NUTRITION IN PLANTS AND ANIMALS

➢ Life Processes

Living forms perform some basic processes. These processes help in the survival and perpetuation of its race. Such processes are called **life processes**. These include Nutrition, Respiration, Transportation, Excretion, Coordination, Transpiration, and Reproduction. Among these processes reproduction helps in perpetuation of race. Remaining processes help the organism not only in its survival but also in its growth.

➢ Introduction to Nutrition:

All the living organisms require continuous supply of energy for their daily activities. It is derived by oxidizing food. Food consists of both organic and inorganic compounds. These chemical compounds, which are required for body building, and for energy production are called **Nutrients**. Intake of nutrients into the body by an organism is called **Nutrition**.

Types of Nutrients:

Nutrients may be organic or inorganic in nature. The organic constituents of nutrients are carbohydrates, lipids, proteins and vitamins. The inorganic constituents of nutrients are minerals and water. Depending upon the quantity or functions, nutrients may be of the following types.

1) Macro nutrients: Nutrients which are required in large amounts by our body are called macro nutrients. These nutrients provide energy and growth. Examples: Carbohydrates, lipids (energy) and proteins (growth).

2) Micro nutrients: Nutrients which are required in less amounts by our body are called micro nutrients. Although they do not provide energy they are called protective foods because their absence or shortage in the body can cause certain diseases and abnormalities in animals including humans. Examples: Minerals vitamins.

➢ Types of Nutrition:

Different organisms use different methods to obtain their nutrients, especially of carbon source. There are three modes of nutrition.

a) Autotrophic nutrition b) Heterotrophic nutrition c) Mixotrophic nutrition.

(a) Autotrophic Nutrition: Organisms, which exhibit autotrophic nutrition, are called Autotrophs. These organisms are able to synthesize their nutrients from simple inorganic compounds. They are capable of converting CO_2 into various complex organic compounds. They require energy for this purpose. Depending on how they obtain the energy for converting CO_2 to organic compounds, they are two types of autotrophs. 1) Photoautotrophs 2) Chemoautotrophs

1) Photoautotrophs: This mode of nutrition is the characteristic of green plants. The green plants possess a pigment called **chlorophyll**. These plants trap solar energy and manufacture their food in form of simple sugars from inorganic compounds like CO_2 and H_2O. This process is known as "**Photosynthesis"**. The presence of water, sunlight and chlorophyll are essential to carry out this process. Photosynthesis can be represent as

$$6CO_2 + 12H_2O \xrightarrow[\text{sunlight}]{\text{Chlorophyll}} C_6H_2O_6 + 6O_2 \uparrow + 6H_2O$$

E.g.: Green plants, some protists like euglena, volvox.

2) Chemoautotrophic Organisms: These organisms obtain energy by oxidizing simple inorganic compounds such as hydrogen, iron containing compounds, sulphur, hydrogen sulphide, ammonia, nitrate and other nitrogen containing compounds. But all these organisms require carbon dioxide as a source of carbon atoms.

E.g.: Sulphur bacteria oxidize hydrogen sulphide while nitrifying bacteria (Nitrobacterium, Nitrosomonas) oxidize ammonia to derive energy for chemosynthesis.

$$6CO_2 + 12H_2S \xrightarrow[\text{Sulphur-bacteria}]{\text{Chemosynthesis}} C_6H_{12}O_6 + 6H_2O + 12S$$

b) Heterotrophic nutrition:

All animals including man, bacteria all fungi are "heterotrophic" (hetero different, trophein = feeding). Obtaining readymade food from other organisms. Some of the bacteria and fungi depend on other dead organisms to obtain nutrients. Those, which live on other organisms, decompose and degrade the complex molecules present in these organisms to simple molecules. Bacteria and fungi absorb these molecules through their body surface. These are called **"Saprophytes"**. In this process, they add several valuable nutrients to the medium in which they live (water or soil).

Interestingly, some plants are also carnivorous especially these type of plants feed on insects. Such plants are called "insectivorous". They supplement their autotrophic nutrition by obtaining nitrogen and phosphorous rich nutrients from the insects. Insectivorous plants are autotrophic and can live by themselves with out feeding on insects. However, their growth is stimulated when they feed on insects. Examples: Nepenthes, Dionea (Venus fly trap), Drosera (sun dew plant) and utricularia (bladderwort).

Nepenthes

Utricularia

Dionea

Drosera

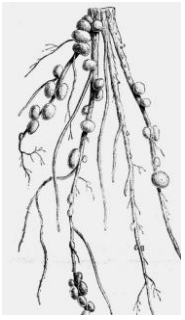
c) Mixotrophic Nutrition:

The third type of nutrition is called mixotrophic nutrition. In this type of nutrition there is an association of two different living organisms. Nutrients may be obtained by both the organisms or only by one organism.

1. When two organisms live together, exchange nutrients and are benefited **mutually**, the nutrition is called "**symbiotic nutrition**". One of the organisms provides nutrients required for the other organism, while the other provides shelter or nutrients or both. Symbiotic mode of nutrition is seen in both plants and animals.

i) Examples in plant kingdom:

a) Nitrogen fixing bacteria living in the root nodules of leguminous plants is a typical example for symbiotic nutrition. Plants provide shelter and nutrients to the bacteria while bacteria provide nitrogenous compounds to the plant. In nitrogen fixation, nitrogen and hydrogen are combined to form ammonium ions and then '**nitrate'**. The process depends upon enzymes that are only possessed by certain bacteria called "nitrogen-fixing bacteria". Some of these bacteria live freely in the soil, but a very important species called Rhizobium leguminosarum lives in swellings called nodules on the roots of leguminous plants such as peas, beans and clover.



Root Nodules

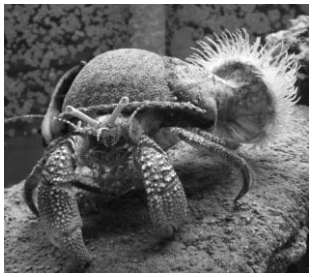
b) Similarly symbiotic association is seen on "**lichens**" where algae supplies food to fungi, fungi provides protection to algae and lives together. Lichens are able to live on bare rock.

Lichen

ii) Examples in animal kingdom:

a) Association of certain crabs with sea anemones is an example of symbiotic nutrition. Here sea anemones give protection to the animal while the small pieces of food particles are provided to sea anemones by the crab.

b) Relationship of ruminants and bacteria is also a good example for symbiosis, in which bacteria break down cellulose by releasing "cellulase" enzyme. In turn bacteria get the shelter and some of the simple form of food.



Crab with Sea anemone

2) In another type of mixotrophic nutrition, though association of two organisms is present, only one of the organism is benefited of the association. This type is called **parasitism. Parasite** is an organism which lives inside (called **endoparasite**) or outside (called **ectoparasite**) of another organism. In this mode of nutrition, only parasite is benefited. Body functions of the host are usually affected badly due to the invasion of the parasite and the host may even die.

Endoparasite: Worms in humans gut and plasmodium which causes malaria.etc. Parasites that live in the gut of their host have a regular supply of ready-digested food, so no need of digestive system of their own. However they have to cope with the harsh environment inside the host's gut. **E.g**. Tape worm

Ectoparasite : The parasite which depends on host body externally.

Eg: flea on a dog, lice in hair, etc.

Photosynthesis as a life process

Carbon and energy requirements of the autotrophic organism are fulfilled by "photosynthesis". Photosynthesis literally means synthesis with the help of light (photo – light; synthesis – building up). Photosynthesis is the manufacturing of simple carbohydrates from CO_2 and H_2O in the presence of sunlight inside the leaf.

➢ Definition of photosynthesis

Photosynthesis is a complex chemical process at the end of which carbohydrates are formed in green plants, using light as a source of energy. So it is a kind of photochemical reaction. It may be defined as **– "Photosynthesis is a photo – chemical reaction, during which carbohydrates are formed from CO_2 and water, in the chloroplasts of the green plants in the presence of light."**

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

You must keep in mind that synthesis of any new compound from simple substances requires energy. This energy is required to form new chemical bonds between the atoms of simple substances or reactants.

Significance of photosynthesis

- Photosynthesis is the only known process on earth by which autotrophic organisms trap solar energy and convert it into food for the rest of the organisms.

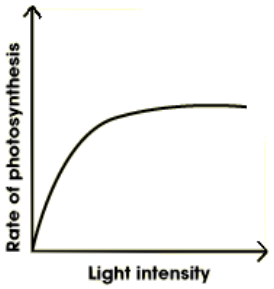
- Photosynthetic products provide energy to all organisms to carry out their life activities.
- All useful plant products such as fodder, timber, firewood, fibers, resin, rubber, drugs, etc. are produced by photosynthesis.
- Photosynthesis is the only known process by which oxygen is added to the atmosphere.
- Green plants purify the atmosphere by removing carbon dioxide gas.
- Besides providing energy as food, photosynthesis led to the formation of large reserves of energy in the form of coal, petroleum, wood and biomass.

Rate of photosynthesis: Limiting factors

The main factors affecting rate of photosynthesis are light intensity, carbon dioxide concentration and temperature. In any given situation any one of these may become a limiting factor, in other words the factors that directly affects the rate at which photosynthesis can take place masking the effects of the other factors.

Light and rate of photosynthesis

At low light intensities, as light intensity increases, the rate of the light-dependent reaction, and therefore photosynthesis generally, increases proportionately (straight line relationship). The more photons of light that fall on a leaf, the greater the number of chlorophyll molecules that are ionised and the more ATP and NADPH generated. Light dependent reactions use light energy and so are not affected by changes in temperature. As light intensity is increased further, the rate of photosynthesis is eventually limited by some other factor. So the rate plateaus.

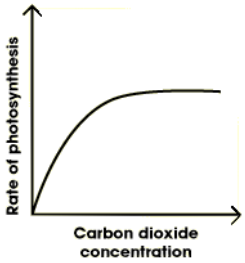


At very high light intensity, chlorophyll may be damaged and the rate drops steeply (not shown in the graph). Chlorophyll 'a' is used in both photo systems. The wavelength of light is also important. PSI absorbs energy most efficiently at 700 nm and PSII at 680 nm. Light with a higher proportion of energy concentrated in these wavelengths will produce a higher rate of photosynthesis.

Carbon dioxide and rate of photosynthesis

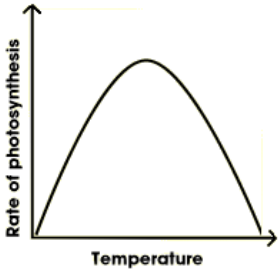
An increase in the carbon dioxide concentration increases the rate at which carbon is incorporated into carbohydrate in the light-independent reaction, and so the rate of photosynthesis generally increases until limited by another factor.

As it is normally present in the atmosphere at very low concentrations (about 0.04%), increasing carbon dioxide concentration causes a rapid rise in the rate of photosynthesis, which eventually plateaus when the maximum rate of fixation is reached.

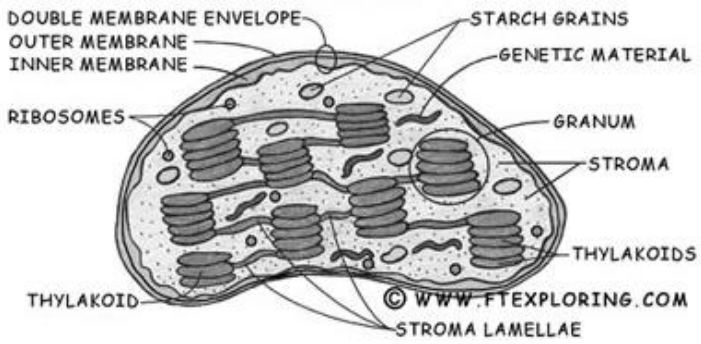


Temperature and rate of photosynthesis

Although the light dependent reactions of photosynthesis are not affected by changes in temperature, the light independent reactions of photosynthesis are dependent on temperature. They are reactions catalyzed by enzymes. As the enzymes approach their optimum temperatures the overall rate increases. It approximately doubles for every 10°C increase in temperature. Above the optimum temperature the rate begins to decrease, as enzymes are denatured, until it stops.



Structure of chloroplast



Chloroplast

It is one of the plastid of plant cell. It is a double membrane organelle. Chloroplast occurs mainly in the **mesophyll** cells of leaves. It is an oval shaped organelle. It is filled with colorless fluid called **stroma** and is having enzymes required for reactions. In the stroma, phospholipid bilayers are present. They are called **thylakoid membranes**. Many chlorophyll molecules are embedded in it. These molecules absorb light energy. Stacks of thylakoid membranes are called **grana.(sing–granum).** Grana increase the efficiency of the light dependent reactions by capturing most of the light energy that enters the cell. Chlorophyll and other accessory pigment molecules are situated in the thylakoid membranes. Chlorophyll is a mixture of four different pigments namely **chlorophyll – a chlorophyll – b, carotene and xanthophylls. Altogether these are called pigment systems**. These different molecules are arranged in a specific manner, facilitating the process of photosynthesis. Chlorophyll and other accessory pigments molecules are situated in the thylakoid membranes and organized to form the **REACTION CENTRES** -- called **photo system – I(PS I) and Photo system– II(PS II).**The reaction centre is different in both the photo systems. In PS-I the reaction centre chlorophyll a has an absorption peak at 700 nm, hence is called **P700**, while in PS-II it has absorption maximum at 680nm, and is called **P680**. The accessory pigments and other chlorophyll molecules harvest solar energy and pass it on to the reaction centres. They absorb photons and convert carbon dioxide and the water molecules into sugar and release oxygen. During this process they also make use of some of the enzymes present in the stroma. By conducting a small experiment it would be possible to show that the chloroplasts are necessary for photosynthesis.

Mechanism of photosynthesis

Let us now see what actually happens during the process of photosynthesis. The following events occur during this process.

- Absorption of light energy by chlorophyll.
- Conversion of light energy to chemical energy and splitting of water molecules into hydrogen and oxygen.
- Reduction of carbon dioxide to carbohydrates.

These steps need not take place one after the other immediately. For example, desert plants take up carbon dioxide at night and prepare an intermediate which is acted upon by the energy absorbed by the chlorophyll during the day.

DO YOU KNOW?

In bio chemical reactions the substance which gives electrons is called DONOR and the substance which accepts the electrons is called ACCEPTOR. **Examples** Nicotinamide adenine dinucleotide (NAD), Nicotinamide adenine dinuecleotide phosphate (NADP), Cytochromes, Plastoquinones ,Ferredoxins etc

As mentioned earlier, photosynthesis is the process in which light energy is converted into chemical energy through a series of reactions that occur in the chloroplasts. The reactions of photosynthesis that occur only in

presence of light are called **light reactions**. During this phase the energy required for the carbon fixation (Dark reaction) is generated.

Light Reactions

Light reaction takes place only in the presence of light in the grana (or) thylakoids of the chloroplast. It is also known as **Hill reaction** because a scientist named Hill discovered it. The reaction involves the following steps.

(a) Absorption of light energy by chlorophyll

When light falls on the chlorophyll, energy present in the photons is absorbed by the chlorophyll molecule; and said to be excited or activated. This energy pushes an electron in the chlorophyll molecule to a higher energy level. As a result chlorophyll gets oxidized. Released electron is accepted by electron acceptor. This acceptor gets reduced by accepting the electron from chlorophyll – thus the energy present in the photons of the sunlight is used to eject an electron from chlorophyll. This is the basic mechanism by which solar energy is trapped by chlorophyll.

$$Chl \xrightarrow{Photons} Chl^{*} \text{ (excited chlorophyll)}$$

$$Chl^{*} \longrightarrow Chl^{+} \text{ (Oxidised Chlorophyll)} + e^{-}$$

$$e^{-} + NADP^{+} \longrightarrow \text{NADPH (reduced from of electron acceptor)}$$

(b) Photolysis of water

With the removal of electron, Chlorophyll is in oxidized state. The oxidized power of chlorophyll is used for splitting water molecule to liberate electrons. By accepting these electrons chlorophyll returns to its original state. Oxygen is formed when the chlorophyll splits water molecule. This oxygen escapes into atmosphere. This can be shown as:

$$2H_2O \longrightarrow \underset{\text{(protons)}}{4H^{+}} + \underset{\text{(electrons)}}{4e^{-}} + O_2$$

Water

$$4e^{-} + 4Chl^{-} \longrightarrow 4Chl$$

(Chlorophyll oxidized) (Original state of Chlorophyll)

Net reaction is:

$$2H_2O + 4Chl^{+} \longrightarrow 4Ch + 4H^{+} + O_2 \uparrow$$

In this reaction, you will notice that the water molecule is split by light activated chlorophyll. Hence this process is called "**PHOTOLYSIS**." (Photo = light; lysis = break down).

It is remembered that the light does not split the water molecule directly. It acts through chlorophyll molecule present on PS II. Also notice that the chlorophyll accepts only electrons leaving behind the protons (H^{+})

Significance of photolysis

- Due to this reaction only O_2 is released, which is an important respiratory gas of living organisms.
- Oxidized chlorophyll is able to come to original state of chlorophyll, so that it is again ready to get oxidized.
- This is the reaction which leads to the further reactions in which ATP'S are formed.

(c) ATP and NADPH are formed during photosynthesis

We have learnt that protons (derived from splitting of water molecule) are left behind. These protons accumulate in the thylakoids. When their concentration becomes sufficiently high, they are transported across the thylakoid membrane into stroma. The energy in movement of protons is used to produce ATP. The electrons from PS II (which are released during oxidation of Chl) are taken up by PS I through a series of other acceptor molecules. In the PS I, these electrons are transferred to NADP to produce NADPH.

Overall view of light reactions

(1) Up to this stage of photosynthesis, all the reactions occur only when light is present. Therefore these reactions are called LIGHT REACTIONS of photosynthesis. (2) O_2, NADPH and ATP are end products of light reaction. (3) It is to be noted that CO_2 has not participated in any of these reactions and glucose is not produced. (4) NADPH, and ATPS are required to lead the reactions that occur in dark reaction.

The Dark Reaction or Carbon Fixation

The dark reaction is independent of light, thus it is called light independent reaction. It is slower than the light reaction and takes place in the stroma of the chloroplasts. The entire series of reactions involved in the conversion of carbon dioxide to glucose were identified by an American scientist, Melvin Calvin. The cycle of reactions in fixation of carbon dioxide are, therefore called Calvin cycle. The first stable product formed in this cycle is PGA (3C). Hence this cycle is also called **C3 Cycle**. Calvin received a Nobel Prize for this work. The following events occur during this process.

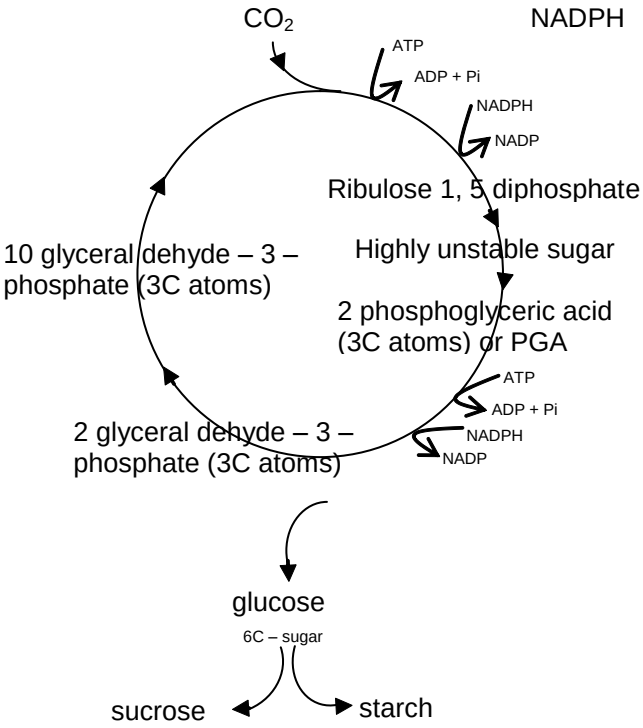
- Carbon dioxide is used for the production of glucose in a series of reactions that occur in stroma.
- ATP, NADPH produced in light reaction, are used in these reactions.

All these reactions take place in three major steps.

(a) Fixation of Carbon dioxide

In the first reaction, one molecule of carbon dioxide is transferred to five molecules of carbon sugar with two phosphates attached to it called Ribulose 1, 5 diphosphate (RUBP). As a result of six molecules of a six carbon sugar phosphate is formed. This is a highly unstable compound and breaks down spontaneously into two molecules of phosphoglyceric acid (PGA). Each PGA has 3 – carbon atoms.

Phosphoglyceric acid undergoes a series of reactions and is converted in to two glyceraldehyde – 3 – phosphates. NADPH, ATP, produced in the light reactions, is used up at this stage. Glyceralydehyde – 3 – phosphate has three carbon atoms.



(b) Formation of Sugars

Glyceraldehyde–3–phosphate undergoes a series of reactions to produce glucose. Two molecules of glyceraldehyde–3–phosphate ($2 \times 3 = 6$ carbon atoms) are used to produce one molecule of glucose and this glucose is converted to starch.

(c) Regeneration of RUBP Ten molecules of glyceraldehyde – 3 – phosphate ($C\ 10 \times 3 = 30$ carbon atoms) are used to regenerate 6 molecules of Ribulose – 1,5 – diphosphate ($6 \times 5 = 30$ carbon atoms.

To make one molecule of glucose 6 turns of the cycle are required. 18 ATP and 12 NADPH molecules will be required to make one molecule of glucose through the Calvin pathway.

NUTRITION IN ANIMALS

Unlike plants animals cannot prepare their own food. Instead they procure food by feeding on other organisms. Hence they are called Heterotrophs. Heterotrophic nutrition is of two types "**saprozoic**" and "**Holozoic**".

Saprozoic Nutrition: Very primitive animals, especially some protozoan and parasites exhibit saprozoic mode of nutrition. Organisms like fungi (yeast, moulds, and mushrooms), many bacteria etc, and take dissolved decaying organic materials from their environment. The organism releases some enzymes to digest the dead organic food and then the nutrients are absorbed through the body surface. In the previous topic, we have discussed parasitism. These parasites exhibit saprozoic nutrition. The characteristic of the animals which follow saprozoic nutrition is not having proper or specific digestive system. They absorb food materials dissolved in water through their body surfaces. Some animals secrete enzymes into the external medium. These enzymes break down the complete organic molecules into simple organic molecules. These simple molecules are then absorbed by the animal through its body surface. In the case of parasites (living in human gut), as the food is already digested, some of these animals may not have special digestive organs. Even if present, the digestive system is very simple.

Holozoic Nutrition: Majority of animals take solid particulate food or liquid food through special feeding, mechanisms and digest them with the help of digestive enzymes. This mode of nutrition is known as **holozoic nutrition.** The food may be a whole plant or whole animal or their parts.

Herbivores, Carnivores, Omnivores:

Animals can be divided into several categories according to the nature of food and the manner in which they obtain it. Size and nature of food consumed is different in different animals. They may consume either small or large plants or animals or both. Animals consuming plants as food are called herbivores and those consuming other animals are called carnivores. Those which consume both animals and plants are called Omnivores.

Examples:

Herbivores	:	Ruminants, Elephant, Rabbit, etc.,
Carnivores	:	Flesh eating animals like lion, tiger, wolf, vultures etc.
Omnivores	:	Man, cat, dog etc.

DO YOU KNOW?*: *Name the various types of heterotrophs on the basis of source of food?

Apart from herbivores, carnivores, and omnivores other heterotrophs are:

Cannibals: *Living organisms which eat upon the members of their own species are called cannibals. e.g., some fishes, certain snakes, cockroach etc.*

Detrivores: *The animals feed chiefly upon dead organic matters present in the mud are detrivores. e.g., earthworms.*

Predators*: When the larger animals feed upon the smaller animals species e.g., birds like eagle, kite etc).*

Insectivores: *These animals feed upon insects e.g., frog, lizards small bats etc. Some insectivores are only ant-eaters e.g., Echidna (Spiny ant eater) and Manis (scaly ant-eater).*

Scavengers or carrion eaters

The animals which feed upon other dead or decaying materials are called scavengers. E.g., vultures, hyena, crow, etc.

Piscivorous ***:****Animals feed on fish. E.g. crocodile.*

Grainivorous *Animals feed upon grains. E.g. pigeon.*

Caprophagous: *Animals feed upon faeces. E.g., pigs, dung, beetles, rabbit etc*

Sanguivorous: *Blood sucking animals etc., mosquito, leech.Herbivores, carnivores, and omnivores also come under this category, which we have already learnt in previous topic.*

Mono and polyphagous animals:

a) Some animals feed only on one type of food material and these are called **monophagous** animals. A typical example for this is the caterpillar larva of silk worm which feeds only on mulberry leaves.

b) Several animals feed on a variety of food materials and they are called **polyphagous** animals. For example we eat various types of vegetables like carrot, radish, ladies finger, drumstick, bottle goard. Sweat potato, onion etc and in the same way we eat leafy vegetables like palak, methi, spinach, pudina etc. In the same way in our life span, we eat various types of animal sources – like, milk, eggs, meet.

c) Diet of an animal may be different in different **sexes** or at different **stages of its life**. For example: Male mosquito feeds on plant juices, while female mosquito feeds on blood. Similarly caterpillar larva feeds on leaves while the butterfly feeds on the nectar.
Thus, there is a great variation in the type of food consumed and the method by which it is consumed in holozoic animals.

Classes of food:

Food is the basic necessity of life. It is required by the body for performing several functions in body. Such as
1) for growth and development
2) for providing energy for various activities.
3. for repair of damaged or worn out parts.
4) for protection against diseases.

On the basis of the function the nutrients **perform in the body, foods** are classified into three broad groups.
1) Energy – giving foods.
2) Body – building foods
3) Protective foods.

1) Energy giving foods:

Carbohydrates and fats are the main energy – giving foods for the body. Fats provide more energy than the carbohydrates and proteins. Both carbohydrates and fats are made up of carbon, hydrogen and oxygen.

Dietary sources:

Major source of carbohydrates in Indian diet are cereals (wheat, rice) millets (jowar, bajra, ragi) roots and tubers (like potato, tapioca, sweet potato), can sugar, geer, honey and fruits like banana and mango.
Major source of fat is ghee, butter, mustard oil, groundnut oil, soya oil and coconut oil. Foods like milk, curd, paneer, khoya, nuts, almond, ground nut, coconut, eggs and flesh foods also contain 8 to 50% of fat in them.

Functions of carbohydrates:

(i) Carbohydrates are oxidized in the body to release energy .One gram of carbohydrate provides 4.2K cal of energy.
(ii) It helps in proper utilization of fat in the body.
(iii) A greater intake of carbohydrates spares the proteins for their body-building function.
(vi) The undigested cellulose (which is a complex carbohydrate) provides the roughage for proper bowel movement.

Functions of fats:

(i) Fats are chief energy producers one gram of fat provide 9.45K.cal of energy.

(ii) Lipids are structural constituents of the cytoplasm, nucleus, mitochondria, biological membranes, and are involved in the formation and regeneration of cell and tissue structures.
(iii) Fat that is stored in the body tissues protects the body from loss of heat.
(iv) Fat deposited around the internal organs like the kidneys, liver etc., cushions the vital organs.
(v) Helps in smooth conduction of nerve impulse in axon.
(vi) Fats are stored in the body for subsequent use.

DO YOU KNOW? ***Fats are stored in the body subsequent use. But explain the consequences of the conditions in a person whose fat storage is beyond a healthy limit?***
Fats are chief energy producers and they are stored in the body for future use. But un healthy storage is said to be obese. The ideal body mass differs from person to person, and depends on height and age. A person who is obese is at risk from a number of life shortening diseases, including diabetes, breathing difficulties atherosclerosis and arthritis.

Body building foods:
Proteins are body building or growth promoting foods. It contains carbon, hydrogen, oxygen, nitrogen and small amounts of sulphur also present. Nitrogen is the most essential element in proteins. Amino acids are simple, smaller units of proteins.
Dietary sources: Rich sources of proteins include milk, milk products, meat, fish, eggs, nuts and pulses.
Functions of proteins:
1) Proteins are used for building muscles, skin, blood and bones.
They repair the body tissues which are worn out and provide protection from infections.
2) Regulate chemical reactions in the form of enzymes and hormones.
3) Contractile proteins bring about muscle contraction, which results in movement.
4) Proteins carry different substances in the blood to different tissues.
5) Approximately 4.1 K cal of energy is released by the oxidation of 1g of protein.

However, the body uses it as the last source of energy when carbohydrates and fats are not available.
Protective foods:
Vitamins and minerals are called “Protective foods”. These are required in almost negligible quantities. But they are important for various body functions. Vitamins are complex organic compounds and minerals are inorganic compounds.
Dietary source:
Vitamins and minerals are present in all food materials. Especially fresh fruits, fresh vegetables, cereals, germinated pulses, milk etc are rich sources.. Couples of vitamins are synthesized by the body. All other vitamins must be supplied by food.
Various minerals that are required by body are –
Calcium, Sodium, Potassium, Phosphorous, Magnesium, , Magnesium, Sulphur, Iron, Chlorine, Copper, Iodine, Zinc, Fluorine, Molybdenum, manganese etc.
Functions of minerals:
1) They involve in forming bones, teeth, blood cells.
2) Assisting in the chemical reactions of the cells.
3) Regulating body fluids.

Based on solubility vitamins are grouped into two categories. They are water soluble vitamins, vitamin B complex and vitamin C and fat soluble vitamins like A, D, E, and K. Among these vitamins, vitamin B_6, B_{12}, B_3 and K are synthesized in the human body by intestinal bacteria.

Functions of vitamins:

1) Vitamins process other nutrients.
2) Regulate nervous system.
3) Form genetic material, proteins, red blood cells and hormones.

Water:

Water is a component of all body fluids and accounts for about 70% of our body weight. It is essential for various metabolic activities. It acts as a solvent in the body for thousands of substances both organic and inorganic. It helps in the transportation of digested foods and oxygen throughout the body. It is used in the excretion of soluble wastes. It helps in regulating body temperature through sweating.

Roughage:

Cellulose constitutes the roughage in our body. Cellulose is the chief component of plant products. In human the digestion mechanism of cellulose is lacking. The undigested cellulose being fibrous in nature helps the movement of the undigested food through the intestine and provides bulk faeces. It stimulates secretion from digestive tract and helps in removal of cholesterol and toxins, vegetables, fruits along with their skin are rich in fiber content. Absence of roughage leads to constipation.

Balanced Diet:

A diet is the food we eat. A diet is also defined as the kinds of foods on which a person lives. Our diet usually contains all the nutrients in varying amounts. However a diet must contain all the essential nutrients in adequate and correct amounts for mainting good health. Such a diet which contains all the nutrients in the correct amount is called a balanced diet. A balanced diet is related to one's age sex, body weight, health and occupation.

Need for Digestion and Digestive Enzymes

Introduction:

In the earlier topic, we have learnt that majority of animals are holozoic with a great variety in the type of food consumed in the mechanism used for capturing the food. Whatever may be the type of food and the mechanism to capture it, an animal has to use the substances present in the food for energy production and body building.

We have learnt in previous topic that carbohydrates, proteins and lipids are the major components in the diet. These substances are present in the diet of all animals. These substances are present in the diet as very large and complex molecules. Animals cannot absorb such large complex molecules and supply them to the cells. Even cells cannot use them in this form. For effective use of food material, all the complex molecules present in the food are to be broken down to simple molecules with which they are made up of. Only in such a simple form, these molecules can be absorbed and utilized by animals. This process of converting complex large macromolecules present in the food to simple and small molecules is called **digestion**.

Types of digestion:

The digestion is classified into two main types on the basis of site of digestion of food.

1) Intracellular digestion 2) Inter or Extracellular digestion:

Intracellular digestion:

We are aware of the fact that there are some single celled animals, like protozoa are also holozoic. They feed on small microscopic solid food material. As these are single celled animals there is no special digestive system in these animals. Complex food molecules are enclosed in a vacuole called ***digestive vacuole***. Digestive enzymes discharged into the vacuole act on the complex molecules and convert them into simple molecules. These are absorbed and utilized by the cell. All these process occur in a single cell,

hence this process is called **intracellular digestion**. Intra cellular digestion also occurs to some extent in the multicellular animals.

(a) White blood cells called phagocytes engulf and destroy the invading organisms to remove them from the body.

(b) In lysosomes also this process occurs. Lysosomes have all the enzymes required for the digestion of carbohydrates proteins, lipids and nucleic acids.

Extracellular or Intercellular Digestion:

Digestion of food takes place in the lumen of digestive tract outside the cells and is a characteristic feature of higher animals. Animals showing intercellular digestion always feed on large pieces. In some cases, the size of the food is greater than the size of the mouth or even the size of the animal. Hence, these animals are having organs associate with the digestive system to reduce the size of food by cutting, chewing and grinding. All these processes are occurring in the central lumen or space present in the digestive system. As this space is extracellular space (space outsides the cell). This type of digestion is called **"extracellular digestion".**

Digestive enzymes:

We have learnt that large complex molecules present in the food are broken down to small and simple molecules in the digestive system. This process does not occur by itself. It requires the participation of enzymes which act as catalysts in the conversion of complex molecules to simple molecules. As these enzymes help in the process of digestion, they are known as digestive enzymes. And these enzymes are also called extracellular enzymes, because these enzymes are synthesized inside cells and then released from cell to perform their functions. The molecules that react in the enzymes catalyzed reaction are called **substrates**, and the molecules produced in the reaction are "**products**".

Enzyme + substrate → enzyme substrate complex → enzyme + product.

Characteristic of digestive enzymes:

a) These are proteins.

b) They act as catalysts – means they speed up reactions without themselves being affected by the reaction.

c) Digestive enzymes are called "**hydrolytic enzymes**" or "**hydrolases**". Because, during reaction these enzymes add a molecules of water and split the chemical bonds in complex molecules. This process of splitting a molecule with the addition of water molecule is called **hydrolysis** (hydro = water, lysis = breaking down**).**

d) There are several digestive enzymes in animal kingdom and each one is specific for its substrate. Enzymes which act on carbohydrates are called **"amylases",** on proteins are called **"proteases"** and on lipids are called **"lipases".** One type of enzyme acts only on its substrates but not on the substrate of another enzyme. For example lipases act only on lipids but not on carbohydrates or proteins. Similarly proteases act only on proteins but not on carbohydrates or lipids.

e) Some of the digestive enzymes are inactive when they are secreted. After their secretion, these enzymes are activated in the lumen of the digestive system. The word **'gen'** is added as a suffix to the name of the enzyme to indicate that the enzyme is in its inactive form. For example the inactive form of **"Pepsin"** is **Pepsinogen** and the inactive form of **chymotrypsin** is **"Chymotrypsinogen".**

f) Factors affecting enzyme activity are **temperature, pH** , **amount of substrate**.

Digestion of Cellulose in Rabbit:

Animals like rabbits are also herbivores but not ruminants. Rabbit produces two types of faecal matter – hard blackish and soft brownish faecal matter. To facilitate the digestion of cellulose the rabbit digests its food twice. A soft brownish fecal matter which has partially digested cellulose. Rabbit once again eats this and it

passes through the digestive system for a second time. Thus cellulose is getting digested completely. This type of feeding is called **caprophagy**.

Digestion of Cellulose in Man:

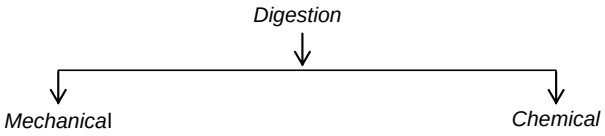
Man has no capacity to digest cellulose. However cellulose fibers add weight to the food and this allows the food to move smoothly in the intestine and facilitates efficient absorption nutrients from the digested food.

Human Digestive System

The alimentary canal, in association with the associated glands makes up the digestive system. The human alimentary canal is a muscular tube which starts with the mouth and ends at the anus. It is having various regions and is different in both structure and function. In addition to the digestive glands located in the lining of the various regions of the digestive tube, two large digestive glands, the liver and pancreas are also associated with it.

DO YOU KNOW? ***Is there is any difference in the process of digestion that takes place in mouth and in stomach or in intestines?***

Yes. The mode of digestion process is different in mouth and in stomach. During the process of digestion, physical and chemical nature of food will get changes. The following information will give clear picture about this phenomenon.



The physical handling of food involves the mechanical breaking down and mixing of the food.

Processing of food by enzymes is called chemical digestion. In which chemical structure of the food will get simplified.

Mechanical	Chemical
1. Breaking and chewing food by the teeth in the mouth. 2. Churning of food in the stomach to form chyme.	The enzymes split proteins, fats and carbohydrates into simpler chemical compounds like amino acids, glycerol fatty acids and monosaccharide's respectively.

Associated Glands

1. **Salivary glands**: Consists of three pairs of glands.
2. **Pancreas**: This is an exocrine and endocrine gland secreting enzymes as well as hormones.
3. **Liver** : Largest gland. It secretes bile
4. **Gastric glands**: Glands present in stomach.

Parts of the Alimentary Canal

1.**Mouth:** Associated structures are teeth and tongue

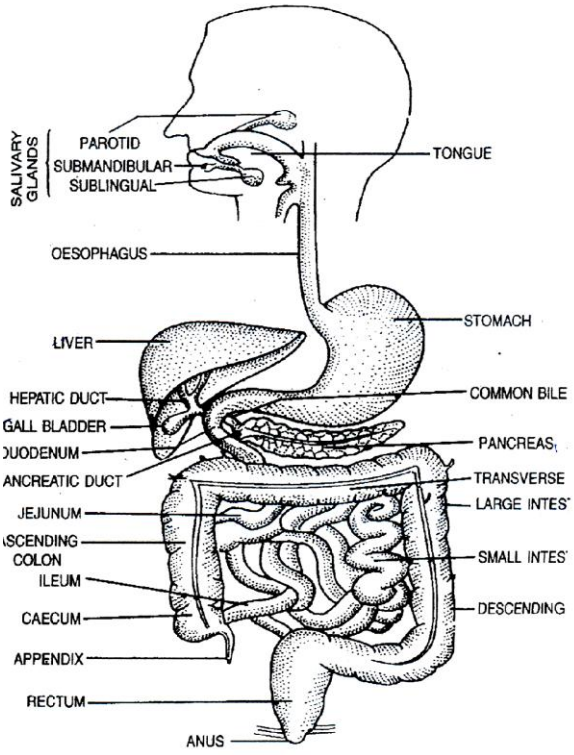
2. **Pharynx:** Common passage for food and air.

3.**Oesophagus:** Tube connecting throat and stomach for passage of food.

4. **Stomach:** Muscular pouch where food is partly digested.

5**. Small intestine**: Divided into three parts – duodenum, Jejunum and ileum.

6**. Large intestine**: Divided into three regions caecum, colon and rectum



The various parts organs of the digestive canal are described as follows:

Mouth: Salivary glands and their functions:

Mouth is only an opening of the digestive system. Taking food through mouth is called **ingestion.** The cavity or space in the mouth is called oral cavity or buccal cavity. Digestion starts in buccal cavity. Teeth tongue and openings of three pairs of salivary glands are presents in buccal cavity. Opening of mouth is formed by the upper and lower lips.

There are four types of teeth in man. They are incisors, canines, premolars and molars, each for a specific function. The arrangement of teeth is same on the upper and lower jaws. An adult human has 32 teeth.

Incisors: They are four front teeth in the centre of each jaw. Their cutting edges are broad and sharp. They are used for biting and cutting.

Canines:

They are on either side of incisors in each jaw. These are sharp and pointed for holding and tearing the food.

Premolars: They are two on each side in each jaw next to the canines. Each premolar has two hill - like projections or cusps, on its surface and hence known as bicuspid. Premolars help in grinding and crushing the food.

Molars:

They are the last three teeth on each side in each jaw. They have larger surface than the premolars. They are principal grinders and crushers of food. The last molar of each side in each jaw is called the “wisdom tooth”. These wisdom teeth appear last at an age of about 17- to 20 years when the human body is reaching maturity.

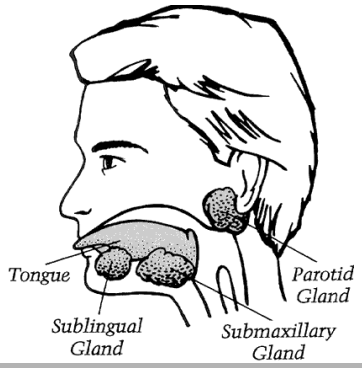
Thus teeth have a very special role. They cut and break the food into smaller bits. The small sized bits have relatively larger surface for the action of enzyme to act for better digestion. Teeth help in speaking and add to facial beauty.

Do you know ……

The human teeth or different in shape and are called "Heterodont". Teeth appear in two sets during life. In humans the first set, or milk teeth consists of 20 teeth, which start growing through the gums when the child is about 7 to 8 months old and are completed when he is about 2 years old. They are called temporary teeth. These temporary teeth will fall down as a result of their roots beings dissolved away in the jaw and are completely replaced by the permanent teeth by about 12 years of age. The number of permanent teeth of mammals is usually indicated in a formula $-\frac{2,1,2,3}{2,1,2,3}=32$; 8 incisors, 4 canines, 8 premolars and 12 molars.

Tongue is muscular and pushes the food on to the teeth during mastication. It also helps to push masticated food into pharynx. Taste buds on the tongue sense the taste of food. Tongue helps in cleaning the food particles from the teeth after eating and also in speaking. Taste buds present near the tip of the tongue are meant for knowing the sweet taste, those present laterally taste the sour substances. While those present in the posterior part of the tongue are meant for bitter taste.

Salivary glands Three pairs of salivary glands are present in the buccal cavity. They are **parotid**, **sub lingual** and **sub-maxillary glands.** Parotid glands are present near the ear, secretion from these glands is sent into buccal cavity through ducts. Other two pairs of glands open below the tongue through ducts. Saliva is released when food is present in buccal cavity. It is also released at the sight, smell and even thought of food.



Composition of saliva:

Saliva contains large amount of water, small amounts of salts and mucous. Saliva is slightly alkaline in nature. It contains an enzyme called salivary amylase (or ptyalin)

Functions of saliva:

1) Mucous present in the saliva makes the food sticky and helps its passage easy through pharynx.
2) Saliva is also useful as a solvent for dissolving the chemical substances present in food.
3) It stimulates the secretion of gastric juice and is required for the act of swallowing food.
4) The presence of "**Lysozyme**" in the saliva makes it bactericidal and protects teeth against caries.
5) Dryness in mouth (due to less water in saliva) gives a feeling of thirst to replenish body water. Thus saliva aids in water balance in the body.

As the food stays only for a short time in the buccal cavity, starch is partly digested here.

$$\underset{\text{[Polysaccharide]}}{\text{Starch}} \xrightarrow{\text{Ptyalin / Salivary amylase}} \underset{\text{[disaccharides]}}{\text{Maltose}}$$

The masticated food is now called **bolus**. It is rolled down to pharynx.

Pharynx:

- The posterior portion of oral cavity is called pharynx. When food reaches the posterior part, tongue is pressed upwards and back wards.
- The food passes from pharynx into esophagus. This is called swallowing. As we learnt in previous class, in pharynx, food and air channels cross each other.
- The food channel continues as "oesophagus" (food pipe).
- The air passage continues as larynx and trachea (wind pipe).
- The opening of the larynx is guarded by a muscular flap called **"epiglottis",** which prevents the entry of food into the windpipe while swallowing (pushing food into esophagus)

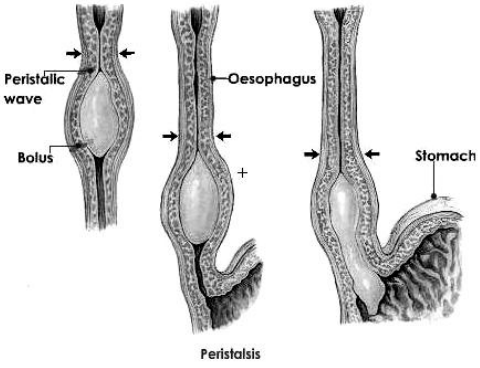
Swallowing and peristalsis:

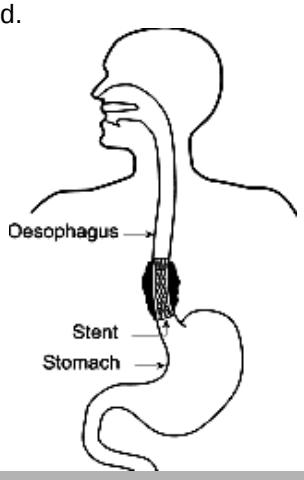
Oesophagus is a narrow tube and connects pharynx and stomach. It has both voluntary and involuntary muscles.

These muscles are arranged circularly and longitudinally. Internally, the wall of esophagus is lined with a mucous membrane which secretes mucous.

Mucous acts as a lubricant and helps in the easy and smooth passage of food. Swallowing is a voluntary act.

- Once food enters oesophagus, swallowing becomes as involuntary act.
- When food enters into oesophagus, the muscles present in its wall contract and relax alternately producing wave like movements.
- These are called peristaltic movements.
- They help in pushing the food down the esophagus into the stomach.
- Peristaltic movements of oesophagus are involuntary.
- There are no digestive enzymes in esophagus. Oesophagus is only a passage through which food enters into stomach.
- Hence, food does not undergo any change in pharynx and oesophagus. However, amylase present in the saliva continues to act on the starch present in the food.





Stomach

- Stomach is a muscular bag.
- It is present on the left side in the abdominal cavity, below the diaphragm. Part of the stomach into which esophagus opens is called **cardiac stomach.**
- Part of the stomach that opens into duodenum is called **pyloric stomach**.
- Opening of the pyloric stomach into duodenum is protected by pyloric sphincter.
- Muscles in the walls of the stomach are involuntary muscles.
- These muscles are arranged longitudinally, diagonally and circularly.
- These muscles, contract in different directions.
- As a result food is churned in the stomach. In an average adult stomach can hold 2 to 3 liters of food.

Stomach has three important roles

(1) It stores the food temporarily
(2) Mixing of various components in the food thoroughly. This occurs due to contraction and relaxation of muscles.
(3) It brings about physical and chemical changes in food. Internally stomach wall is lined by mucous membrane.

A number of glands called **gastric glands** are present in this membrane. Each gastric gland opens by a small pore into the lumen of (cavity) stomach. Gastric glands secrete **gastric juice and mucin.**

Composition of Gastric juice:

Gastric juice is a thick, clear and straw colored fluid, gastric juice contains hydrochloric acid and enzymes. It is a colourless highly acidic juice.

Functions of HCl:

1) Hydrochloric acid kills bacteria present in food.
2) It also destroys the structure of proteins, so that enzymes can digest them easily.
3) Acid coverts inactive pepsinogen in to pepsin.

Functions of enzymes:

Pepsin and lipase are the enzymes present in the gastric juice. When pepsin is secreted, it is inactive and is called pepsinogen. Acid converts inactive pepsinogen to pepsin which is the active form of the enzyme. Pepsin breaks down proteins into peptones and proteases. Lipase converts fats into fatty acids and glycerol. In children, another enzyme called **Rennin** is secreted into the stomach. It causes curdling of milk. This enzyme disappears as the child grows:

$$\underset{\text{[Inactive or proenzyme]}}{\text{Pepsinogen}} \xrightarrow{HCl} \underset{\text{[Active]}}{\text{Pepsin}}$$

$$\underset{\text{[Inactive or proenzyme]}}{\text{Prorennin}} \xrightarrow{HCl} \underset{\text{[Active]}}{\text{Rennin}}$$

$$\text{Proteins} \xrightarrow{\text{Pepsin}} \text{Proteoses and peptones [Peptides]}$$

$$\underset{\text{[Milk protein]}}{\text{Casein}} \xrightarrow{\text{Rennin}} \text{Paracasein}$$

$$\text{Paracasein} + Ca^{++} \longrightarrow \underset{\text{[Curd]}}{\text{Calcium paracaseinate}}$$

$$\text{Calcium paracaseinate} \xrightarrow{\text{Pepsin}} \text{Peptones}$$

After being processed in the stomach food is passed to the small intestine via the pyloric sphincter. The majority of digestion and absorption occurs here after the milky chyme enters the duodenum. Here it is further mixed with three different liquids.

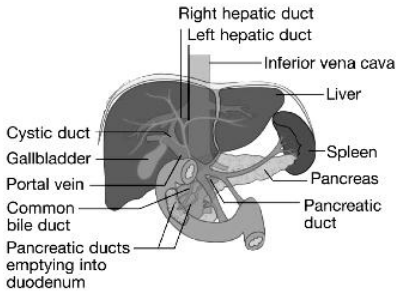
- **Bile** which emulsifies fats to allow absorption and neutralizes the chyme.
- **Pancreatic juice** made by the pancreas.
- **Intestinal juice** contains enzymes of the alkaline mucosal membranes. The enzymes include maltase, lactase and sucrase.

As the p^H level changed in the small intestines and gradually becomes basic. More enzymes are activated further and chemically break down various nutrients into smaller molecules to allow absorption into the circulatory or lymphatic systems.

Liver

- Liver is present on the right side of duodenum, below the diaphragm.
- It is brown in colour.

- There are four lobes in the liver.
- Cells present in the liver are called "**hepatocytes**".
- Liver produces **bile.**
- Bile reaches duodenum through a duct called bile duct.



Gall Bladder:
It is a pear shaped dark colored sack. Bile juice is stored temporarily also concentrated (by the removal of water) in the gall bladder. Bile from the gall-bladder is sent to bile duct through **cystic duct.**

Composition of Bile:
- This is a yellowish green sticky fluid produced in the liver.
- It has about 86% of water, bile salts, and bile pigments.
- The colour of the bile is due to certain pigments called **biliverdin** and **bilirubin**, formed by the break down of the dead or worn out red blood cells.
- It contains salts called **sodium cholate** and **sodium deoxycholate**.
- These salts neutralized the acid content of the food received from the stomach and make it alkaline to enable the pancreatic and intestinal enzymes to act.
- Bile salts change the fats into small microscopic colloidal particles. This is called "**Emulsification**".
- Emulsification of fats helps lipase to act on fats.
- Emulsification of fats by bile salts is an important step in the digestion of lipids and absorption of fatty acids.

(i) Fat $\xrightarrow{\text{bile}}$ emulsified fat

(ii) Acidic chyme $\xrightarrow[NaHCO_3]{\text{bile}}$ alkaline chyme

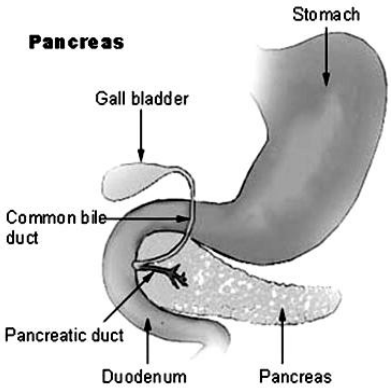
DO YOU KNOW? ***How is Jaundice is related to liver?***

When bile duct is blocked, bile gets mixed with blood and circulates in the body. Because of this, the eyes and skin become yellow. This is called Jaundice. Thus jaundice is related to liver.

Pancreas

- It is a yellowish grey gland and is present on the left side of duodenum, below the stomach. There are two parts in pancreas.
- One of them is called **exocrine pancreas**.
- Cells of exocrine pancreas open into ducts and secrete a juice called pancreatic juice.
- All the small ducts join to form a pancreatic duct which opens into duodenum.
- The second part of pancreas is called **endocrine pancreas**. It is called **islets of Langerhans cells** which help in secretion of "**insulin**". It is a hormone.
- It regulates the blood sugar levels.
- Deficiency of insulin leads to a disease called **diabetes.**
- In this condition sugar levels of blood will increase.

- This excess sugar is eliminated through urine.
- This is the main symptom of diabetes mellitus.



Composition of pancreatic juice

- **Trypsin, chymotrypsin, amylase and lipase** are important enzymes present in pancreatic juice.
- It also contains large amounts of bicarbonates which neutralizes the acid present in the chyme and makes the chyme slightly alkaline.
- Trypsin and chymotropisn are hydrolyze proteins.
- These two enzymes are produced in their inactive form called **trypsinogen and chymotrypsinogen**.
- These are converted into their active forms by another enzyme called **enterokinase.**
- But it is present in the intestinal juice.
- Once a small amount of active trypsin is formed, it converts the rest of the inactive enzymes into active enzymes. This is called "**autocatalysis**".
- Trypsin and chymotrypsin are active in alkaline medium.
- They convert remaining proteins into peptones and the peptones into peptides and amino acids**.**
- Amylase present in pancreatic juice acts on carbohydrates, producing **dextrin** and finally converts them into **maltose sugars**.
- Amylase also acts on dextrin formed due to action of salivary amylase and converts them into maltose sugars.
- **Lipase** present in the pancreatic juice converts **emulsified fats into glycerol and fatty acids.**

$$\underset{\text{[Proenzyme]}}{\text{Trypsinogen}} \xrightarrow[\text{intestinal juice}]{\text{Enterokinase of}} \underset{\text{[Active]}}{\text{Trypsin}}$$

$$\underset{\text{[Proenzyme]}}{\text{Chymotrypsinogen}} \xrightarrow{\text{Trypsin}} \underset{\text{[Active]}}{\text{Chymotrypsin}}$$

$$\underset{\text{[Proenzyme]}}{\text{Procarboxypeptidase}} \xrightarrow{\text{Trypsin}} \underset{\text{[Active]}}{\text{Carboxy peptidase}}$$

$$\text{Proteins} \xrightarrow{\text{Trypsin}} \text{Large peptides}$$

$$\text{Proteins} \xrightarrow{\text{Chymotrypsin}} \text{Large peptides}$$

$$\text{Elastin} \xrightarrow{\text{Elastase}} \text{Large peptides}$$

$$\text{Large peptides} \xrightarrow{\text{Carboxypeptidases}} \text{Dipeptides} + \text{Amino acids}$$

Small intestine

The small intestine in an adult human measures about 7 meters in length and is approximately 2.5 – 3 cm in diameter. Although the small intestine is much longer than the large intestine it gets its name from its comparatively smaller diameter.

The small intestine is divided into three structural parts.

- Duodenum 26cm in length
- Jejunum 2.5 m
- Ileum 3.5m

Cells present in the intestinal wall secrete mucous and enzymes in the form of intestinal juice. This is called "**Succusentericus**". Intestinal juice contains carbohydrate digesting enzymes like maltase, sucrase and lactase which act as follows:

$$\text{Maltose} \xrightarrow{\text{Maltase}} \text{glucose} + \text{glucose}$$

$$\text{Sucrose} \xrightarrow{\text{Sucrase}} \text{glucose} + \text{fructose}$$

$$\text{Lactose} \xrightarrow{\text{Lactase}} \text{glucose} + \text{galactose}$$

Intestinal juice contains enterokinase [Activate the trypsinogen into trypsin] and protein digesting enzymes aminopeptidases and dipeptidases.

$$\text{Large peptides} \xrightarrow{\text{Aminopeptidases}} \text{dipeptides} + \text{amino acids}$$

$$\text{Dipeptides} \xrightarrow{\text{Dipeptidases}} \text{amino acids}$$

Intestinal juice also contains lipase, nucleotidases and nucleosidases which acts as follows

$$\text{Fat} \xrightarrow{\text{Lipase}} \text{glycerol} + \text{fatty acids}$$

$$\text{Nucleotides} \xrightarrow{\text{Nucleotidases}} \text{Nucleosides} + \text{Inorganic phosphates}$$

$$\text{Nucleosides} \xrightarrow{\text{Nucleosidases}} \text{N} - \text{bases} + \text{Pentose sugars}$$

The final stage of the mechanical and chemical processing of food takes place here. The completely digested liquid in the ileum is called "**Chyle**".

Absorption of nutrients

The final products of food are mainly absorbed in the intestine itself.

Meaning of absorption: Absorption is a process by which nutrients pass from the alimentary canal into the blood and lymph through its mucous membrane.

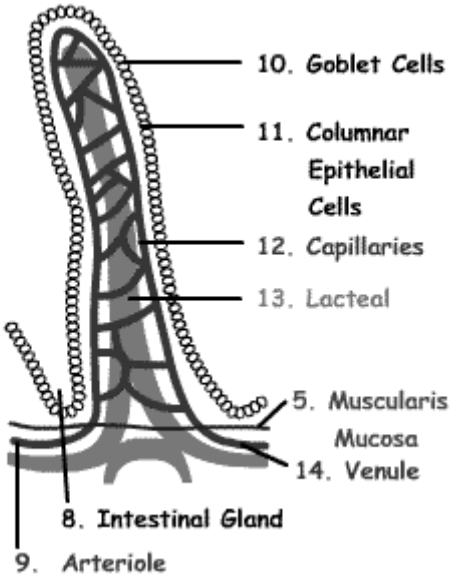
Nutrients to be absorbed: Amino acids, monosaccharides, fatty acids, glycerol, salts electrolytes vitamins and water are to be absorbed.

Site of absorption:

- Some water and salts, alcohol, some drugs such as aspirin and moderate amounts of sugar are absorbed in the stomach.
- Water and products of bacterial digestion (amino acids, vitamin B complex and vitamin k) are absorbed in the large intestine.
- Absorption mainly occurs in the small intestine.
- Most absorption happens from the **ileum**, the lower part of the small intestine.
- The ileum is very well adapted to perform this task.

(a) It is very long, about 6m in an adult human, so food takes a long time to pass through it and there is enough time for absorption to occur.

(b) The surface of the ileum is highly folded, which gives a much larger surface area for absorption than a simple fuse would. The lining of the ileum is folded into hundreds of thousands of tiny finger like structures, the **"Villi".** Blood vessels and lymph vessels are present in the form a network in the villi. Products of digestion are absorbed first into the villi and from there into the blood vessels and lymph vessels. Villus has the following components to absorb various nutrients.



Villus

Epithelium: Only one cell thick so that there is a short distance for absorption by active transport and diffusion.

Goblet cell: Produces mucus which protects gut lining against digestion by body's own enzymes.

Capillary: Transports glucose (from carbohydrate breakdown) and amino acids (from protein break down)..

Lacteal: Transports fatty acids and glycerol (the products of fat break down).

Vein: Delivers absorbed products to the liver via the **hepatic portal vein.**

Artery: Delivers blood to villi.

Absorption of different nutrients

Absorption occurs by simple diffusion, osmosis, facilitated diffusion and active transport.

1) Absorption of carbohydrates:

Glucose and galactose are absorbed by active transport. Glucose and galactose and fructose are absorbed into blood capillaries. The most rapidly transported monosaccharide is galactose with glucose running a close second.

2) Absorption of amino acids:

Amino acids are absorbed by active transport. They also enter the blood stream.

3) Absorption of fatty acids and glycerol and fat soluble vitamins:

- Fatty acids and glycerol are insoluble in water; therefore, they cannot reach the blood stream directly.
- They are turned into small, spherical, water soluble droplets called micelles with the help of bile salts, in the intestinal lumen.
- From the micelles fatty acids, glycosides, sterols and fat soluble vitamins are absorbed in to the intestinal cells by diffusion where they are resynthesized in the endoplasmic reticulum.

- Latter they are released from the intestinal cells into the lymph present in the lymphatic capillaries, the **"lacteals".**
- It emerges into larger lymphatic vessels and is transported via the lymphatic system and the thoracic duct up to a location near the heart. From here they are transported to liver for further processing or to fat tissue for storage.

4) Absorption of water:
The absorption of water by small intestine occurs by osmosis from the lumen of the small intestine through epithelial cells and into the blood capillaries in the villi.

Colon (large intestine):
The large intestine is about 1.5mts long the diameter of large intestine is greater than the diameter of the small intestine. Lrarge intestine is present between small intestine and rectum. The wall of colon is made of involuntary muscles. It has three parts
(a) Ceacum, (b) Colon, (c) Rectum.

1) Ceacum: It is a pouch like structure which is about 6cms. The vermiform appendix is an outgrowth of the caecum. **Appendix** is a vestigial organ. The inflammation of vermiform appendix is called **appendicitis.** The caecum is well developed in herbivorous mammals like rabbits, horses etc.

2) Colon: The caecum leads into colon which is divided into four regions, the ascending, transverse, descending and sigmoid colon. **Ascending colon is the shortest part of colon.** The colon has three longitudinal bands called **taeniaecoli.**

Functions of large intestine:
The chief function of the large intestine is the absorption of water and elimination of solid wastes. However moderate quantities of vitamin k and vitamin B complex are manufactured by bacteria in the large intestine.

Rectum:
Colon opens into rectum. It comprises the last 20 centimeters of the digestive tract and terminates in the 2cm long anal canal.

Anus:
The opening of the anal canal is called Anus. The anus has an internal anal sphincter composed of smooth muscle fibers and an external anal sphincter comprised of striped muscle fibers.

Do you know…….
Structures formed due to enlargements of veins of anal columns in anal canal as well as anus are called hemorrhoids or piles.

Elimination/Defecation:
Water and mineral salts present in the chyme are absorbed in the colon and soft, solid faeces are formed. Faeces consist of undigested food material, dead bacteria, bile salts and bile pigments. By the peristaltic movements of large intestine, faeces are pushed towards rectum. It is expelled out through anus. This happens when the sphincter muscles that guard anus expand. This activity is called defecation.

Disorders of digestive system
Worm infestations
Worm infestations of the intestines are caused by tapeworm, roundworm, threadworm, hookworm, pinworm, etc.

Indigestion: In this condition, the food is not properly digested leading to a feeling of fullness. The causes of indigestion are inadequate enzyme secretion, anxiety, food poisoning, over eating and consuming spicy food.

Constipation: Faeces are retained with in the rectum as the movements of intestines (bowel) occur irregularly.

Diarrhoea: The abnormal frequency of bowel movement and increased liquidity of this faecal discharge. It reduces the absorption of food. It is due to infection caused by bacteria and some protozoan.

Peptic ulcer: Imbalance in the rate of secretion of gastric juice leads to peptic ulcer, which are depressed lesions in the mucous membrane of stomach.

ASSIGNMENT

NUTRITION IN PLANTS

1. Which pigment is present universally in all green plants? [ ]
(A) chlorophyll a (B) chlorophyll d (C) chlorophyll c (D) chlorophyll e

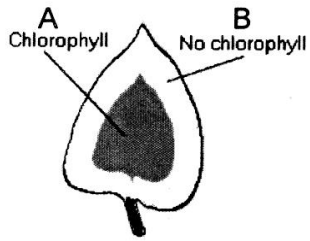
2. During the dark reaction, the synthesis of carbohydrate occurs from CO_2 in the …….. of the chloroplast. [ ]
(A) grana (B) stroma (C) mesophyll cells (D) plasmodesmata

3. Which statement is correct regarding insectivorous plants? [ ]
(A) They are purely saprophytes (B) They are purely autotrophs
(C) They are carnivores (D) They are heterotrophs

4. Bacteria are often classified on the basis of their nutrition. Which of the following is a true statement? [ ]
(A) All bacteria are prokaryotes, so they are by definition heterotrophic
(B) Methanogens derive their energy by consuming methane
(C) Some bacterial autotrophs derive energy from simple inorganic reactions
(D) All bacteria require oxygen to generate ATP

5. Photosynthesis takes place in…… [ ]
(A) Xylem (B) Phloem (C) Epidermal cells (D) guard cells

6. Which of the following part of the leaf will become blue black with iodine test? [ ]



(A) A (B) B (C) Both (A) and (B) (D) None of these

7. When light strikes chlorophyll molecule in a photosynthetically active chloroplast, they lose electrons. Which of the following accepts these released electrons initially? [ ]
(A) PGA (B) RUBP (C) NADP (D) $C_6H_{12}O_6$

8. Hydrophytes take in CO_2 in the form of [ ]
(A) Carbonates (B) Bicarbonates (C) CO (D) Both (A) and (B)

9. Photolysis is _____. [ ]
(A) the absorption of light by chlorophyll
(B) the assimilation of carbon dioxide
(C) the splitting of water
(D) none of the above

10. You are able to live on Earth due to this waste product of photosynthesis: [ ]
(A) Carbon Dioxide (B) Water (C) ATP (D) Oxygen

11. Accessory pigments (such as carotenes, xanthophylls, and anthocyanin): [ ]
(A) Add color the plant but do not absorb light energy
(B) Absorb colors of light that chlorophyll cannot absorb
(C) Receive electrons from the electron transport chain of Photosystem I
(D) Are not involved in Photosynthesis

12. The stomata: [ ]
(A) Are holes in the leaves created by insects
(B) Allow H2O, CO2, and O2 in and out of the leaf
(C) Are surrounded by specialized cells called guards
(D) B and C

13. Which of the following environmental factors does NOT directly influence the rate of photosynthesis: [ ]
(A) Light Intensity (B) Oxygen Concentration
(C) Carbon Dioxide Concentration (D) Temperature

14. PGAL from the Calvin Cycle are: [ ]
(A) 3 Carbon sugars (B) used to produce organic compounds
(C) used to regenerate RuBP (D) All of the above

15. When a Chlorophyll molecule absorbs light, [ ]
(A) Some of its electrons are excited to a higher energy level
(B) It disintegrates
(C) It absorbs mostly green light
(D) It absorbs all wavelengths of light.
(C)Respiration (D) Intermediates

16. One of the following is not electron acceptor: [ ]
(A) Ferridoxin (B)Cytochrome (C)Plastoquinone (D)ATP

17. External factors of photosynthesis are: [ ]
(A) Chlorophyll, light (B) Light, CO_2
(C)Light, H_2O (D) Chloroplasts, CO_2

18. Autotrophic mode of nutrition requires: [ ]
(A) CO_2 and H_2O (B) Chlorophyll (C) Sunlight (D) All of these

19. For the survival of human race oxygen is released into the atmosphere through a process called: [ ]
(A) Photosynthesis (B) Respiration (C) Excretion (D) None

20. What do you call the particles of light rays which carry energy? [ ]
(A) Electrons (B) photons (C) Neutrons (D) Protons

21. The process of addition to high energy phosphate to ADP to form ATP is called [ ]
(A)Fermentation (B)Phosphorylation
(C)Respiration (D) Intermediates

22 One of the following is not electron acceptor: [ ]
(A) Ferridoxin (B)Cytochrome (C)Plastoquinone (D)ATP

23 External factors of photosynthesis are: [ ]
(A) Chlorophyll, light (B) Light, CO_2

(C)Light, H_2O (D) Chloroplasts, CO_2

24. Internal factors are: [ ]
(A)Chloroplasts, H_2O (B) Light, CO_2
(C)CO_2, H_2O (D) Chloroplasts , H_2O

25. In photosynthesis the spectrum of light that absorbed more is? [ ]
(A)Blue and Red (B) Blue and Green
(C) Green and Yellow (D) Violet and Red

26. Expanded portion of leaf is called [ ]
(A)Leaf lamina (B) Petiole (C) Veins (D) All

27. Stomata are present in [ ]
(A)Upper epidermis (B) Lower epidermis
(C)Spongy parenchyma (D) Palisade parenchyma

28. The rate of diffusion of the gas depends upon the number of: [ ]
(A) Stomata present on lower epidermis. (B)Stomata present on upper epidermis.
(C) Stomata present on both sides. (D) None.

29. Dark reaction takes place in [ ]
(A) Grana (B) Stroma (C) Thylakoid (D) Lamellae

30. Number of glyceraldehyde-3-phosphate molecules required to make one molecule of glucose: [ ]
(A) 02 (B) 03 (C) 05 (D) 07

CPP

NUTRITION IN ANIMALS

I. Choose the Correct Answer.

1. Pancreatic juice does not contain enzymes to digest : [ ]
(A) proteins (B) fats (C) carbohydrates (D) vitamins

2. Enzymes present in gastric juice are: [ ]
(A) pepsin (B) renin (C) lipase (D) all of these

3. Which of the following animals follow heterotrophic nutrition? [ ]
(A) Dog (B) Man (C) Elephant (D) All of these

4. Protective foods are: [ ]
(A) carbohydrates (B) proteins
(C) fats (D) vitamins and minerals

6. Silkworm caterpillar is an example of: [ ]
(A) polyphagous animal (B) monophagous animal
(C) caprophagous animal (D) frugivorous animal

7. In _____ type of nutrition, enzymes play a major role in digestion of food. [ ]
(A) saprozoic (B) autotrophic (C) holozoic (D) none of these

8. _____ cells of gut secrete enzymes. [ ]
(A) Epithelial cells (B) Gland cells (C) Muscle cells (D) Special cells

9. In man, the type of digestion is: [ ]
(A) intracellular (B) intercellular (C) holozoic nutrition (D) heterotrophic nutrition

10. In humans, protein digestion takes starts in: [ ]
(A)Stomach (B) Small intestine (C) Duodenum (D) abomasums

11 In Rabbits type of feeding is called; [ ]
(A) Symbiotic (B) Caprophagy (C) Parasitic (D) saprophytic

12. What is the main diet of ruminants? [ ]
(A) Starch (B) cellulose (C) fatty acids (D) proteins

13. Villi are absent in: [ ]
(A) duodenum (B) jejunum (C) Ileum (D) none of these

14. What is common among amylase, rennin and trypsin? [ ]
(A) These are cells produced in stomach (B) These are all enzymes
(C) These act as pH (D) None of these

15. Lactase is found in: [ ]
(A) saliva (B) pancreatic juice (C) bile (D) intestinal juice

16. Largest gland of human body is: [ ]
(A) gall bladder (B) liver (C) pancreas (D) brain

17. Chemical compounds required for body building and for energy production are called: [ ]
(A) nutrition (B) nutrients (C) bile (D) enzymes

18. _____ teeth are absent in ruminants. [ ]
(A) canines (B) molars (C) premolars (D) all of these

19. Which of these exhibit holozoic nutrition? [ ]
(A) Yeast (B) Mould (C) Amoeba (D) Hydra

20. Pigeon is [ ]
(A) Grainivores (B) Detritevores (C) Scavenger (D) Piscivores

(ii) Assertion and Reasoning pattern (Q.No. 21- 25)

Each question contains STATEMENT – 1 (Assertion) and STATEMENT – 2 (Reason). Each question has 5 choices (A), (B), (C), (D) and (E) out of which ONLY ONE is correct.

OPTIONS
(A) If both assertion and reason are true and reason is correct explanation of assertion
(B) If both assertion and reason are true and reason is not correct explanation of assertion
(C) If assertion is true but reason is false
(D) If assertion is false but reason is true.
(E) If both assertion and reason are false

21. Assertion: Animals showing intracellular digestion are always microphagous.
Reason: In these animals, food is to be ingested within a digestive food vacuole.
[ ]

22. Assertion: Ruminants are commonly called cud-chewing mammals.
Reason: Ruminants show symbiotic digestion of cellulose in their compound stomach. [ ]

23. Assertion: Saliva secretion is a reflex action.
Reason: Saliva secretion is controlled by only brain and not the hormones. [ ]

24. Assertion: Carbohydrates are called richest source of energy. [ ]
Reason: Carbohydrates provide highest amount of energy on oxidation.

25. Assertion: Starch is hydrolysed to maltose by ptyalin. [ ]
Reason: Sucrase hydrolyses sucrose to lactose.

26. Caloric value for carbohydrates, proteins and fats is: [ ]
(A) 50 cal, 4.68 cal and 80 cal respectively
(B) 40 cal, 80 cal and 100 cal respectively
(C) 4.1 Kcal, 4.1 Kcal and 9.45 Kcal respectively
(D) 5.6 Kcal, 100 Kcal and 30 Kcal respectively

27. The vitamin required for absorption of Iron _____ [ ]
(A) vitamin "A" (B) vitamin B_6 (C) vitamin C (D) vitamin D

28. The vitamin required for absorption of Iron _____ [ ]
(A) vitamin "A" (B) vitamin B_6 (C) vitamin C (D) vitamin D

29. The element required for formation of haemoglobin [ ]
(A) Fe (B) Ca (C) Na (D) K

30. If food intake is greater than energy used the surplus is deposited as [ ]
(A) Fat (B) protein (C) glycogen (D) fat and glycogen

31. A starving man first consumes [ ]
(A) fat (B) protein (C) glycogen (D) vitamin

32. Most important property of water for which it is needed in the body. [ ]
(A) It is a liquid (B) It cools the body
(C) It is a universal solvent (D) It is tasteless and colourless

33. Sunshine vitamin is [ ]
(A) E (B) C (C) D (D) A

33. Muscle fatigue is due to [ ]
(A) Na^+ (B) K^+ (C) Lactic acid (D) Citric acid

34. Which of the following disease is shown by the picture? [ ]
(A) Beriberi (B) Scurvy (C) rickets (D) Anaemia

34. Sanguivores are [ ]
(A) Blood suckers (B) flesh eaters (C) plant eaters (D) all of these

35 The major part of our food constitutes generally [ ]
(A) Glucose (B) sucrose (C) fat (D) car