroplasts in their cells in higher plants.
2. Green Herbaceous stems: Take part in Photosynthesis, as they contain chlorenchymatous tissues with chloroplasts in their cells.



The structure of the chloroplast:

Appears as a homogeneous mass as the shape of a convex lens through the light microscope. The chloroplast appears through the electron microscope with a double thin membrane that enclosed it (about 10 nanometer thick). Inside the chloroplast, there is the matrix (stroma) which is a colorless proteinic substance. Embedded in the stroma are disc shaped grana. Each granum is about 0.5 micron

in diameter and about 0.7 micron thick. Grana are arranged as clusters along the body of the plastid where they are linked together by thin membranes (grana lamellae). Each granum is a pile of 15 or more discs arranged over each other. Each disc is hollow from the inside, while its margin extends outside the granum to meet the margin of another disc in a neighboring granum, this to increase the exposed surface area of the discs, these are responsible for carrying the pigments that absorb light energy.

The chloroplast contains 4 main pigments. as in the following table:

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

It is clear from the table why green color dominates colors of other pigments in the plastid.

The role of chlorophyll: Is to absorb light energy required for plants to carry out photosynthesis.

The structure of chlorophyll molecule:

The structure of the chlorophyll molecule is complex, it has the molecular formula: $C_{55}H_{72}O_5N_4Mg$. The Magnesium atom occupies the centre of the molecule; there is a relationship between the presence of Mg in the chlorophyll and the ability of chlorophyll to absorb light.

N.B: Starch grains are produced inside the chloroplast. They are minute in its size, and are the temporary product of photosynthesis. They will soon change back to soluble sugar in order to be translocated to other organs of the plant.

The structure of the leaf and it's adaptation to Photosynthesis

The structure of the plant leaf:

The leaf is composed of three main tissues:

1. The upper and the lower epidermis:

Each is composed of one row of adjacent, barrel-shaped parenchyma cells with no chlorophyll. Stomata spread between them, and the outer walls of these cells are covered with cutin.

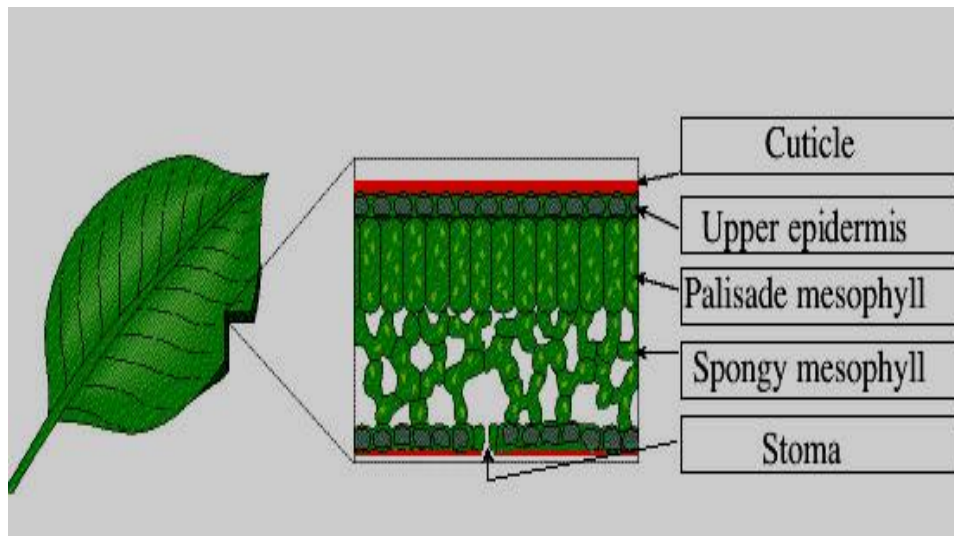
2. The mesophyll tissue:

Lie between the upper and the lower epidermis and it is transversed by veins. It consists of two main layers:

a. The Palisade layer:

It lies below the upper epidermis. It consists of one row of elongated cylindrical parenchyma cells that are arranged in a columnar form perpendicular to the leaf

surface. Palisade cells possess many chloroplasts that are arranged at the upper parts of these cells to receive as much sunrays as possible.



b. The spongy layer:

It lies below the palisade layer. It consists of irregularly shaped and loosely arranged parenchyma cells with large intercellular spaces between them. Spongy cells contain less chloroplasts than the palisade cells.

3. The vascular tissue:

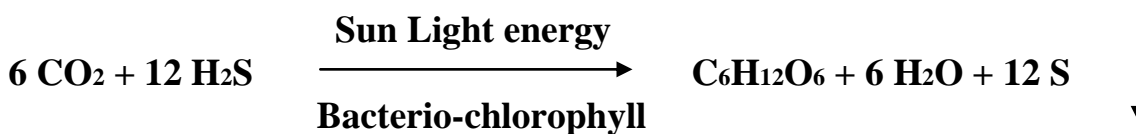
The midrib contains the main vascular bundle, while veins and venules contain many smaller secondary vascular bundles. Inside the vascular bundle there are xylem vessels that are arranged in vertical rows between which xylem parenchyma cells exist. Next to xylem towards the lower surface of the leaf, phloem exists. Phloem translocates the soluble organic foodstuffs that are formed in the mesophyll to all the plant parts.

Mechanism of Photosynthesis

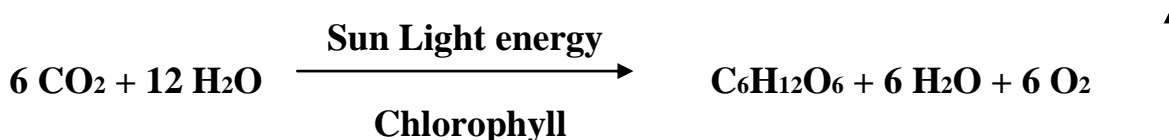
Source of Oxygen released during Photosynthesis:

Van Neil was the first person who pointed out the role of light in Photosynthesis. He studied photosynthesis in sulfur bacteria (green and purple). These bacteria are autotrophs, as they contain bacteriochlorophyll (simpler in structure than ordinary chlorophyll). These bacteria live in swamps and bogs where Hydrogen Sulfide is abundant. Hydrogen Sulfide is the source of Hydrogen used by these bacteria to reduce Carbon dioxide into carbohydrates, Sulfur is released.

Van Neil assumed that light decomposes Hydrogen Sulfide into Hydrogen and Sulfur. Hydrogen is then used afterwards in a certain dark reactions to reduce Carbon dioxide into carbohydrates. As in the following equation:



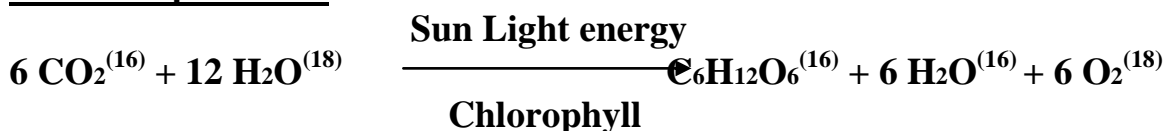
On this basis, Van Neil assumed that light reactions in green plants are similar to that happening in sulfur bacteria, except that in green plants it is water that is decomposed by light into Hydrogen and Oxygen. Hydrogen is used afterwards to reduce Carbon dioxide in a series of reactions that don't require light into carbohydrates, and Oxygen releases. So, Van Neil proposed that the release of Oxygen comes from water, a case which is similar to Sulfur that is released from Hydrogen Sulfide. So the general chemical equation that represents Photosynthesis in green plants:



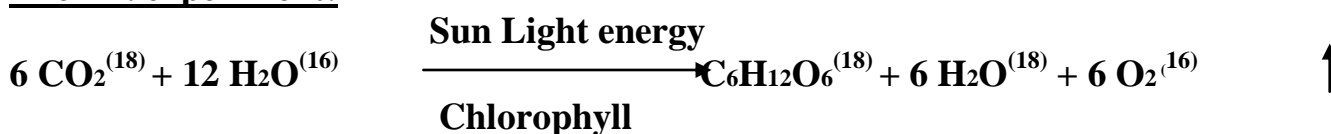
Verifying the theory of Van neil experimentally:

A group of scientists in California University used the green alga Chlorella in an experiment to prove the correctness of Van Neil theory experimentally.

The 1st. experiment:



The 2nd. experiment:



Light reactions and dark reactions

During his experiments to study the limiting factors of Photosynthesis as light, heat, and Carbon dioxide, Blackman concluded that Photosynthesis process is divided into two types of reactions:

1. Light reactions:

In which light acts as the limiting factor of the process. Light reactions take place in grana.

2. Dark reactions:

Dark reactions are sensitive for temperature and are not affected by light. These reactions take place in both light and darkness. And temperature is the limiting factor for the rate of the process. Dark reactions take place in stroma.

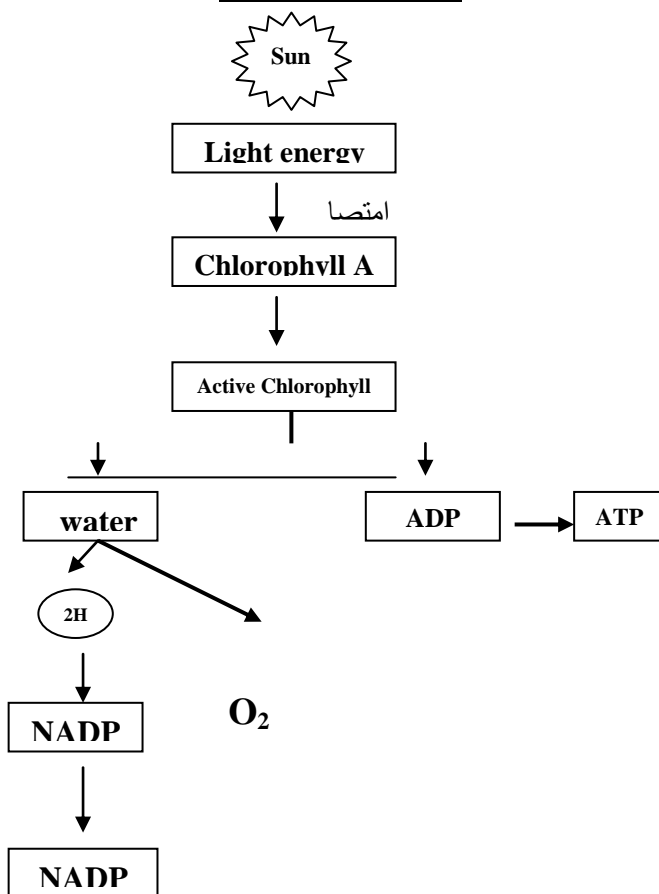
1. Light reactions of Photosynthesis:

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}:

$$\text{ADP} + \text{P} + \text{energy} \longrightarrow \text{ATP}$$
- f. Hydrogen resulting from decomposition 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 NADPH₂. In this way Hydrogen will not escape or recombine with Oxygen once more.
- g. Oxygen releases as a bi-product for the decomposition of water.

Light reactions



Melvin Calvin Experiment To reveal the nature of Dark reactions

2. Dark reactions of Photosynthesis:

A group of reactions that takes place in the stroma of the chloroplast outside the grana, in which:

Hydrogen carried on NADPH_2 is used to fix CO_2 gas into carbohydrates with the help of the energy stored in ATP molecules.

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 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:

When photosynthesis is proceeded with the briefest flash possible of light, the 1st. stable compound to be produced is PGAL (Phospho-glyceraldehyde) which is a 3-carbon compound. PGAL acts as crossroads in the metabolic network, from which glucose, starch, proteins, and fats are formed. It can be utilized in the cellular respiration. The Hexose's sugar is formed throughout several enzymatic intermediate reactions.

Revision II

1. Mention the scientific term that represents each of the following:

- a. The elements that are required in very small quantities and act to activate enzymes. (-----)
- b. Passage of any substance through the cell membrane by the help of some chemical energy. (-----)
- c. The process that can be considered as the principle foundation of Life on Earth. (-----)
- d. The source of Hydrogen needed by plants to reduce CO_2 into carbohydrates during photosynthesis. (-----)
- e. The source from which plants obtain Carbon. (-----)
- f. The matrix in which grana are embedded in chloroplasts. (-----)
- g. Narrow tiny pores which are the main sites of gaseous exchange in the plant leaf. (-----)
- h. The layer that covers the upper and the lower epidermis of the leaf. (-----)
- i. The tissue that lies between the upper and the lower epidermis of the plant leaf. (-----)
- j. A layer of irregularly shaped and loosely arranged parenchyma cells in the plant leaf. (-----)
- k. The source of Oxygen evolved during photosynthesis. (-----)
- l. The limiting factor of light reactions of photosynthesis. (-----)
- m. The limiting factor of dark reactions of photosynthesis. (-----)
- n. Acts as Hydrogen receptor during photosynthesis. (-----)

- o. A compound that acts as the energy currency in living cells. (-----)
- p. The 1st. stable compound to be produced during photosynthesis. (-----)
- q. Elongated cylindrical parenchymatous cells that possess many chloroplasts in the plant leaf. (-----)
- r. Thin membrane that links the grana together in the chloroplast. (-----)

2. Give reasons for each of the following:

- a. Both sugar and Oxygen are essential for salt ions absorption by plants.
- b. Movement of salt ions through root tissues towards the vascular tissue is helped by the presence of intercellular spaces of the cortex.
- c. Absorption of mineral salts affects water absorption.
- d. Photosynthesis process is the principle foundation of Life on Earth.
- e. Water and Carbon dioxide are the most important raw materials for photosynthesis.
- f. Stems of some plants can photosynthesize.
- g. Starch grains may present inside the chloroplast.
- h. The leaf blade is thin and flattened.
- i. Presence of mid-rib, veins, and venules spreading allover the leaf.
- j. The upper and the lower surfaces of the plant leaf are covered with a layer of cutin.
- k. Stomata occur on the leaf surface.
- l. The epidermal cells of the plant leaf are barrel shaped and transparent.
- m. The epidermal cells of the plant leaf are adjacent and compact.
- n. The upper surface of the plant leaf appears to be greener than the lower surface.
- o. Collenchyma tissue is present in the plant leaf.
- p. Sulfur Bacteria live in swamps and ponds where Hydrogen Sulfide is abundant.
- q. Photosynthesis process passes through two kinds of reactions.
- r. Chlorophyll is an energy converter.
- s. ATP can be considered as the energy currency in living cell.
- t. NADP acts as a Hydrogen receptor during photosynthesis.
- u. PGAL acts as a sort of crossroads in the metabolic network.

3. Draw a labeled diagram to show:

- a. The fine structure of the chloroplast.
- b. A transverse section in a dicotyledonous plant leaf.
- c. The light reactions of photosynthesis.

4. Mention the function(s) of each of the following:

- a. Micro-nutrients.
- b. Chlorophyll.
- c. Stomata.
- d. Cutin that covers leaf epidermis.
- e. The palisade layer.
- f. The spongy layer.
- g. Xylem of the leaf.
- h. Phloem of the leaf.
- i. ATP during photosynthesis.
- j. NADP during photosynthesis.

k. Mineral salts during photosynthesis.

5. Describe Van Neil assumptions concerning the mechanism of photosynthesis process, and mention how did scientists of California verify his assumptions experimentally.

6. Describe Blackman conclusion concerning the limiting factors of photosynthesis.

7. Describe the steps of light reactions of photosynthesis.

8. Describe the experiment of Melvin Calvin to clarify the nature of dark reactions of photosynthesis, with drawing.

9. Compare between photosynthesis in Sulfur Bacteria and that happens in green plants.

10. Give an account for mechanism of mineral salts absorption.

Heterotrophic Nutrition – Digestion in Man.

Concept and importance of Digestion:

The heterotroph obtains its food as ready-made organic compounds. These compounds are complex and of large molecules (Proteins / Starch / and Fats) that they can not pass through the cell membranes of the living organisms. These large molecules have to be broken down into molecules of smaller size and simpler structure (Amino acids / Glucose / and Fatty acids and glycerol). As these molecules are small and soluble in water, they can easily be absorbed by the cell, either by diffusion or by active transport. Cells will then use these simple compounds as a source of energy, or in growth of new tissues.

Digestion:

Digestion is the conversion of large food molecules (polymers) into smaller ones (monomers) by means of hydrolysis. This process is helped by enzymes.

Enzymes.

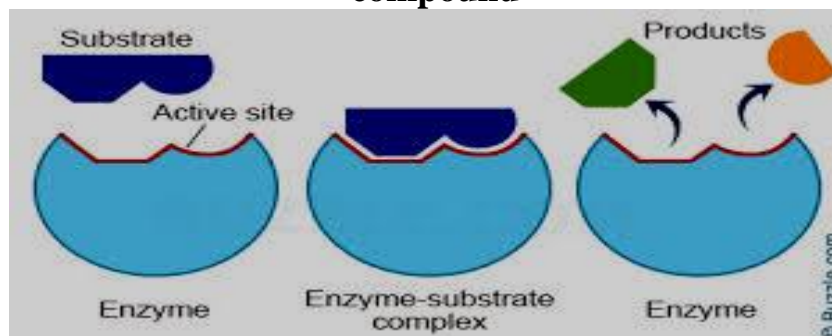
The enzyme:

A protein substance that has the properties of a catalyst, as it has specific ability to activate a particular chemical reaction.

Enzymes are specific in their actions. The reaction which is catalyzed by a certain enzyme depends on:

a. The structure of the reacting molecules.
b. The nature of the enzyme.

An enzyme + The reacting substance \longrightarrow Unstable intermediate compound \longrightarrow The enzyme + Products of the reaction



Enzymes only accelerate the rate of a reaction until it reaches a case of equilibrium. They never affect the product of the reaction. Some enzymes may have a reversible effect: this means that the same enzyme that catalyzes the decomposition of a complex molecule into two simpler ones may recombine the two simple molecules to give the same complex molecule once more. Some enzymes are secreted by the cell in an inactive state. So, they need certain substances to be present to activate them. Ex.: Pepsin enzyme is secreted by the stomach as inactive Pepsinogen, that is changed into active Pepsin in the presence of Hydrochloric acid

in the stomach. The intensity of an enzymatic reaction depends on the temperature and the PH value.

Digestion in Man

Human digestive system is built up of a long tube extending from the mouth to the anus. It comprises the mouth, the pharynx, the esophagus, the stomach, the small intestines, the large intestines, and the anus.

1. Buccal Digestion (Digestion inside the mouth):

The Human digestive system begins with the mouth opening. Mouth contains:

a. The teeth:

Teeth in one jaw are differentiated into:

- 4 incisors: at the front of the jaw to cut food.
- 2 canines: one at each side of the incisors to tear food.
- 4 premolars: two at each side to crush and grind food.
- 6 molars: three at each side to crush and grind food.

b. The tongue:

- Acts as the taste organ.
- Manipulates food and mixing it with saliva.

c. Saliva:

Is secreted from 3 pairs of salivary glands that open in the mouth cavity through ducts that pour saliva over food. Saliva contains mucous that softens food and lubricate it to facilitate its swallowing. Saliva contains Amylase (Ptyalin) enzyme that acts in a weak alkaline medium. Amylase enzyme catalyzes the hydrolysis of starch to the disaccharide maltose.

d. The pharynx:

Pharynx exists at the back of the mouth. It is a common passage for both food and air. Two tubes extend downwards from the pharynx: the esophagus (that leads to the stomach) and the trachea (which is a part of the respiratory system). Swallowing process is an organized reflex action: as food is pushed from the mouth to the esophagus. Top of the trachea together with the larynx are elevated, so the epiglottis closes over the glottis entrance to the air passage.

e. The esophagus:

A tube of 25 cm long, that extends from the pharynx downwards through the neck and into the chest cavity. It lies parallel to the vertebral column. The esophagus is lined with glands secreting mucus. Food is carried through the esophagus to the stomach by a series of rhythmical muscular contractions and relaxations which is called peristalsis. This movement is continuous along the length of the digestive system. It is responsible for pushing the food forwards, churning it, and mixing it with the digestive juices, and the absorption of the digested food.

2. Gastric Digestion (Digestion inside the stomach):

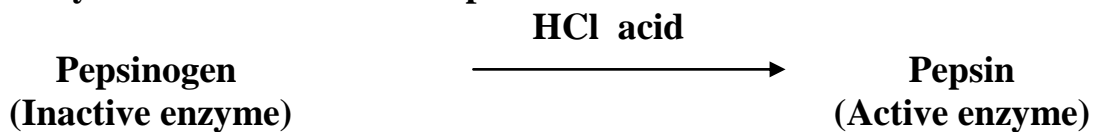
The stomach is a dilated muscular sac that lies in the abdominal cavity. It is joined to the lower part of the esophagus by a constricted circular muscle called the cardiac sphincter. The stomach is joined to the small intestines by a muscular valve of circular smooth muscle called the pyloric sphincter.

Proteins are the only food substances that are affected by the gastric juice.

The gastric juice:

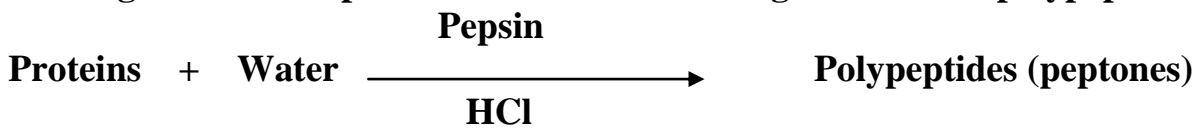
A colorless acidic liquid that contains:

1. Water: 90%
2. Hydrochloric acid: to create an acidic medium (PH 2.5 – 1.5) that stops the action of Ptyalin enzyme and kills the harmful bacteria that may enter with the food and activates the gastric enzyme Pepsinogen into active Pepsin.
3. Pepsin enzyme: which is secreted in an inactive form as Pepsinogen, that is activated by HCl acid into active Pepsin:



Digestion of Proteins:

Pepsin catalyzes the hydrolysis of proteins by breaking certain peptide linkages in the long chain of the protein to form smaller fragments called polypeptides:



Chyme:

The muscular contractions of the stomach wall help in churning and mixing up the food with the gastric juice. The large capacity of the stomach helps to act as a reservoir to store food long enough to be digested. At the end of the gastric digestion, the food becomes a heavy semi-fluid with a consistency suitable for being discharged from the stomach into the small intestines by the relaxation of the pyloric sphincter.

Why does the gastric juice not affect the inner epithelial lining of the stomach?

1. The presence of copious mucus secretion protects the inner epithelial lining of the stomach against the effect of the digestive enzymes.
2. Pepsinogen which is inactive will be activated only when it is mixed with the acid in the cavity of the stomach away from its wall.

3. Intestinal digestion (Digestion inside the small intestine):

The small intestine has 8 meter long and about 3.5cm in diameter (at its beginning) and 1.25cm (at its end). Coils and loops of the small intestines are connected together by a membranous structure which is called the mesenteric membrane. The small intestine is differentiated into two parts: the duodenum and the ileum. Inside the small intestine, the following juices are secreted over food:

a. Bile:

Bile is secreted from the liver over food during its passage in the duodenum. Bile emulsifies fats (divides large masses of fats into fine fatty globules). This helps to facilitate and accelerate the enzymatic action on fats that are insoluble in water.

b. Pancreatic juice:

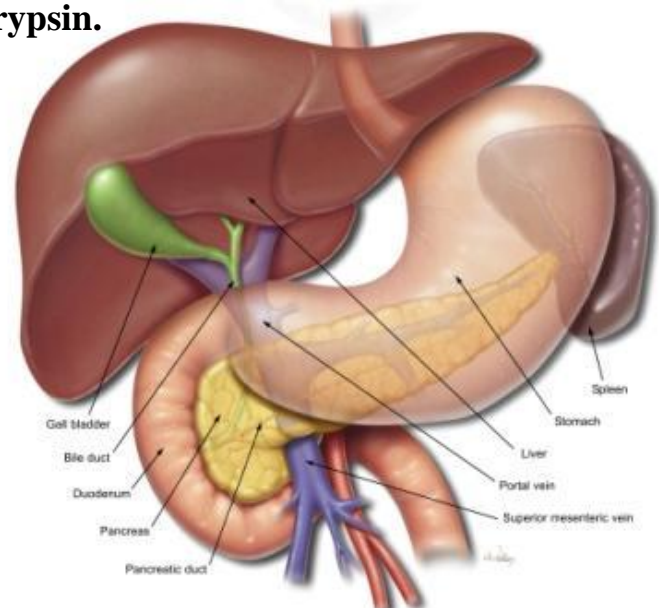
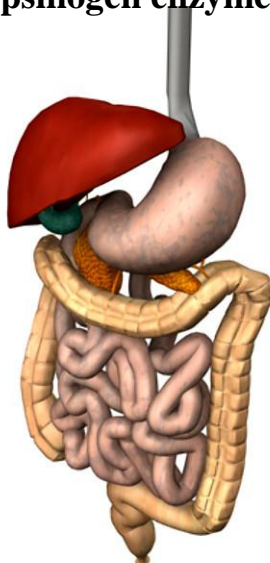
Pancreatic juice is secreted from the pancreas over food during its passage in the duodenum. Pancreatic juice contains the following components:

- **Sodium Bicarbonate:** That neutralizes HCl acid and renders the medium alkaline.
- **Pancreatic amylase:** Catalyzes the hydrolysis of starch and glycogen into a disaccharide called maltose.
- **Trypsinogen enzyme:** Is an inactive enzyme that is activated when it reaches the duodenum by the action of a co-enzyme called enterokinase (secreted from the lining of the small intestines) into active trypsin. Trypsin which has an effect of proteins, as it catalyzes the hydrolysis of proteins into polypeptides.
- **Lipase:** Catalyzes the hydrolysis of fats (which are in the form of fatty emulsion) into fatty acids and glycerol.

c. Intestinal juice:

Intestinal juice is secreted from certain cells in the lining of the small intestines. It contains a mixture of enzymes that completes the action of the previous enzymes:

- **Peptidases:** A group of enzymes. Each enzyme is able to hydrolysis a peptide linkage between certain amino acids in the polypeptide chains. This completes the digestion of various protein fragments to various amino acids.
- **Enzymes that hydrolyze disaccharides to monosaccharide:**
 - **Maltase:** Hydrolyzes maltose sugar to two molecules of glucose.
 - **Sucrase (invertase):** Hydrolyzes sucrose sugar (cane sugar) to glucose and fructose.
 - **Lactase:** Hydrolyzes lactose sugar (milk sugar) to glucose and galactose.
- **Enterokiase:** Is not a digestive enzyme. It acts as a co-enzyme that activates trypsinogen enzyme into active trypsin.



Absorption of Food.

Absorption of food is the transfer of digested food substances to blood and lymph through the epithelial cells lining the ileum of the small intestines.

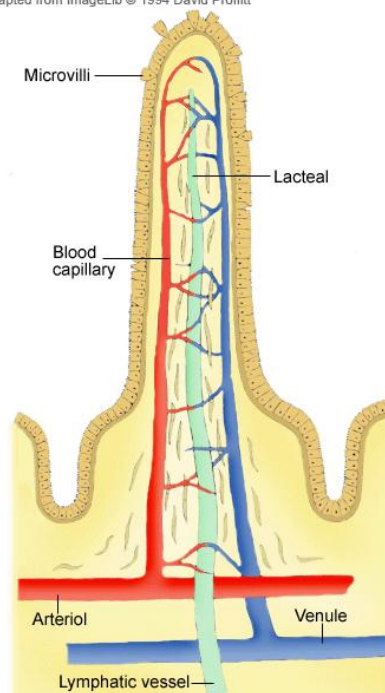
The structure of the wall of the small intestines:

The inner epithelial lining of the ileum suits its function as it provides an enormous surface area for the absorption of nutrients (that reaches 10 m^2 – approximately 5 times as the whole surface area of the human body). This is due to its folds and convolutions as well as innumerable tiny-like projections called villi. The surface area of absorption, therefore, increases greatly.

The structure of the villus:

The villus is composed of an outer covering of a single-celled layer of epithelial cells that encloses a lacteal vessel surrounded by a network of both venous and arterial blood capillaries. Under the electron microscope, tiny projections protrude from the epithelial cells of the villi are seen, these are called micro-villi. The micro-villi help to increase the area of the absorbing surface. Products of the digestive process are transferred to the blood and the lymph by the membranous diffusion and active transport.

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Absorption routes:

There are two routes for absorption of the digested substances through the villi:

1. The blood route:

It starts with the blood capillaries inside each villus where blood carries: water, mineral salts, mono-saccharides, amino acids, and soluble vitamins. These substances are carried to the hepatic portal vein, then to the liver, then out of the liver through the hepatic vein to be emptied into the inferior vena cava, then to the heart.

2. The lymphatic route:

Fatty acids and glycerol pass to lacteals with the dissolved vitamins A,D, and K. Some of these fatty acids and glycerol may recombine to form fats again in the epithelial cells of the villi. Some of the finely emulsified fats are absorbed by being engulfed by the epithelial cells. All fats pass to the lacteals inside the villi, then to the lymphatic system which carries them slowly to the superior vena cava then to the heart.

Metabolism:

Metabolism is the process in which the body gets benefit from the absorbed digested food substances. It includes two opposite stages:

1. Anabolism: In which the simple food substances convert into complex compounds that share in the body construction as:

a. Conversion of simple sugars into complex carbohydrates (polysaccharides) that are stored in the liver and muscles as glycogen.

b. Conversion of amino acids into proteins needed by the body.

c. Conversion of fatty acids and glycerol into fats that is stored in the body especially under the skin.

2. Catabolism: In which the absorbed food substances are oxidized, especially sugars to produce energy which is needed by the body to carry out its vital process.

Large intestines and defecation:

Undigested food passes from the small intestines to the large intestines where water and some salts are absorbed from these residues by means of the lining of the large intestines that has many folds and convolutions helping in that. So, the undigested residues become in the form of semi-solid. They decay due to the presence of some species of bacteria. Waste remains are expelled as faeces through the anus by means of strong muscular contractions of the rectum accompanied with relaxation of the two muscles of the anal sphincter at the two sides of the anus. The large intestines secrete mucus that facilitates passage of the wastes out.

Revision III

1. Give the scientific term that represents:

- a. Conversion of polymers into monomers by means of hydrolysis. (-----)
- b. A protein substance that has the properties of a catalyst as it has specific ability to activate a particular chemical reaction. (-----)
- c. The enzymatic chemical reaction in which the same enzyme may catalyze the decomposition of a complex molecule into two simpler ones may recombine the two small molecules to give the same complex molecule once more. (-----)
- d. A long tube extending from the mouth to the anus. (-----)
- e. A cavity at the back of the mouth that leads to the esophagus and the trachea. (-----)
- f. Lies parallel to the vertebral column, between the lungs, behind the heart and trachea, and passes directly to the stomach through the diaphragm. (-----)
- g. A constricted circular muscle that joins the stomach to the lower part of the esophagus. (-----)
- h. The circular smooth muscle that controls the passage of food to the small intestines. (-----)
- i. The structure that joins coils and loops of the small intestines. (-----)
- j. The first part of the small intestines. (-----)
- k. A powerful constricted muscle that controls passage of faeces out. (-----)
- l. The enzyme that catalyzes the hydrolysis of starch to the disaccharides maltose. (-----)
- m. A movement in which a series of rhythmical muscular contractions and relaxations extend along the esophagus to sweep food down. (-----)
- n. The PH value inside the stomach. (-----)
- o. A colorless acidic liquid 90% of which is water, and the rest is HCl acid and the gastric enzyme. (-----)
- p. An inactive enzyme presents in the gastric juice. (-----)
- q. The enzyme that catalyzes the hydrolysis of proteins to produce polypeptides. (-----)
- r. The bonds that bind amino acids in the polypeptide chain. (-----)
- s. Heavy semi-fluid that discharges into the small intestines by relaxation of the pyloric sphincter. (-----)
- t. Result due to the action of bile on fats. (-----)
- u. The chemical the neutralizes HCl acid and makes the medium of the small intestines alkaline. (-----)
- v. A pancreatic enzyme that catalyzes the hydrolysis of glycogen and starch into the disaccharide maltose. (-----)
- w. An inactive pancreatic enzyme that if it is activated, it will be able to affect proteins. (-----)

- x. The co-enzyme that activates the pancreatic enzyme responsible for protein digestion. (-----)
- y. The enzyme that catalyzes the hydrolysis of fats into fatty acids and glycerol. (-----)
- z. The enzyme that catalyzes the hydrolysis of maltose sugar to two molecules of glucose. (-----)
- a. The enzyme that catalyzes the hydrolysis of proteins to polypeptides inside the small intestines. (-----)
- b. A group of enzymes, each one catalyzes the hydrolysis of a peptide linkage between certain kinds of amino acids in the polypeptide chain. (-----)
- c. The enzyme that hydrolyzes cane sugar into glucose and fructose. (-----)
- d. The enzyme that hydrolyzes milk sugar into glucose and galactose. (-----)
- e. The transfer of digested food substances to blood and lymph. (-----)
- f. The two main mechanisms used in absorption of the digested food. (-----)
- g. Tiny finger-like projections that arise from the inner epithelial lining of the ileum. (-----)
- h. Tiny projections that arise from the epithelial cells of the villi which can be seen using the electron microscope. (-----)
- i. The system that carries fats after its absorption slowly through a network of vessels. (-----)
- j. The vein in which the absorbed fats are poured to join the blood. (-----)
- k. The vein that carries food substances after its absorption to the liver. (-----)
- l. Stored glucose inside the liver. (-----)
- m. A vein in which the food substances that are actually required by the body pass out of the liver to be emptied into the inferior vena cava. (-----)
- n. The process in which the body gets benefit from the absorbed digested food substances. (-----)
- o. The process in which the simple food substances convert into complex compounds that share in the body construction. (-----)
- p. The process in which the absorbed food substances are oxidized, especially sugars to produce energy which is needed by the body to carry out its vital process. (-----)

2. Give reasons for each of the following:

- a. occurrence of digestion in heterotrophs.
- b. Enzymes are specific in their actions.
- c. Some enzymes may have a reversible effect.
- d. The stomach is guarded by two circular muscles.
- e. Children are advised to chew food well.
- f. Saliva has a digestive effect.
- g. Swallowing is an organized reflex action.
- h. Food is swept downwards inside the esophagus.
- i. Secretion of HCl acid inside the stomach is essential.
- j. Proteins are digested inside the stomach.
- k. The large capacity of the stomach.

- l. The gastric juice doesn't affect the epithelial lining of the stomach.
- m. Bile has a great effect on fats digestion in spite of it contains no enzymes.
- n. Importance of Sodium Bicarbonate for the intestinal digestion.
- o. Proteins are also digested during its passage in the small intestines.
- p. Fats are digested during its passage in the small intestines.
- q. The intestinal juice completes proteins digestion.
- r. Digestion of carbohydrates is completed in the small intestines.
- s. Enterokinase is not a digestive enzyme, in spite of that, it has great digestive effect.
- t. The inner epithelial lining of the ileum provides an enormous surface area for absorption.
- u. Villi are ideal structures for food absorption.
- v. The lymphatic system has a role in food absorption.
- w. Large intestines have a role in food absorption.
- x. The ability of the rectum to expel waste remains as faeces.

3. Define each of the following:

- | | | |
|-------------------------|---------------------|-----------------|
| a. Digestion. | B. Enzyme. | C. Peristalsis. |
| d. Mesenteric membrane. | E. Food absorption. | f. Metabolism. |
| g. Catabolism. | H. Anabolism. | |

4. Draw a labeled diagram that represents:

- a. The connection between the liver, the pancreas, and the duodenum.
- b. The internal structure of the villus.

5. Mention the role played by each of the following in digestion and food absorption:

- | | | |
|--------------------------|--|----------------------|
| a. an enzyme. | b. Teeth. | c. The tongue. |
| d. The pyloric sphincter | e. The cardiac sphincter. | f. salivary amylase. |
| g. Peristalsis. | h. HCl acid inside the stomach. | i. Pepsin. |
| j. Bile. | k. Sodium Bicarbonate inside the small intestines. | |
| l. Pancreatic amylase. | m. Trypsin. | n. Enterokinase. |
| o. Lipase. | p. Peptidases. | q. Maltase. |
| r. Lactase. | s. The lymphatic system in food absorption. | |
| t. sucrase. | u. The anal sphincter. | v. Catabolism. |
| w. Anabolism. | | |

6. Describe the mechanism of food absorption through:

- a. The lymphatic route.
- b. The blood route.

7. Why does the gastric juice not affect the epithelial lining of the stomach?

8. Describe the mechanism of defecation to get rid of the indigestible remains.